STAR OF THE SOUTH MARINE ECOLOGY SURVEY PROGRAM

Benthic Ecology Study Report

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Contents

Tables

Plates

Figures

Acronyms and abbreviations

bsl	Below sea level
CBiCs	Combined Biotope Classification Scheme (Victoria)
CMECS	Coastal and Marine Ecological Classification Standard (United States of America)
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DCCEW	Department of Climate Change, Environment and Water (Commonwealth)
DELWP	Department of Environment, Land, Water and Planning (Victoria)
EIA	Environmental Impact Assessment
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EUNIS	European Union Nature Information System
FFG Act	Victorian *Flora and Fauna Guarantee Act 1988* (repealed by the *Flora and Fauna Guarantee Amendment Act 2019* in June 2020)
G&G	Geophysical and geotechnical surveys
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
JNCC	Joint Nature Conservation Committee (United Kingdom)
km	Kilometres
MESP	Marine Environmental Survey Program
MNES	Matters of National Environmental Significance
MSL	Mean sea level (Australian height datum)
NOAA	US National Oceanic and Atmospheric Administration
NM	Nautical miles
OECA	Offshore export cable area
OPA	Offshore project area
OTU	Operational taxonomic unit
OWF	Offshore wind farm
OWFA	Offshore wind farm area
PMST	Protected Matters Search Tool
SBRUVs	Stereo baited remote underwater video system
SOTS	Star of the South
TOC	Total organic carbon
TP	Total phosphorous
TRG	Technical reference group
WTGs	Wind turbine generators

Definitions

Assemblage	All the species that occur together in a given area
Biodiversity	The number of species, taxa or operational taxonomic units (OTUs) occurring within a single sample
Biotope	A geographical unit combining the concepts of habitat and community; a habitat supporting a specific assemblage or community of plants and animals, which operate together at a specific scale (Connor et al. 2004); a fundamental organisational unit of marine ecosystems (Olenin and Ducrotoy 2006)
Biounit	The lowest level classification of the Victorian Combined Biotope Classification Scheme (Victoria) – level 6 (bioregional unit).
Circalittoral	Seabed within the coastal zone between the limit of the euphotic zone (infralittoral) and the continental shelf edge that is dominated by sessile invertebrates. The upper limit is taken to be ~30 m in Victorian coastal waters (typical) while the lower limit is the shelf break at ~200 m depth. Seabed communities are dominated by animals due to low light availability, though low-light adapted macroalgae may occur. The coastal circalittoral zone (relevant to this study) has a weak seasonal temperature variation (commonly <10 °C in temperate waters), which changes slowly between seasons (MarLIN 2021)
Community	A group of interacting species populations occurring together in space
Depth	Depths used in this report are metres below mean sea level (MSL) unless otherwise stated.
Epibiota	Flora and/or fauna living on or attached to the seabed or submarine structures
Euphotic zone	The layer of marine waters that receives sufficient light for photosynthesis
Habitat	A place where an organism lives; an area where a species occurs (Olenin and Ducrotoy 2006); an area of seabed with specific physico-chemical conditions
Infralittoral	Seabed within the euphotic coastal zone where there is sufficient light for macroalgae or seagrasses to dominate benthic habitats. The lower depth limit of the infralittoral zone in Victorian coastal waters is generally defined as 30 m depth. Hard substrate habitats are commonly dominated by macroalgae (kelps and other seaweeds) and seagrasses may occur on unconsolidated sediment. The annual temperature range may be greater than in deeper (circalittoral) waters due to coastal influences (MarLIN 2021).
IMCRA	Integrated Marine and Coastal Regionalisation of Australia (Commonwealth of Australia 2006).
Offshore Export Cable Area	The offshore export cable area contains the export cables which transport electricity between the offshore wind farm and the shore crossing at Reeves Beach.
Offshore Project Area	The maximum offshore geographical extent that would be used for the development of the project, including permanent structures and cables and areas used for construction and operation works. This area comprises both the offshore export cable corridor and the offshore wind farm area.
Offshore Wind Farm Area	The area covered by the exploration licence granted to Star of the South for site investigations comprising an area of 496 km^2, located between 8 and 13 kilometres from the central Gippsland Coast, south of Yarram and Port Albert. The area where the wind turbine array is proposed to be built.
Operational Taxonomic Units	Taxonomic definition used to group closely-related individuals. A taxonomic grouping method that groups biota by similarity (eg morphotypes) rather than strictly aligning with Linnaean taxonomy.
The Project	The Star of the South offshore wind farm project
Project Area	Comprising the OWFA and OECC
Sessile	Fixed in one place; immobile
Species abundance	The number of individuals of each species in an area
Species diversity	The number of species as well as the abundance and distribution of each species in an area
Species richness	The number of species in an area

Study Area	The spatial area relevant to the benthic ecology study, including the OWFA, OECC, a 2 km adjacent zone surrounding the OWFA, a 5 km buffer zone surrounding the OWFA, and two reference zones 5-6 km from the edge of the OWFA

EXECUTIVE SUMMARY

Star of the South (SOTS) is proposing to develop an offshore wind farm in Commonwealth waters off Gippsland, Victoria. Benthic habitats have the potential to be impacted during construction and operations of the proposed development. Baseline information on the presence, diversity and distribution of benthic habitats and communities in the Study Area is needed to inform the Environmental Impact Assessment (EIA). A benthic ecology survey was undertaken between 17 November and 4 December 2020, with supplementary subsea video collected between 17 January and 16 February 2022.

Survey 1 (the main survey) included 21 towed camera transects (500 m), 70 drop camera video sites and 135 sediment grab samples in and around the offshore wind farm area (OWFA). Survey 2 (supplementary) included 8 towed camera transects (2 km) and 14 drop camera video sites. Survey 2 was aimed at better understanding the distribution of reef and seagrass habitat in the offshore export cable corridor (OECC) and surrounds. The benthic habitat dataset was augmented by habitat images from 123 winter time and 134 summer time SBRUVs survey sites, which were sampled during the fish ecology survey program.

Still images collected during camera deployments, infauna and sediment physico-chemical characteristic data derived from grab sampling and positional data were analysed to characterise benthic habitat features and biological assemblages to determine the spatial distribution of habitats across the Study Area. The imagery and grab sample data were then used to define and characterise benthic biotopes in the area.

The outcomes of the benthic ecology study provide a baseline characterisation of the benthic habitats and infauna and epibenthic communities of the Study Area, appropriate for supporting a robust environmental impact assessment. Key findings are listed below.

- Seabed habitat in the Study Area included large areas of low relief unconsolidated sediments including sand and mixed coarse sediment (sand, shell, granules, cobble) and large areas of moderate relief (<1 m) 'angular' sediment seabed including sand and mixed coarse sediment. There were small areas of exposed low profile (<0.5 metre high) and higher profile (>1 metre high) reef. Megaripples are present in shallower areas (rising 1 m above ambient seabed level). Substrate types observed were broadly consistent with the limited existing data in the area.
- Sediments in the Project Area were clean, with ANZG (2018) guidance level exceedances for arsenic being attributed to natural (geological) sources.
- Infaunal analysis from grab sampling recorded 18,690 individuals, representing 236 taxa from a sampled area of 13.5 m^2. Infaunal assemblages across the study area were dominated by the Arthropoda (59 per cent of the total number of individuals identified), Annelids (31 per cent of total individuals) and Mollusca (5 per cent of total individuals).
- Increasing silt/clay (<63 µm) and gravel (4-64 mm) particle size fractions (and consequently decreasing % sand composition) was correlated with increased number of infauna species. Coarse and mixed coarse sediments were likely to be more diverse than finer sediments. Coarse and mixed sediments mostly occurred in deeper water (> 30 metres).
- Sessile epibiota on high profile reef in water depths less than 30 metres and areas of low profile reef and biogenic hard substrates in water depths deeper than 30 m appeared to be well established because most sessile organisms/colonies were relatively tall and the assemblages were relatively diverse. This indicates that these habitats have low exposure to sediment movement.
- Sand in the inshore zone is thought to be highly mobile due to the nature of epibiota on low-profile reef habitat in this area: epibiota associated with low-profile reef habitat was sparse, low diversity and low profile, consistent with periodic inundation by sand.
- Thirty five epibiotic biotopes and 12 infaunal biotopes were defined from substrate and biological data in this study.
- Bioturbation of soft sediments was common, mostly due to the feeding, movement or digging/burrowing actions of benthic biota.
- Patchy and sparse seagrass (*Heterozostera tasmanica,* recently listed as threatened under the FFG Act) was recorded between 20 and 25 m depth in the north-western and north-eastern sections of the study area. Camera records showed patches tended to be small (a few square metres to tens of square metres).

- No other listed species or threatened ecological communities of State or National significance were identified during the benthic survey.
- Shells of the invasive New Zealand screw shell (*Maoricolpus roseus*), were recorded in patches and dense aggregations on low-relief seabed in the deeper southern part of the Study Area, in 25 m to 52 m water depth.
- Target and non-target invertebrates of commercial fisheries interest were recorded during the surveys (specifically the commercial scallop *Pecten fumatus* and the doughboy scallop *Mimachlamys asperrima*), but at relatively low densities and in small areas.
- Seasonal variation in cover of benthic macrophytes, namely red algae species, documented by winter and summer baited video surveys (targeting fish), indicate that the biological assemblages of broad habitat types in the Study Area vary seasonally in their abundance and composition, which is typical of temperate environments.

1 INTRODUCTION

1.1 Project background

The Star of the South Offshore Wind Farm (the project) is Australia's first proposed offshore wind farm being developed by Southerly Ten. Located within and off the central Gippsland coast, it would help transform Victoria's future energy supply – complementing other forms of power generation and creating a more reliable system.

The project is located within both Commonwealth and Victorian jurisdictions and is subject to planning and environmental assessment and approval under Commonwealth and Victorian legislation.

The Commonwealth Minister for the Environment has decided that the project is a controlled action (as set out in notice dated 2 June 2020) and is required to be assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) through preparation of an Environmental Impact Statement (EIS) and the Victorian Minister for Planning has determined that an Environment Effects Statement (EES) is required (as set out in notice dated 11 May 2020) under the *Environment Effects Act 1978* (EE Act).

To inform the environmental impact assessment, a marine ecology survey program (MESP) began in December 2019 under the Exploration Licence granted by the Commonwealth Government in March 2019. The design of the surveys was defined by the Exploration Licence Area, totalling 496 km^2 as shown in Figure 1-1.

After completion of the MESP, Southerly ten was granted a Feasibility Licence for the project under the *Offshore Electricity and Infrastructure Act 2021* in May 2024. The offshore project area was amended as part of the licencing process.

1.2 Project components

The Project comprises both offshore (marine) and onshore (terrestrial) infrastructure. The offshore project area (OPA) includes:

- The offshore wind farm area (OWFA) – where the wind turbine generators (WTGs), foundations, offshore substations, interlink and inter-array cables will be located, within Commonwealth waters.
- Offshore export cable area (OECA) – extending from the shore crossing at Reeves Beach, to the OWFA. The OECA is where they offshore export cables will be located, connecting the wind farm to the onshore transmission system. The area traverses Commonwealth waters and Victorian coastal waters.

At the time of the MESP the onshore project area extended from the Reeves Beach shore crossing, Woodside, to the Latrobe Valley, connecting to either Loy Yang or Hazelwood power stations as shown in Figure 1-1. The onshore transmission infrastructure would include underground cables, onshore substation (s) and grid connection infrastructure.

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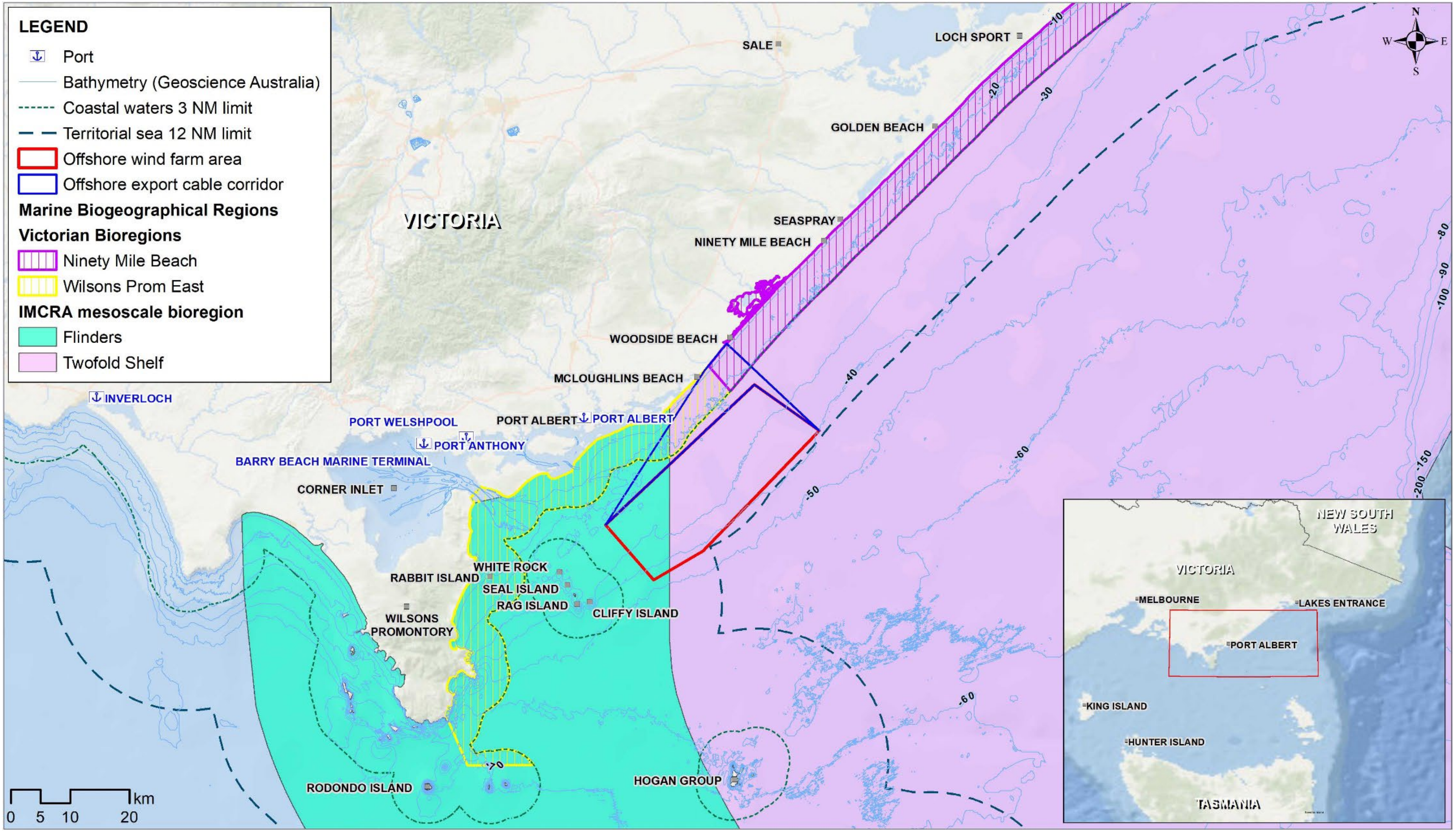


Figure 1-1: SOTS OWFA, OECC and local IMCRA bioregions and biounits

1.3 Marine Ecology Survey Program

The Marine Ecology Survey Program (MESP) was an extensive program of field surveys and studies to collect data on components of the offshore (marine) ecosystem that may be impacted by the Project. Baseline surveys were identified as being required to inform knowledge gaps because protected species were identified to occur in the area but little knowledge existed about their use of the area. The baseline surveys were intended to provide information on species composition, abundance, distribution and habitat use and to enable comparison of these parameters over multiple seasons within a year and over consecutive years via repeated surveying. This was because existing information was not sufficient to predict possible adverse environmental impacts. The main objectives of the MESP were to:

- Characterise the marine environment at the project site
- Fill data gaps regarding regional populations of marine species
- Determine the ecological significance of the Project Area
- Inform the concept project design
- Enable a robust and quantitative assessment and modelling of project impacts
- Inform future construction and operational monitoring requirements.

The MESP comprised four sets of studies under the following groupings:

- Coastal processes
- Benthic ecology
- Fish ecology
- Marine mammals
- Seabirds and shorebirds.

The MESP study reports are appendices to the technical reports that comprise the project EIA. They present the data collected during the MESP, the results of statistical analyses and modelling, and interpret the results in the context of the study objectives. The MESP studies were supported by a study of hydrodynamic and wave processes within and around the OWFA.

This report is on the benthic ecology study of the MESP.

1.4 Benthic ecology study

1.4.1 Study Area

The Study Area defined for the MESP benthic ecology study (see Figure 1-2) comprised:

- OWFA and OECC where project construction activities may occur and infrastructure will be installed
- 2 km adjacent zone around the OWFA where indirect impacts may occur during construction and operation
- 5 km buffer around the OWFA where diffuse indirect impacts may occur during construction and operation
- Reference zones 5-6 km alongshore from the OWFA to the northeast and southwest, including the full range of water depths found in the OWFA, considered beyond the range of detectible indirect or direct impacts.
- Sampling sites were all deeper than the 15 m depth contour – the limit defined for safe vessel and equipment operation.
- The reference zones were defined to provide data on seabed habitats up to 5-6 km from the OWFA (considered to be beyond the influence of the proposed development on seabeds). The zones were also designed to provide a range of depths representative of those found in the OWFA. The outer extent of the reference zones was limited by benthic bathymetry, the presence of islands to the south-west, and

to remain representative of sediments in the OWFA. For example, the OWFA and south-western reference zone are located in the Corner Inlet secondary coastal sediment compartment (number 19, VEAC 2019b). If the south-western reference zone is moved further west, it is likely to cross into secondary coastal sediment compartment 18, Wilsons Promontory (east). This means that the sediments in the reference zone may no longer be adequately representative of the OWFA.

- Following engagement with the Technical Reference Group, some additional subsea video sites outside of the planned study area were included in the final survey design to provide additional context. The north-eastern reference zone is already likely to fall within the adjacent secondary coastal sediment compartment 20, Gippsland Lakes (VEAC 2019b), but moving them closer to the OWFA may reduce its value as a reference zone. The sample design includes the placement of sampling sites between the OWFA and potential reference locations, allowing assessment of the relevance of the sediments and habitats in the reference zones for ongoing monitoring.
- The Study Area was designed to allow characterisation of benthic habitats and assemblages within and adjacent to the Project Area (OWFA and OECC).

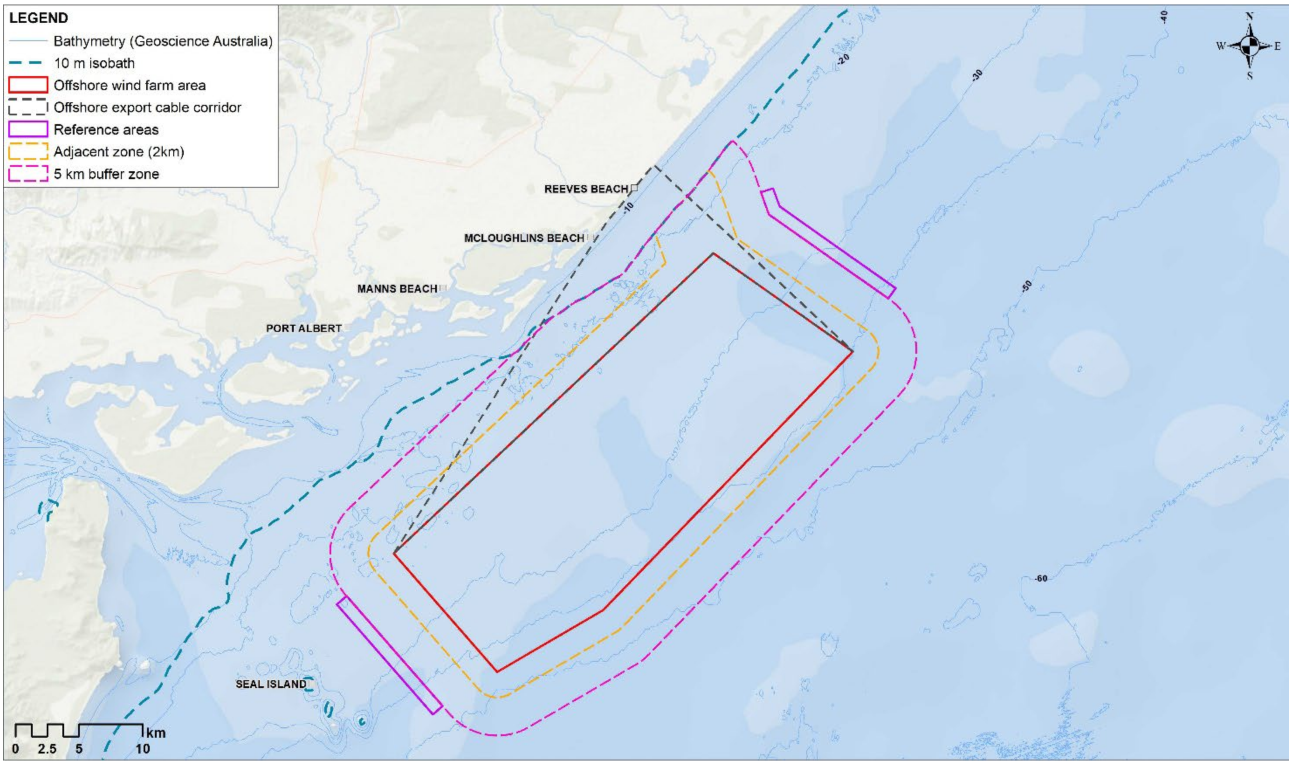


Figure 1-2: The benthic ecology Study Area

1.4.2 Aims and objectives

The benthic ecology study aims to provide key information required to support a robust assessment of environmental impacts of the Project on benthic habitats and communities.

The objectives of the study were to characterise the benthic ecology of the Study Area so that the potential impacts and risks from the project could be appropriately determined.

Key potential impacts and risks from the Project relevant to benthic ecology include:

- Loss of habitat (direct removal of natural habitat from infrastructure footprints)
- Habitat modification (including within the OECC)
- Generation of new habitat on and around WTGs and cables (seabed and midwater)
- Effect on food webs in the OWFA.

Other potential impact pathways and risks include:

- Temporary increase in suspended sediments/turbidity arising from construction activities
- Sedimentation arising from construction activities
- Scour around installed infrastructure
- Introduction of non-indigenous marine species (NIMS)
- Mortality and disturbance of benthic biota (infauna, epibiota) during construction (eg trenching, piling)
- Accidental pollution events

1.5 Relevant legislation and guidance

Commonwealth and State legislation, management plans and other potentially-relevant documentation relevant to the MESP benthic ecology study are listed below. These documents were used to identify sensitive species and receptors that might occur in the Project Area thus supporting identification of appropriate survey methods and metrics, and to confirm permit requirements.

Key legislation includes:

- Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)
- Flora and Fauna Guarantee Act 1988 (Victoria) (FFG Act; repealed by the Flora and Fauna Guarantee Amendment Act 2019 in June 2020)
- Marine and Coastal Act 2018 (Victoria) (MACA).

Also potentially relevant are:

- Australia Marine Park Management Plans
- Biosecurity Act 2015
- Historic Shipwrecks Act 1976
- Sea Installations Act 1987
- Telecommunications Act 1997
- International Cable Protection Committee (ICPC) recommendations
- Environment Protection (Sea Dumping) Act 1981
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES Convention)
- IUCN Red List of Threatened Species (IUCN Red List)
- London Convention, 1972/96 (for dredge spoil disposal).

1.6 Ecological background

At the time of scoping the benthic field studies, there was little existing scientific information on benthic ecology or sediment physico-chemistry in the Study Area. A general description of benthic ecology in the Study Area is presented below based on studies for industry, adjacent marine protected areas and regional scientific sampling and reviews. These studies include primary data (project-specific field studies) as well as syntheses of information from other studies.

The benthic ecology of the Study Area is the product of the available physical habitat, water depth, climate, light, nutrients, hydrodynamic regime, seasonality, introduced marine species, short-term and long-term perturbations, and connectivity with local and regional ecosystems.

Physical habitats

Seabed in the proposed OWFA ranges from around 14.6 m to 46.6 m water depth (Fugro, 2020). Most seabed in the Study Area was expected to be unconsolidated sediment substrate (Victorian Biotope Atlas records available in Coastkit (DELWP 2021)), Advisian 2018, Przeslawski et al. 2016a, Wilson and Poore 1987; Figure 1-3). The Project Area falls within the Corner Inlet secondary coastal sediment compartment (number 19, VEAC 2019b). Seabed imagery from adjacent areas (Przeslawski et al. 2016b) indicated that the seabed in the Study Area was likely to include large areas of mollusc shells (bivalve and gastropod shell accumulations), shell fragments and gravel.

Biogenic substrates provide habitat for settlement by sessile benthic organisms (invertebrates and algae), and is an important habitat for 'cryptic' motile macrofauna, such as squat lobsters. They are known to support increased biodiversity relative to other mobile sediment habitats. Biogenic substrates that have previously been reported in the region include:

- consolidated bivalve shell beds, such as those that have been reported in the nearby Beagle Australian Marine Park using geophysical survey methods (such as backscatter data from multibeam echosounders; Jacquomo Monk, pers. comm.)
- unconsolidated substrate comprising gastropod shells (eg New Zealand screw shells *Maoricolpus roseus*) and bivalve shells (eg scallops *Mimachlamys* spp. and *Pecten* spp., and file shells *Limatula* sp.), with substantial areas of this substrate having been described by Przeslawski et al. (2016a,b)
- beds of oyster (eg the Australian flat oyster *Ostrea angasi*) and scallop shells that were harvested from apparently extensive shellfish beds in 15–24 m water depth between Five Mile Beach (Wilsons Promontory) and McLaughlins Entrance (Nooramunga) in the late 1800s (Ford and Hamer, 2016).

Areas with bedforms such as sand waves show heterogeneity at small spatial scales. The sand waves themselves can comprise medium to coarse-sand, but coarser material (including shell, gravel and pebbles) or finer depositional material may be present in the trough. Sand waves indicate highly mobile sediments, and sessile biological assemblages in sand wave areas are likely to be subject to periodic inundation (smothering) by sand. Data from a geophysical survey undertaken on behalf of Star of the South (Fugro 2020) indicated that sand waves did occur in the Study Area.

Rocky reef habitat was known to be present in the Study Area but there was considered to be a large degree of uncertainty as to its extent. Rocky reef in the area was considered to be mostly low-relief (up to 1 metre above the seabed) calcarenite/limestone or other sedimentary rock. Consultation with members of the recreational and commercial fishing communities indicated that there were a number of rocky reefs and potential reefs within the Study Area ("Snapper Reefs"). These are shown in Figure 1-3 with other open coast biotopes (Ierodiaconou 2017) and habitat classifications from anecdotal evidence (Geoscience Australia Marine Sediment database 2017). Most reef habitat appeared to be in the inshore part of the Study Area, but it was considered that there may have been lesser known reefs in deeper water. Consolidated sediment habitat was reported by Museum of Victoria studies from 1979–84 (Poore et al. 1985) but its distribution and extent was unknown. Consolidated substrates were represented by consolidated sediments (Wilson and Poore 1987, Advisian 2018) and/or consolidated biogenic substrates such as mollusc shell beds.

Climate, nutrient and hydrodynamic regime

The area has a temperate climate with seawater temperatures ranging from around 12–13 °C in winter to 19 °C in summer. Regional currents flow eastward in winter (driven by prevailing westerly winds) and westward in summer (prevailing south-easterly winds) (Gibbs et al. 1986).

Local metocean conditions are also likely to be influenced by winter storms. Ebb and flood tides produce longshore currents of 0.1–0.2 m/s in the Study Area. Nutrient concentrations in Bass Strait are typically low (mesotrophic to oligotrophic) but rise in winter due to upwelling of nutrient-rich water along the eastern Bass Strait shelf break (Gibbs et al. 1986). The proximity of the Study Area to the continental shelf break (130 km south-east) means it may have higher nutrient availability than other parts of Bass Strait and may be more productive.

The Study Area is exposed to swell from the south-west through south-east and locally generated wind waves from all directions. Mean significant wave heights are in the order of 2–3 m (Hemer et al. 2007), with much larger waves at times of local or remote storms (generating long-range swells). Wave disturbance to the seabed in the offshore deeper parts of the Study Area would occur only during extreme wave conditions, while frequent wave disturbance would occur in the inshore, shallower parts of the Study Area.

Light attenuation due to resuspended seabed sediments and phytoplankton in the water column determines the lower depth limit for benthic macroalgae and seagrass. Light attenuation in the Study Area may be higher on average than in central Bass Strait due to the higher productivity (phytoplankton biomass) and resuspension of sediments by tidal currents, which can be strong in areas.

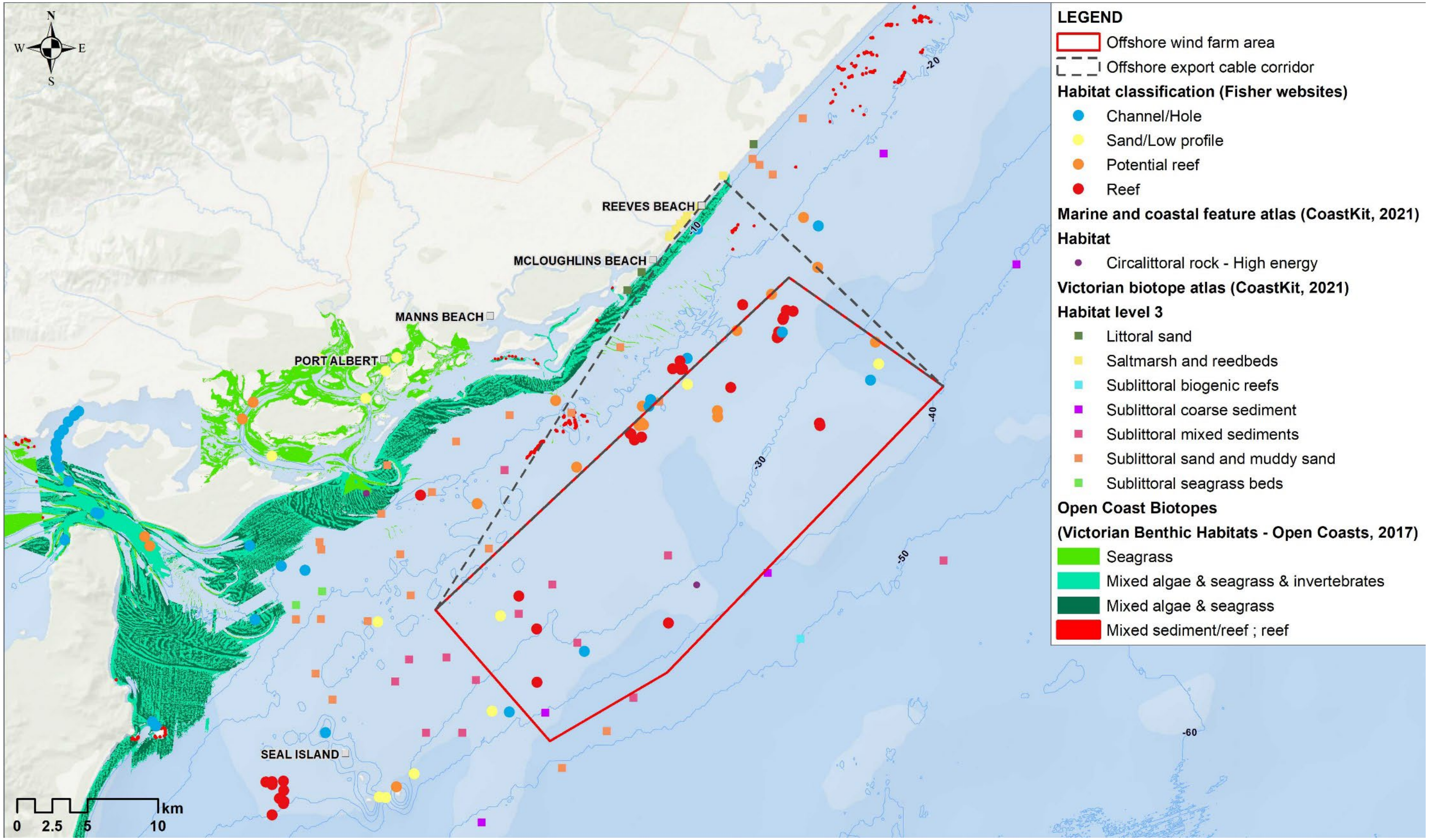


Figure 1-3: Pre-existing data available for the Project Area

Benthic biodiversity

The benthic biodiversity of the Study Area comprises algae, seagrasses, meiofauna, macroinfauna, motile and sessile epifauna. Most species are widely distributed across south-eastern Australia; however, endemic species are also likely to be present.

Macroalgae include red, brown and green seaweeds that are mostly associated with hard substrates including rocky reef and shell/cobble. Macroalgae also occur as epiphytes on other species or as drift. Only one genus of green algae, *Caulerpa* sp., commonly occurs on unconsolidated seabed in Victoria, but its presence, diversity and distribution in the Study Area was unknown. Macroalgal diversity and biomass tend to be highest on shallow rocky reefs with good light availability. Most reefs in the Study Area are quite deep (> 20 m) and even shallower, nearshore reefs have low macroalgae abundance (Barton et al. 2012), likely due to low light caused by sediment resuspension. The brown macroalgae *Undaria pinnatifida* (Japanese kelp/ wakame) is a non-indigenous marine species that has been recorded in the region but its occurrence/distribution is currently unknown in the study area.

Larger macroalgae (*Ecklonia radiata* kelp and other large brown algae) grow on reefs in water depths of up to 20–30 m, along with a range of smaller red and green algae. The giant kelp threatened ecological community is unlikely to occur in the Study Area (DSEWPaC 2012, DoE 2013). Giant kelp (*Macrocystis pyrifera*) forests once occurred on many reefs in Bass Strait but their distribution has shrunk considerably (DSEWPaC 2012).

The distribution of seagrasses in the Study Area was unknown; however, seagrasses were likely to be widespread on sandy seabed in the shallower parts of the Study Area (less than 20 m). The main seagrass species in Victoria are *Heterozostera nigricaulis*, *H. tasmanica*, *Z. muelleri*, *Halophila australis*, *Posidonia australis* and *Amphibolis antarctica*. Eelgrasses (*Heterozostera* spp.) are the predominant seagrasses in Victoria's sheltered bays and inlets and include *Zostera muelleri* on intertidal flats and *H. nigricaulis* in the subtidal zone. *Posidonia australis* was known to be abundant in the shallow subtidal zone of Corner Inlet. *Heterozostera tasmanica* was known to occur on wave and current exposed sandy seabed along the open coast, and was present in nearby areas (Advisian, 2018).

Infaunal macroinvertebrates that live within sediments are expected to comprise a diverse mix of crustaceans (eg isopods, amphipods, decapods and cumaceans), polychaetes (bristle worms), molluscs, echinoderms and less common phyla. Infaunal invertebrates have key roles in sediment biogeochemistry through bioturbation of sediments, cycling of organic nutrients and are a major prey item for benthic and demersal invertebrates and fish.

Epifauna include a diverse range of sessile and motile invertebrates. Sessile invertebrates are predominantly filter-feeders and include sponges, hydroids, anthozoans (soft corals, gorgonians, anemones), bryozoans, bivalves, and colonial and solitary ascidians (sea-squirts). Sponges, hydroids, soft corals and anemones, bryozoans and ascidians typically attach to hard substrates including rocky reef, shell and gravel/cobble, though several of these groups have burrowing representatives. These sessile invertebrates increase habitat complexity, providing space and refuge for other sessile and mobile invertebrate species. The Gippsland Area includes habitat formed by dense growth of sessile invertebrates at spatial scales of < 1 m^2 to 10s or 100s of m^2 (Przeslawski 2016a,b).

Other sessile invertebrates live in sandy habitats with little hard substrate. The Study Area is in the range of the endemic soft-coral (*Pseudogorgia godeffroyi*) which occurs on sandy or gravel seabeds (Utinomi and Harada 1973).

The commercial scallop (*Pecten fumatus*) was considered to be common, though sparsely distributed, throughout the area and was predominantly found on sandy seabeds (Przeslawski et al. 2016a). The doughboy scallop (*Mimachlamys asperrima*) forms dense aggregations in some areas (Przeslawski et al. 2016a), as does the introduced New Zealand screw shell (*Maoricolpus roseus*) (Marine pests 2021), which Parks Victoria have listed as an introduced species of concern (VEAC 2019a).

Mobile benthic invertebrates likely to occur in the area include gastropods, crustaceans (eg crabs, hermit crabs, rock lobsters), cephalopods (octopus, squid, cuttlefish), echinoderms (sea stars, brittle stars, feather stars, sea cucumbers, sea-urchins). Mobile benthic invertebrates may prey on sessile and mobile fauna (such as scallops), eat detritus, graze on algae, or adopt several of these strategies. Sea stars including the eleven-arm sea star (*Coscinasterias muricata*) and the southern sand star (*Luidia australiae*) were common on sandy seabeds in the region (Przeslawski et al 2016a, Advisian 2018), and are key scallop predators. The Northern Pacific seastar, *Asterias amurensis*, is a non-indigenous marine species that has been recorded in the region (e.g. Port Phillip Bay) but its occurrence/distribution is currently unknown in the study area.

Infauna and epibiota can modify habitats, providing ecological niches and refugia from predation for a wide range of species. They do this by stabilising and consolidating mobile sediments, increasing oxygenation in sediments via burrows and bioturbation, overgrowing and binding sediment surfaces, or by increasing the structural complexity of the seabed habitat. These aspects increase benthic biodiversity and provide important habitat for key life stages of benthic, demersal and pelagic species (eg spawning and nursery habitat).

Benthic vertebrates are generally represented by demersal fish, which can be key components of benthic communities, but the strength of the relationship between fish and habitat – and hence how characteristic they are of a specific habitat type – was dependent on a number of factors, including the spatial scale of each species 'home range'. These are primarily addressed in the fish ecology report (RPS 2021a).

Benthic habitats

Benthic habitats are areas with distinct physical seabed characteristics, wave and current exposure, nutrient and light availability and biological activity (physical and chemical modification of the seabed). They can be defined as areas with specific physico-chemical conditions (Connor et al. 1997). For the purposes of this study, it was important to recognise the relationship between habitats and biological assemblages (which is critical for environmental impact assessment and subsequent monitoring), the term 'habitat' has been used to describe the specific environmental conditions of a sample site (eg physico-chemical conditions/substrate type), with 'biotope' used to describe the combined habitat and biological assemblage.

Benthic habitats in the OWFA range from 15 to 45 m water depth and have low wave exposure, moderate tidal and wind-driven current exposure, and likely reduced light availability with increasing depth. Benthic habitats in the OWFA are expected to include mobile sediments (silt, sand, shell, and other coarse sediments) with diverse infauna communities (Wilson and Poore 1987) and epibenthic fauna (Przeslawski et al. 2016a,b), seagrass and drift algae (Advisian 2018), consolidated sediments with or without sessile biota, rocky reef with a diverse range of epifauna and macroalgae, and possibly biogenic reef.

Benthic habitats in the OECC range from the shoreline to 20 m water depth and have high (shallow areas) to low (deeper areas) wave exposure, and moderate tidal and wind-driven current exposure. Benthic habitats likely to occur in the OECC include mobile sediments with diverse infauna, reef with epifauna and macroalgae, seagrass, and possibly biogenic reef habitat.

Benthic biotopes

Classification systems using the concept of 'biotopes' to combine habitat and species information are being used worldwide in geographic mapping for conservation and resource management purposes. A 'biotope' is defined as 'a habitat supporting a specific assemblage or community of plants and animals, which operate together at a specific scale' (Connor et al. 1997). Examples likely to be found in the region include seagrass meadows and kelp beds. The term 'biotope', therefore, is useful in environmental management and functional ecology as it combines the concepts of both habitat and community when defining geographic mapping units (Connor et al. 2004, Olenin and Ducrotoy 2006).

Several habitat and or biotope classifications have been developed in Australia, including the National Intertidal/Subtidal Benthic Habitat Classification Scheme (NISB habitat classes; Mount et al. 2007), Combined Biotope Classification Scheme (CBiCs, Edmunds and Flynn 2015, 2018, DELWP 2017) and SeaMap Australia (Butler et al. 2017). CATAMI (CATAMI Technical Working Group 2013) is a standard classification scheme for scoring marine biota and substrate types in underwater imagery from points rather than a 'whole image' level, though the guidance recommends using this approach as alternative to an existing classification scheme (such as habitat classification schemes).

The habitat classification scheme elected for use in this study is CBiCs. The main reasoning being that this classification scheme provides direct comparability of SOTS benthic ecology outcomes with data in the Victoria Biotope Atlas (and Coastkit). CBiCs is also derived from international habitat classification schemes that have been used to support the environmental assessment of wind farms in Europe and the USA (eg Hutchison et al. 2020). Biotope classifications provide a robust process for indicating change (natural and anthropogenic) in environmental and biological aspects of receiving environments. This approach also supports effective impact assessment, as it provides potential to predict the ecological significance of change from one biotope classification to another.

1.6.1 Physical environment

Geology and geological history

The OWFA and the broader study area are located across the Southern Terrace and Southern Platform that form the southern limit of the Gippsland Basin. The largely inactive Foster Fault system transects the middle of the site from approximately west to east dividing the Southern Terrace from the Southern Platform (Fugro, 2020). Sediments over 10 km deep have accumulated over millions of years with the most recent (shallower) layers comprising marine carbonate sediments (Geoscience Australia, 2022). The shallow geology and geomorphology of the area has been shaped by successive marine transgressions and regressions (sea level rises and falls) over tens of thousands of years leaving buried barrier systems (dunes/shorelines) and channels (Fugro, 2020).

The nearest non-sedimentary bedrock seabeds are within the Bassian Rise to the east (Wilsons Promontory to Flinders Island and islands in between) – the granite sill which separates eastern from central Bass Strait. The Central Deep to the northeast contains most of the gas and oil fields in the basin (none have been exploited in the Southern Terrace or Southern Platform (Geoscience Australia, 2022).

Seafloor sediments and other features

Surface sediments across the study area, and more broadly in the region are dominated by biogenic (carbonate) gravel and sand (Kennedy, 2021). Existing samples in the region show carbonate is derived mostly from bryozoan skeletons (James et al., 2008). The narrow nearshore coastal zone (dunes, beaches and surf zone) where there is considerable sediment transport is the exception, here silicaceous sand dominates. The major sediment supply to the nearshore coastal zone is from Wilsons Promontory and Corner Inlet (terrigenous), rather than the carbonate sediments from the shelf offshore (Kennedy, 2021). Fine sediment material tends to be winnowed out of coastal and shelf sediments in eastern Bass Strait by tides and wave action, leaving coarser sediment behind (Fanguin et al 2005, Harris and Heap 2009).

A geophysical survey in the study area in early 2020 was used to develop a seabed survey data model (Fugro, 2020) and showed mobile (unconsolidated) sediment was the predominant seabed type (Wood-Thilsted, 2020). Unconsolidated sediment layers were deep, ranging from 10 m deep inshore to 20 m deep offshore, with calcarenite layers and interbedded calcarenite/sand below (Wood-Thilsted, 2020). Studies for the Basslink project found similarly deep unconsolidated layer of 12 m (AMOG, 2001). The data also showed that calcarenite formations were present at and just below the surface in minor parts of the survey area, these are most likely buried and partly cemented relic beach zones (Wood-Thilsted, 2020) and occur throughout eastern Bass Strait (Fugro, 2020, AMOG, 2001). These features form the reef systems described near the coast (AMOG, 2021) but appear to be less common further offshore. Erosional features (depressions), sand waves and undulating or irregular features were also present (Fugro, 2020). Undulating or irregular features may represent weakly cemented sediment or shell beds (Fugro, 2020).

Seabed across the site was generally low relief (flat) though areas of higher relief were present in places. Higher relief seabed (variations of 5-6 m vertically over 100-200 m) occurred along the inshore side of the OWFA, particularly in the northwest and northeast corners. Moderate relief seabed (variations of 1-2-3 m vertically over 100-200 m horizontally) occurred along the offshore edge of the OWFA.

Physical influence of currents and waves

Waves and tidal currents generate significant longshore and onshore-offshore sediment transport in the nearshore zone (Kennedy, 2021, Cardno, 2022), however sediment transport and movement in deeper water offshore (ie greater than 30 m) is likely to be low.

Tidal currents in the Study Area are strong enough to mobilise unconsolidated sand and finer sediment, however net sediment movement due to oscillating tidal currents in Bass Strait is negligible (Fangjun et al 2005).

Geostrophic currents (atmospheric pressure and water density driven) and wind driven currents generally flow from west to east through Bass Strait and play a significant role in shaping and changing the seabed, particularly near the shelf edge (Fangjun et al 2005). These currents are likely to be relatively weak in the Study Area as it is sheltered by Wilsons Promontory to the west.

Wave generated bed-shear near in the Study Area may be strong enough to mobilise medium sand offshore and and coarser sand nearer the coast (Harris and Heap, 2009). However, waves are not thought to be important for sediment transport in deeper water due to the orbital water movement (Fangjun et al 2005). Combined with tides and geostrophic currents, waves would help winnow out fine material. Waves are more important where they break in the nearshore zone generating longshore and onshore-offshore sediment transport.

Modelling by RPS shows that bedshear stress is lowest in the southwest portion of the study area (deeper and in the lee of Wilsons Promontory) and highest in the northeast portion of the study area (shallower and more exposed). A region of higher bed shear stress extends south into the OWFA approximately corresponding with an area of angular seabed identified by the 2020 geophysical survey (Fugro, 2020). Fitzpatrick (2022) found that this area is likely to be a sediment starved ‘bedload parting zone’ (or ‘head’ of an offshore sediment transport pathway).

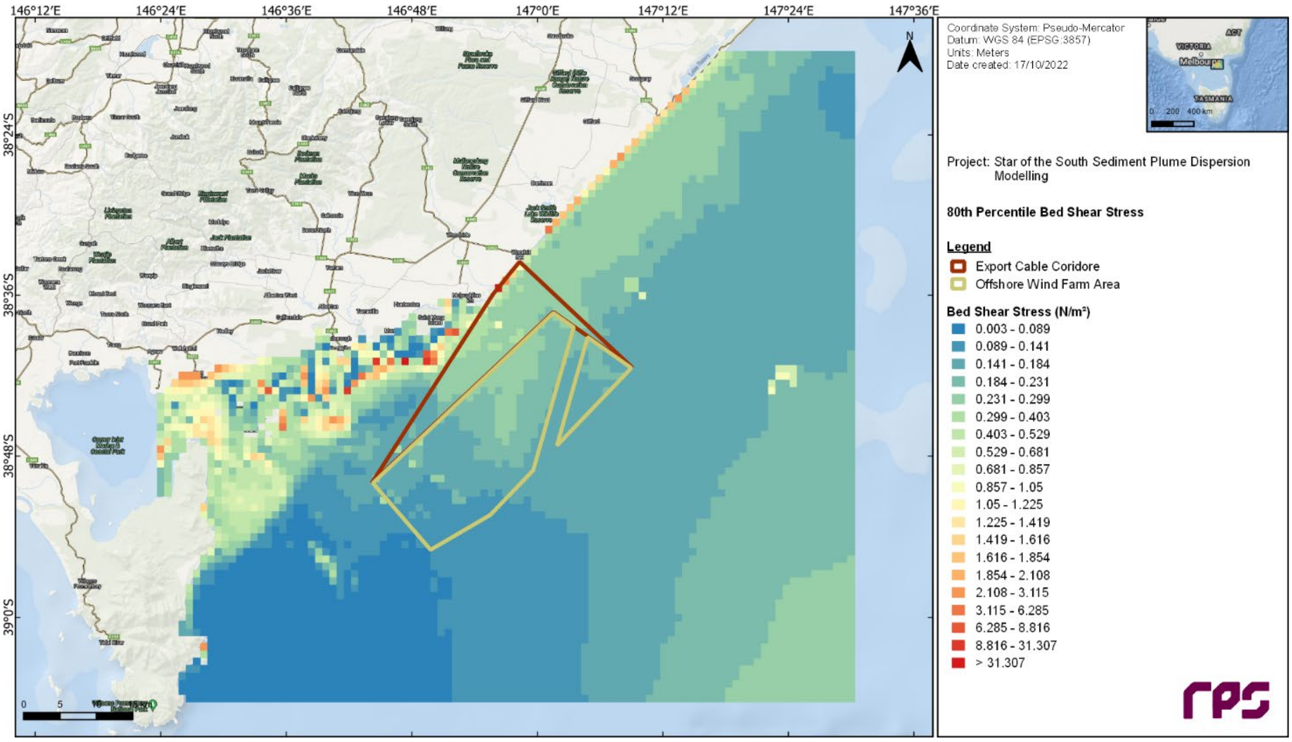


Figure 1-4. Modelled 80th percentile bed-shear stress in the study area

Fugro (2020) and Fiztpatrick (2022) assessed that seabed sediments in the area may be prone to mobilisation and migration due to water currents. However net transport in the OWFA and broader study area is likely to be low, with the exception of the nearshore coastal zone. Areas of sediment erosion and accretion in Bass Strait are mostly localised to the entrances where currents are strongest (around King Island and Flinders Island), and along the shelf edge (Fangjun et al 2005).

Influence of currents and waves on ecology

The bed-shear stress caused by waves and drag caused by currents will have a strong influence on the biota living there. Large or weakly anchored organisms may be dislodged during storms, so there will be an upper limit to the size of organisms like sponges, bryozoans and ascdians. The mostly mobile seabed and weakly cemented hard substrate (where it occurs), means turn-over of sessile benthic organisms will be higher than in areas with consolidated seabed or bedrock and/or weaker currents. A wide range of dislodged sponges, ascidians and seaweeds, often still attached to the shell or rubble they grew on, are typically present on Ninety Mile Beach, particularly after storms.

The currents in area would be beneficial to and lead to high abundances of many benthic invertebrates as they act to carry food to suspension (filter) feeding organisms such as sponges, hydroids, soft corals, bryozoans, ascidians and crinoids.

1.6.2 Species and matters of conservation importance

State-listed values

The published FFG Act Threatened List (as of 2 May 2019) was reviewed to identify Victorian state-listed marine invertebrate species and communities, and observations in the Victorian Biodiversity Atlas (VBA) (DEECA) and the Atlas of Living Australia (ALA) (CSIRO) reviewed for observations in the Study Area.

There are sixteen conservation-listed marine invertebrates in Victorian State waters: two species of cnidarian (one hydroid and one sea jelly), three crustaceans (all shrimps), eight echinoderms (two brittle stars and six sea cucumbers), and three molluscs (two opisthobranchs and one chiton). With the exception of the sea jelly, all are benthic. Many more invertebrate species are likely to require conservation listing as numerous species potentially have highly localised distributions (VEAC 2019a). There are also unequal listings across different types of biota; many more large, charismatic species are listed (such marine mammals and birds) than invertebrate species. This is not due to the considered conservation status of marine invertebrates but reflects the existing state of knowledge of marine species and priorities for listing. The large number of currently undescribed and unknown species makes effective protection of marine invertebrates challenging (VEAC 2019a).

Several of the species referred to above are listed as 'vulnerable' under the FFG Act, including:

- brittle stars *Ophiocomina australis* (now *Clarkcoma australis*) and *Amphiura trisacantha*
- sea cucumbers *Apsolidium densum*, *A. handrecki*, *Pentocnus bursatus*, Thyone nigra and *Trochodota sheperdi* (now *Rowedota sheperdi*)
- stalked hydroid *Ralpharia coccinea*
- opisthobranchs *Platydoris galbana* and *Rhodope spp*.
- southern hooded shrimp *Athanopsis australis*
- ghost shrimps *Eucalliax tooradin* and *Michelea microphylla*.

The following species is considered under the conservation status of 'vulnerable' or 'data deficient' in Victoria, but is not listed under the FFG Act:

- the sea cucumber *Apsolidium falconerae*.

References to species names in this report use the names stated in Victorian statutes. Most of these species are unlikely to be captured in grab or video sampling as they are found in non-target habitat (eg shallow/intertidal habitat or under rock). The species most likely to be recorded during the marine ecology surveys as they may occur in the region and may be found in similar water depths/habitats in the area:

- brittle star species *O. australis* (now *C. australis*) and *A. trisacantha*
- sea cucumber species *Thyone nigra* and *Trochodota (Rowedota) sheperdi*
- opisthobranchs *Platydoris galbana* and *Rhodope* spp.
- southern hooded shrimp *Athanopsis australis*
- ghost shrimps *Eucalliax tooradin* and *Michelea microphylla*.

The actual likelihood of detecting these species is unknown as there is very little information on their distribution in Victorian marine waters. No FFG Act threatened communities occur in the Study Area.

Recent amendments to the FFG Act will result in a single list of threatened flora and fauna. As part of this process, the Conservation Status Assessment project has overseen the review of the assessments of each species to ensure that it is compliant with the common assessment method (a consistent approach to the assessment and listing of threatened species across Australian jurisdictions). The consolidated FFG Act Threatened List was not available at time of scoping the benthic field studies.

State bioregionalization

The Study Area comprises several State-defined biounits (sub-level classifications of Commonwealth marine bioregions):

- Wilsons Promontory East and Ninety Mile Beach
- Ninety Mile Beach subtidal sandflat.

The following important ecological communities could also potentially occur in the area, though were not previously reported:

- rhodolith beds
- giant kelp forests of south east Australia are an EPBC Act listed threatened ecological community.

Commonwealth-listed values and bioregionalisation

A report on matters of national environmental significance and other matters protected by the EPBC Act that may occur within the Study Area was produced using the DAWE Protected Matters Search Tool (PMST) on 2 May 2019, to inform the survey design, and again on 8 August 2022 to check for more recent listings. Coordinates for the Project Area were used in both searches (shown below), with a five-kilometre buffer to encompass the Study Area:

A	B	C	D	E
S 38.62056 E147.02528	S38.69028 E147.15139	S38.87361 E146.92556	S38.9175 E146.82944	S38.83333 E146.7361

The PMST report provided information on listed threatened ecological communities, listed threatened species and listed migratory species.

The Study Area comprises one MNES and two IMCRA bioregion:

- Commonwealth Marine Area (CMA) MNES
- Flinders and Twofold shelf IMCRA bioregions

The following could also potentially occur in Commonwealth waters in the area, though have not been previously reported:

- rhodolith beds
- giant kelp forests of south east Australia are a listed threatened ecological community.
- The Project Area overlaps the Flinders and Twofold shelf marine bioregions defined by IMCRA and the Wilsons Promontory East and Ninety Mile Beach Victorian biounits (Figure 1-1).
- The Flinders marine bioregion includes Wilsons Promontory, Flinders Island and other islands in Bass Strait. The marine benthic values that distinguish this bioregion include smooth-surfaced granite reefs, shallow reefs with a diverse, dense cover of macroalgal species (particularly coralline algae), and deeper reefs with dense sponge communities, soft corals and sea whips. The diversity of macroalgal and fish species is considered to be greater than those found in adjacent Tasmanian marine bioregions (VEAC 2019b). Significant natural values of the Flinders marine bioregion include the sponge gardens and abundant diversity of reef fish found around Wilsons Promontory.
- The Twofold Shelf marine bioregion stretches from the east of Wilsons Promontory to Tathra in New South Wales. In this bioregion, marine reef fish and invertebrate assemblages are dominated by warmer water species that are common in southern New South Wales. Dominant macroalgal species include the kelps, *Ecklonia radiata* and *Phyllospora comosa*. Kelp beds on shallow reefs are grazed by the black sea urchin, *Centrostephanus rodgersii*.(Carnell and Longmore 2014)
- The Wilsons Promontory East IMCRA biounit (biounit 16) is the point at which the eastern and western marine biogeographic provinces of southern Australia meet. It is therefore presumed to be the limit of species distributions for at least 126 species (VEAC 2019b). The main substrate type (and high level biotope) is circalittoral fine sand, which represents 44 per cent of the 60,387 hectare biounit. This biounit is considered to have high biodiversity and biotope richness, with the following rare or unique habitat and biotope types known to occur (VEAC 2019a,b):
- Seagrass beds (Posidonia australis, Heterozostera spp. and Ruppia spp.)

- Highly persistent kelp (brown macroalgae) assemblages on moderate energy rock
- Sessile invertebrates, including bushy, branching and low erect sponges on high energy circalittoral rock, and a covering of small colonies with well-spaced erect sponges on moderate to high complexity circalittoral rock
- Infralittoral and circalittoral rock (eg sediment, shell hash, granite and deep holes) (VEAC 2019b).
- The Ninety Mile Beach IMCRA biounit (biounit 21) covers an area of 95,267 hectares, and extends from east of Nooramunga to the east of Marlo. This biounit has extensive sediment beds, non-reef-forming sediment epibiota and scallop beds. Rare or unique habitats represented in this biounit include:
    - Seagrass beds (*Heterozostera* spp.)
    - High densities of the feather star *Cenolia* sp.
    - Non-reef-forming sessile invertebrate assemblages dominated by sponge mounds
    - Low complexity circalittoral rock.
- Other important natural values named in this biounit that are potentially relevant to the Project Area include:
    - The Port Albert to Lakes Entrance sandy plain, an area of high infauna diversity, and may include the ghost shrimps *Biffarius arenosus* and *Trypaea australiensis*
    - Patchy, low profile reefs which are dominated by sessile invertebrates and periodically covered by sand
    - Scallop and epibenthic communities
    - Endemic or rare species, namely the soft coral *Pseudogorgia godeffroyi*, the seastar *Coscinasterias muricata*, the opisthobranch mollusc *Platydoris galbana*, and the crab *Halicarcinus* sp. (VEAC 2019b).

The following habitats will also require appropriate consideration in the assessment:

- Ninety Mile Beach subtidal sandflat, the most extensive sandflat in Victoria, which is known to have a diverse infaunal assemblage
- Rhodolith beds (also known as maerl beds) formed by slow-growing, long-lived coralline red algae in water depths of 20 to 50 m, which are known as having very high biodiversity and may be important for larval settlement.

No benthic species were identified in the EPBC Act Matters of National Environmental Significance (MNES) protected matters search undertaken for the area. The following aspects must be considered in this study and subsequent environmental impact assessment (https://www.environment.gov.au/epbc/what-is-protected/):

- The Commonwealth Marine Area (CMA) is a matter of national environmental significance protected under Part 3 of the EPBC Act (Commonwealth of Australia 2013). Significant impact criteria resulting from an action that are relevant to benthic ecology include (but are not limited to):
    - establishment of known or potential pest species in the CMA
    - modification, destruction, fragmentation, isolation or disturbance of an important or substantial area of habitat resulting in an adverse impact on marine ecosystem functioning or integrity
    - substantial adverse effect on populations of marine species or their life cycle (eg feeding, migration, breeding) and spatial distribution
    - accumulation of persistent or other potentially harmful chemicals (eg organic chemicals, heavy metals) in the marine environment that may adversely affect biodiversity, ecological integrity, social amenity and/or human health.
- Giant kelp forests of south east Australia are a listed threatened ecological community, though this TEC would be unlikely to occur in the Study Area (DSEWPaC 2012, DoE 2013, PMST search report created 09/08/21 16:15:36).

2 METHODS

2.1 Survey scoping

2.1.1 Additional data sources used to inform planning

SOTS Geophysical and Geotechnical survey

Fugro undertook a geophysical and geotechnical (G&G) survey of the OWFA and a corridor area in March 2020, on behalf of Star of the South (Fugro 2020). The survey array in the OWFA comprised 13 primary line groups with five crosslines, each with a 3 km spacing. Each primary line group was comprised three survey lines at 60 m spacing. The corridor area (between the OWFA and the shore) was approximately 9 km by 2 km, with primary line spacing of 250 m and secondary line spacing of 1.2 km.

The following processed data were reviewed as shapefiles or geotiffs for analysis in ArcGIS:

- Multibeam echosounder (MBES) bathymetry
- MBES backscatter
- Sidescan sonar (SSS)
  - High frequency (HF)
  - Low frequency (LF).

Processed data were imported into ArcMap 10.8 and reviewed against other available data (such as Gebco bathymetry data, habitat data from a range of sources, OECC geophysical data). Examples of the following seabed features were observed in the data:

- Reef – high profile
- Reef – patches
- Reef – emergent (low profile)
- Other emergent bedrock features (eg boulders, pavement)
- Sand waves and megaripples
- Transition from rock to sand
- Sediment features
- Sediment linear features
- Unclassified features.

Although the G&G survey did not provide 100 per cent coverage of the seabed in the OWFA (approximately ten per cent was surveyed), the outcomes were useful in identifying likely habitat types and heterogeneity (variability and patchiness) of seabed features across the Study Area, providing useful context in planning the benthic ecology survey design. An initial array of sampling sites was defined based on a random stratified design (stratified by water depth and control/impact areas), which was then overlaid on the geophysical data in GIS. Additional survey sites were added to the initial array following review of the geophysical data to provide benthic ecology data on examples of features of potential relevance to the impact assessment (e.g. emergent bedrock). See following sections for further detail.

Habitat imagery from stereo baited remote underwater video system (SBRUVs) surveys

Winter SBRUVs survey imagery collected for the fish ecology studies provided an additional source of information on benthic ecology in the Study Area. A single still image was extracted from video records at each of the SBRUVs sampling locations during the winter survey and used to describe the benthic habitats at fish survey sites (Figure 2-1).

2.1.2 Assumptions and limitations

- Habitat mapping
  - The habitat maps derived from interpolation of spot-point data are presented for guidance and environmental impact assessment purposes only.
  - The habitat extents are designed to show areas likely to be dominated by a broad habitat, rather than a single consistent habitat in each defined area. The seabed is naturally heterogeneous at a range of spatial scales.
- SBRUVs imagery
  - The SBRUVs cameras provided images with a broader field of view than the drop/tow camera system, which provided additional spatial context for the assessment of the benthic habitat at deployment locations. The limitation of this approach was that the greater distance between the camera and the seabed seabed, water clarity (eg turbidity) and ambient light affected the resolution of seabed features in the images and the ability to identify substrate and biological components. This meant that the further away the biota were from the camera lens, the lower the taxonomic resolution and ability to identify and count biota. Although quantification was still possible, the resolution of the data (in terms of number of taxa/morphotypes/ invertebrate complexes and the level of taxonomic resolution) was lower than for the stills images from the drop/tow camera system.

2.1.3 Peer review

The survey design report (RPS 2021b) underwent a peer review process prior to mobilisation of the benthic ecology survey. The survey design report provided background information on the understanding of the existing environment in the Study Area, the proposed survey methods, and described processes used in the design of the field survey. It was revised to address the peer reviewers comments and resubmitted for final review.

The peer reviewer, Dr Jacquomo Monk is a recognised independent academic expert in the field of benthic ecology. Dr Monk is a research fellow at the Institute for Marine and Antarctic Studies, University of Tasmania, based at Deakin University in Warrnambool, Victoria. His research is focused on how spatio-temporal heterogeneity of epibenthic assemblages respond to different anthropogenic and natural stressors. He is interested in understanding how spatial scale of sampling and the density of data recorded from each sample affects our ability to detect change in benthic and demersal assemblages. Dr Monk has published 25 peer-reviewed articles on habitat mapping and organism-habitat interactions, plus over 45 consulting reports. He is currently part of an interdisciplinary and interagency team within the government-funded National Environmental Science Program (NESP) Marine Biodiversity Hub program supporting and guiding sustained monitoring of Australia’s marine park network.

The outcomes of the peer review identified that the revised document is “a scientifically defensible, best practice approach to establishing a comprehensive baseline dataset for an environmental impact assessment for the benthic ecology component of the Star of the South development area”.

2.1.4 Technical Reference Group (TRG)

Following the survey and initial data analysis, RPS and Star of the South engaged with representatives of the TRG (specifically DELWP, DAWE) to present the survey designs and some early results. This provided regulators and regulatory advisors the opportunity to comment on the benthic ecology study. TRG recommendations included collecting data at a few additional sites within and adjacent to the OECC. The TRG felt that the random stratified sampling design had left some potential for spatial gaps in the data for which it would be worth obtaining additional information. This was addressed by a second survey in 2022.

2.2 Study sites and sampling

The location of all sites sampled in Survey 1 and Survey 2 are shown below in Figure 2-1. The sections below describe the number and location of sites in each survey.

2.2.1 Survey 1 – primary survey

Survey 1 included 80 planned sampling study sites distributed across the study area (Table 2-2). Eleven sites were included opportunistically (camera sampling only). Planned sampling sites used in Survey 1 were stratified by factors including water depth, the project area (OWFA & OECC), adjacent and reference areas.

Table 2-1. Planned survey 1 sites and stratification

Depth	Single sample sites			Replicate sample sites			Camera transects		
	OWFA & OECC	Adjacent (0-5 km)	Reference (5-6 km)	OWFA & OECC	Adjacent (0-5 km)	Reference (5-6 km)	OWFA & OECC	Adjacent (0-5 km)	Reference (5-6 km)
10 – 20 m	0	5	2	0	1	2	6	3	2
20 – 30 m	8	4	4	5	2	2			
30 – 40 m	5	4	2	3	2	2	5	2	2
>40 m	1	4	1	1	0	0			
Totals		**40**			**20**			**20**	

There were 40 sites planned for single-grab sampling and drop-down camera sampling. Single samples for infauna, sediment particle size distribution (PSD) and sediment quality (organic carbon, nutrients and contaminants) were collected from all 40 sites, and images and video were collected from 40 drop down camera deployments.

There were 20 planned sites for replicated grab sampling (5 infauna, 3 PDS and drop-down camera sampling. Replicate sediment grab samples were collected at all but one of these sites (hard seabed at and around R17 prevented sampling). Three replicate sampling sites were moved to alternate positions around 500 m away after hard seabed was found at the original site (and drop-down camera sampling was completed at both the original and alternate sites). Sediment samples collected included 95 infauna samples (19 by 5 replicates), 56 particle size distribution samples (17 sites by 3 replicates and 2 sites by 2 replicates) and 36 contaminant samples (19 sites by 2 replicates).

There were 20 sites planned for 500 m long camera transects and 20 plus one opportunistic transects were completed (21 total). A further ten sites were included opportunistically with drop-down camera sampling completed at each.

Table 2-2. Survey 1 study sites and sampling as completed

Survey 1 sampling sites			Sampling completed				
Site code	Site description	Number of sites	Drop-down camera	Camera transect (500 m)	Sediment infauna (grab)	Sediment PSD (grab)	Sediment quality (grab)
S	Single grabs	40	40	-	40	40	40
R	Replicate grabs	20	23	1	95	56	36
T	Camera transect (500 m)	21		21	-		
Opportunistic		10	10				
	Totals	**91**	**73**	**22**	**135**	**96**	**76**

2.2.2 Survey 2 – supplemental survey

The planned sites for Survey 2 included 10 sites for drop-down camera sampling (targeting seagrass habitat), two reference transects (200 m) outside the OECC for towed/drop-down camera transects (to address regulator feedback) and eight long transects (2 km) within the OECC (to quantify the amount of high-value habitat in the OECC such as rocky reef or seagrass). Opportunistic camera transects were included at high-relief features identified while transiting through the OWFA (BReef and MH01).

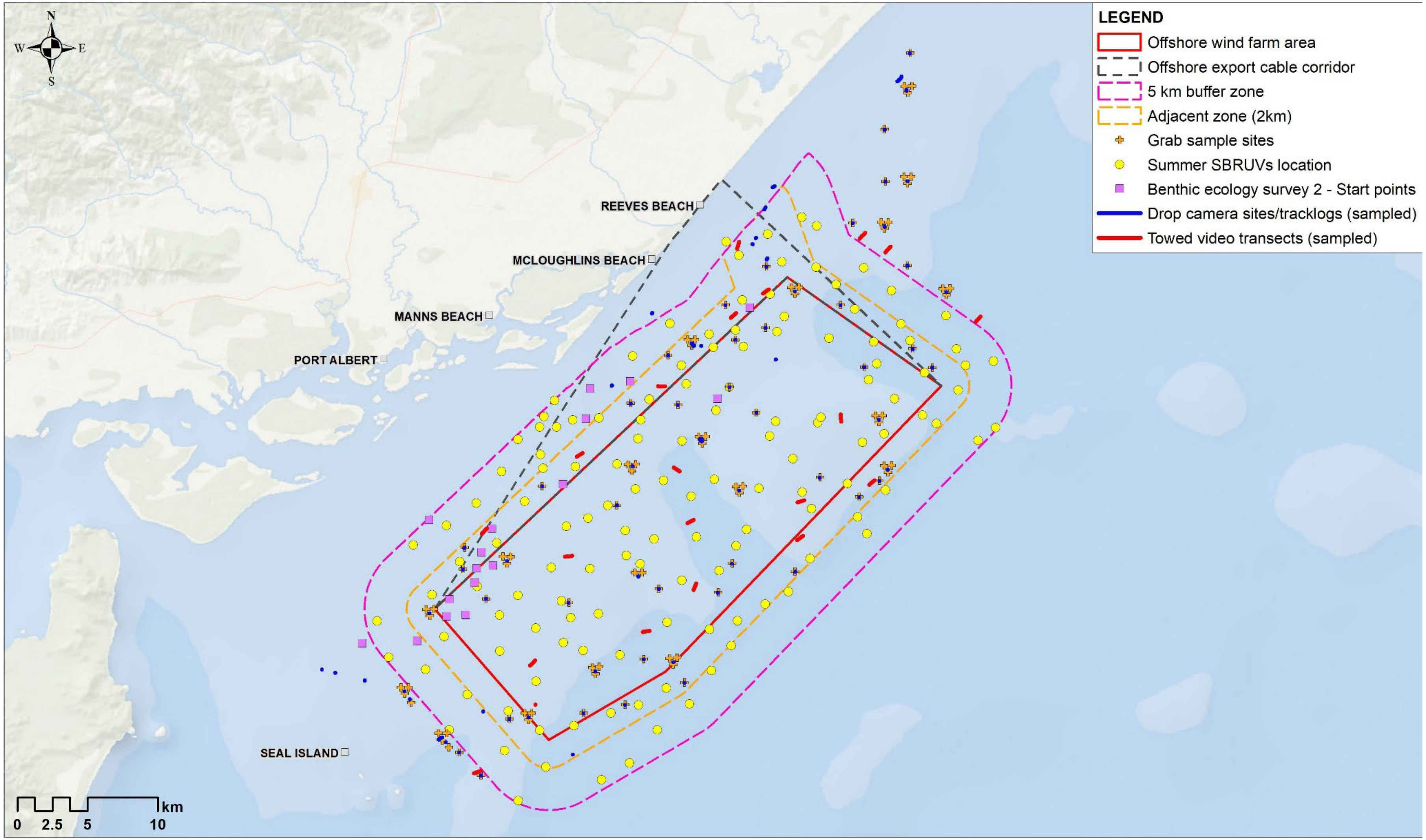


Figure 2-1: Sites sampled during the first and second benthic ecology surveys and the SBRUVs summer survey

2.3 Survey objectives

2.3.1 Survey 1 (primary survey) objectives

The objectives of the primary benthic ecology survey (November/December 2020) were to characterise environmental and biological aspects of seabed types across the Study Area. Additionally, the survey was to characterise biotopes and their spatial distributions, which will provide environmental and biological indicators of benthic condition to inform environmental impact assessment.

The benthic ecology survey covered representative areas of benthic habitat in the Study Area. Sampling was stratified by factors including water depth, potential 'impact' areas and potential 'reference' areas (Figure 1-2). A single survey period was undertaken during late spring/early summer 2020, which aligned with the occurrence of high above-ground seagrass biomass (to be able to identify seagrass distributions) and the MESP summer fish ecology SBRUVs survey to allow direct comparability between the benthic ecology subsea imagery and the summer SBRUVs habitat imagery.

Two complimentary methods were used – subsea imagery and grab sampling – that provide compatible information at different spatial scales, and are complimentary in that they sample different aspects of benthic habitats and mitigate risk of being unable to collect data at survey locations due to environmental conditions and seabed types.

Due to the paucity of existing data in the Project Area, the benthic ecology survey was designed as a characterisation survey. The survey focused on obtaining high data density with broad coverage across the Study Area, whilst obtaining replicate data to support an understanding of baseline conditions. The benthic ecology survey design considered international approaches for baseline and monitoring studies, and Australian best-practice (Przeslawski and Foster, 2020). Sampling designs for each survey method were generally based on a random stratified design, with stratification based on pre-identified reference/impact zones and depth ranges. Additional sites were added for subsea video to ground-truth features identified from a SOTS geophysical and geotechnical survey. Further details are provided in the survey design report (RPS 2021b).

The high-level objectives of the primary benthic ecology survey were to:

- characterise environmental and biological aspects of seabed types across the Study Area
- characterise biotopes, which will provide environmental and biological indicators of benthic condition to inform environmental impact assessment
- identify likely spatial distributions of biotopes across the Study Area.

2.3.2 Survey 2 (supplemental survey) objectives

- A second survey was mobilised to refine the understanding of the distribution of habitats, particularly reef and seagrass habitat, in the shallower parts of the Study Area. Survey 1 identified areas of high profile (1-2 m high) rocky reef and seagrass habitat in the inshore parts of the OWFA and OECC. DELWP suggested more information from adjacent (reference) areas alongshore from the OECC would be useful. Rocky reefs and seagrasses are generally considered high-value marine habitats by community stakeholders with an expectation that offshore infrastructure developments avoid or minimise impacts to these habitats. These habitats occur patchily in the area, hence the survey was designed to document the spatial scale of patches to understand the feasibility and/or need for micrositing project infrastructure around them.

Subsea imagery was collected between 17 January and 16 February 2022 using towed cameras.

The high-level objectives of Survey 2 were to:

- Collect additional towed camera imagery along long 2 km transects to characterise variation in seabed habitat types and distribution of high-value habitats at eight additional OECC sites.
- Collect additional towed camera imagery from short 200 m transects at two additional reference sites (one to the west and one to the east of the OECC).

- Obtain additional towed camera imagery from ten sites within the ‘sand with patchy seagrass and epibiota habitat’ area on the western side of the OWFA and OECC identified from survey 1, to provide additional information on the potential distribution of seagrass within that area

2.4 Seabed imagery

2.4.1 Objectives

The objectives of the towed/drop-down subsea video surveys were to:

- Provide high-level information on the physical characteristics of surface sediments
- Quantify coverage of benthos by different physical and biological components
- Describe the epibiota communities
- Survey of habitats not amenable to grab sampling (specific to survey 1)
- Identify and characterise high biodiversity value habitats and biotopes, such as reefs, sponge beds, giant kelp beds, seagrass beds and biogenic hard substrates (shell, rhodolith).
- Characterise/define epibiota biotopes for the Study Area
- Map epibenthic habitats.

2.4.2 Sampling

Survey 1

Subsea video survey with stills imagery is a commonly used, non-invasive and robust technique for obtaining quantitative data on benthic habitats (e.g. Przeslawski & Foster 2020). An STR SeaSpyder “Telemetry” subsea video system (Plate 2-1) was used in this study. The video system comprised a 24 megapixel underwater digital stills camera, IP video camera (with a 52° field of view in water), dual scaling lasers, 250 kHz precision altimeter, combined compass and depth sensor and lights mounted on a tow/drop frame. The video frame was deployed from a survey vessel on site, and slowly lowered to near the seabed. A video slate, showing project details, site number and date was recorded before deployment. A GPS position, time and date was recorded at regular intervals (every 2 seconds) throughout the deployment using ArcPad (survey 1). The water depth was also recorded when the camera reached and left the seabed, and during the deployment.

An array of 60 pre-determined drop video sites (at grab locations), 20 pre-determined video transects, 10 additional opportunistic drop video sites and one additional opportunistic video transect, provided coverage across the Study Area.

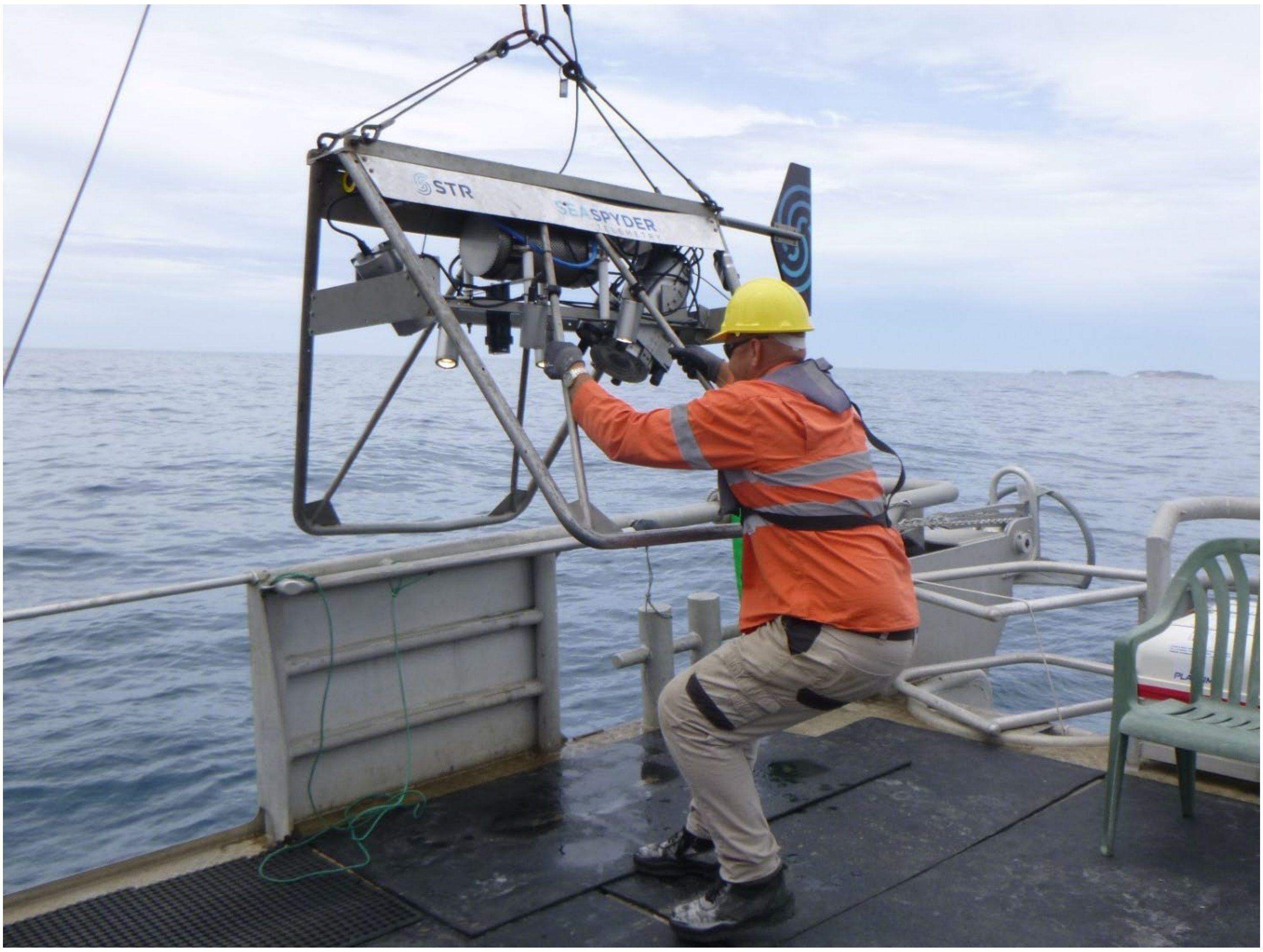


Plate 2-1: The STR SeaSpyder "Telemetry" drop camera system

Two deployment types were used to capture different aspects of habitats and biological assemblages:

- Drop-down camera deployment (spot sites)
- towed camera deployment (transects).

Drop-down camera (spot sites)

Drop camera deployments were undertaken at each of the 60 planned grab sampling sites prior to grab sampling. The camera was deployed to the seabed and 'hopped' along the seabed to obtain close-up high-quality imagery of seabed habitat and biota. The camera was retrieved to the deck after between 10 to 20 still images representative of the full range of habitats and biota present (more images were collected form more varied habitats). The imagery was used to determine whether the sea bed was suitable for grab sampling, if reef habitat was present but little or no sediment, grab samples were not attempted. Only one of the 60 planned grab sampling sites was found to be unsuitable.

Towed camera (transects)

Twenty 500 m long video transects were recorded across the Study Area. The camera system was deployed to approximately 0.5 m above the seabed (depending on sea conditions and visibility) and the vessel drifted with prevailing currents/wind at a speed of less than 0.5 knots – minimal propulsion was used to control drift speed. The camera system was lowered onto the seabed regularly to obtain 30 to 100 high-quality stills images of benthic habitats – more stills were collected along transects with more varied habitats.

Although two separate methods were used to collect subsea imagery during the benthic ecology survey (drop-down video and video transects), the still imagery from both types of deployment were analysed in the same manner, and hence are presented together in sections 2.3 and 3.1.

Opportunistic sites

Additonal imagery was collected from 10 opportunistic sites where time permitted. These sites were located across the study area, often where suspected or known reef habitat was identified before or during the survey – so mostly in the shallower parts of the study area.

Survey 2

Towed imagery was collected with a small, light, hand operated 'towfish' between 17 January and 16 February 2022. The towfish equipment comprised a standard definition CCTV video camera, connected to a digital video recorder and screen at the surface, in view of the camera operator. A stills camera (SONY HDR-AS50) with wide angle lens (18.4 mm) set to capture images every two seconds was mounted below the CCTV camera. The towfish was drifted slowly just above the seabed (around 10 cm) and regularly landed on the seabed to collect still images and video. Waypoints were recorded at the start and end of each transect and trackpoints were recorded at regular intervals along the transect on a hand-held GPS (Garmin GPS 73). The time settings on the cameras and GPS were synchronised to local time at the start of the survey with the GPS records used to assign positions to still images. The camera position was within 5-10 m of the GPS position after allowing for the catenary in the tow line between the vessel and towfish.

2.5 Sediment grab sampling

2.5.1 Objectives

The primary objective of sediment sampling was to provide data on sediment quality and infauna communities in the Study Area (Figure 1-2).

Data was collected to meet the following additional objectives:

- comparison of sediment quality data with relevant sediment quality guidelines (ANZG 2018)
- characterisation of a range of sediment types based on physico-chemical characteristics
- characterisation of infaunal assemblages
- characterisation and spatial mapping of infaunal biotopes (combining habitat and assemblage data)
- infaunal biotopes and habitat classifications derived from video imagery overlaid to provide an indication of the range and spatial distribution of habitat types in the Study Area.

2.5.2 Sampling

Sixty offshore sites were sampled within the OWFA, OECC, buffer zones and reference zones using a 0.1 m^2 Smith-McIntyre grab sampler, with the survey based on a random-stratified sampling design.

Replicates were planned at one third of grab sampling sites (20 sites), which were distributed to quantify within-site variability (heterogeneity) across the Study Area. These were defined as the primary sites. Three replicate grab samples were collected for particle size distribution analysis and 5 grab samples for infauna analysis at each replicate site. A single sample for each analyte was collected from the remaining forty grab sampling sites (secondary sites), for providing 'infill' data to determine the potential spatial distribution of different habitat types across the Study Area.

The grab sampling survey design, including determination of sampling effort (number of replicates), was based on consideration of the following:

- AS/NZS 5667.12-19999 and equivalent ISO standards
- international (eg UK) industry best practice, and considering UK offshore windfarm baseline survey examples
- requirements for scientific (and statistical) robustness
- NATA-accredited laboratory recommendations and requirements
- State and Commonwealth legislative environment and environmental understanding (eg VEAC 2019a,b)
- Resolution of existing data

- Seabed type and suitability for grab sampling.

Grab samples were successfully collected from all but one of the 60 planned sites. Reef was present at planned replicate site 17, and again several hundred metres away. Some sites required multiple attempts before successful sample returns. Where grabs were unsuccessful or not enough material was collected it was usually due to shell or rubble becoming lodged in the grab jaws allowing sediment to fall out as the grab was retrieved, with a small number of grab attempts returning no material at all, indicating hard substrate. Of the 323 grabs attempted, just 20 were unsuccessful.

- Prior to deployment at each site, the internal surface of the 0.1 m^2 day grab sampler (Plate 2-2) was cleaned with Decon 90™ to prevent between-site contamination of contaminants samples. Once deployed, the grab was lowered at a steady speed to the seabed and retrieved as soon as slack was observed in the rope. A GPS position, time, date and water depth record was taken each time the grab hit the sea floor. Where sample volumes were insufficient to provide an adequate sample, the attempt was rejected. Following retrieval of the grab to the deck, the following information was recorded for each attempt:
- successful sample (Y/N)?
- volume of sample collected (either proportion of grab or estimated volume in litres)
- sediment description
- sediment features
- conspicuous fauna
- sample type(s) collected from sample
- a photograph of the sample, with a photo slate in view showing project number, site number and date.

The following laboratory samples were collected from grab returns at each site:

- contaminants
  - metals and metalloids
  - nutrients
- particle size distribution samples (one at single sites, three at replicate sites)
- infauna samples (one at single sites, five at replicate sites).

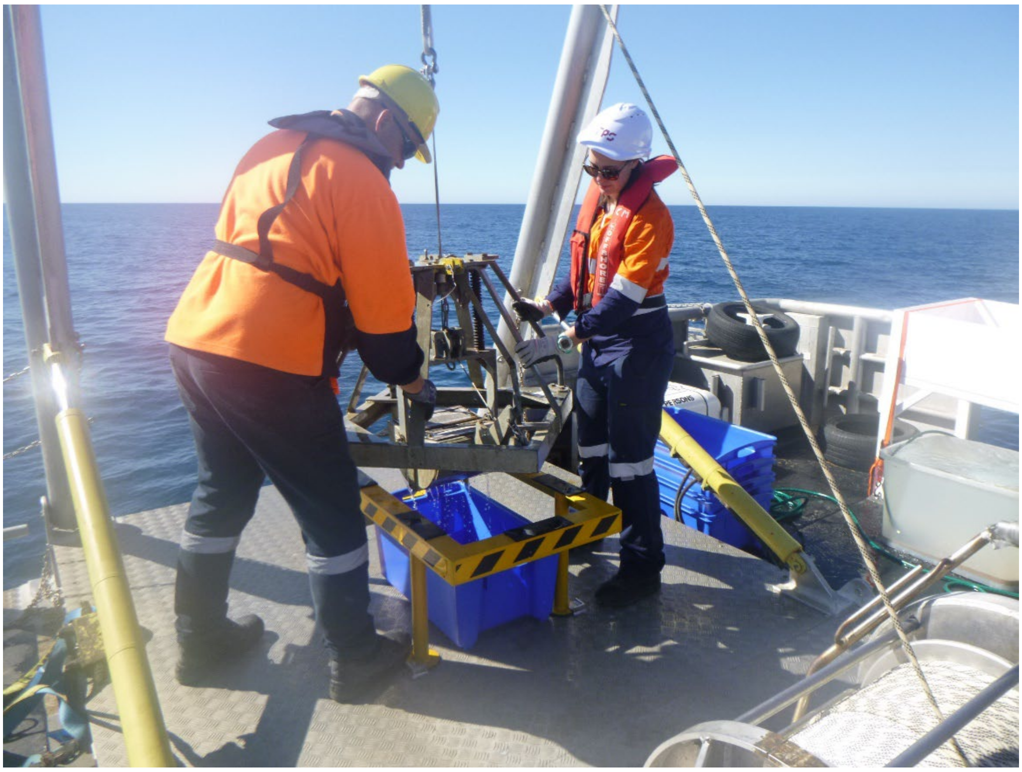


Plate 2-2: The 0.1 m^2 Smith-Macintyre grab sampler

2.5.3 Sediment quality

Sediment quality samples were taken from the surface layer of sediment (upper 2–5 cm) at each sampling site where possible, prior to any other sampling. Full contamination risk mitigation protocols were implemented during sampling, which included careful assessment of sampling areas and use of clean gloves each time samples were collected.

Surficial sediments within the grab were carefully removed and transferred to a glass bowl using plastic sampling utensils pre-cleaned with Decon 90™. Sediment within 5 mm of the sides of the grab were not analysed to minimise risk of contamination.

The collected sediment was then homogenised in a glass bowl before being transferred to sample jars. Two 70 ml samples were collected for metals and nutrients (TOC and TP). Samples were processed on board by filling the jars to the neck whilst leaving sufficient airspace in the sample container to allow for expansion when frozen.

The samples were sent for analysis by a National Association of Testing Authorities (NATA)-accredited laboratory for the following parameters:

- Metals and metalloids
  - Aluminium (mg/kg)
  - Antimony (mg/kg)
  - Arsenic (mg/kg)
  - Cadmium (mg/kg)
  - Chromium (mg/kg)
  - Copper (mg/kg)
  - Cobalt (mg/kg)
  - Iron (mg/kg)
  - Lead (mg/kg)

- Manganese (mg/kg)
- Mercury (mg/kg)
- Nickel (mg/kg)
- Selenium (mg/kg)
- Silver (mg/kg)
- Vanadium (mg/kg)
- Zinc (mg/kg)

- Nutrients
  - Total organic carbon (%)
  - Total phosphorus (mg/kg).

2.5.4 Sediment particle size distribution

A particle size distribution sample of approximately 300–500 ml, representative of the full depth of the grab sample, was also taken for subsequent laboratory analysis. Each sample was placed in a labelled plastic ziplock bag and frozen until they could be transferred to the analysing laboratory refrigerated storage.

Particle size distribution data was interpreted to provide a number of descriptive metrics, including:

- sediment description
- sorting
- per cent cobbles, gravel, sand and silt/clay
- Folk sediment classification.

The PSD data were imported into PRIMER for multivariate analysis.

2.5.5 Infauna

The entire volume of the grab was processed when collecting infauna samples. A photo of the sample was taken prior to removal from the grab, and notes made of the physical nature of the sediment, any features (eg worm tubes, smell, anoxic layer) and of any conspicuous biota. The entire grab sample was passed slowly through a 1 mm sieve. The material remaining on the sieve mesh was then transferred into 10 per cent buffered formalin for transfer to the taxonomic laboratory. Large pieces of rubble or shell were discarded after inspection for fauna to prevent damage to the samples during transport.

2.5.6 Storage and transport

All samples were clearly labelled with the following information:

- Sample type: i.e. contaminants/nutrients type(s), PSD or infauna
- Sample ID: Site number (i.e. S1)
- Date of sampling
- Project and Client name

All samples were preserved and handled in accordance with the requirements of the Australian and New Zealand Standards (AS/NZS 5667.12:1999 Water quality – sampling guidance on sampling of bottom sediments) and the National Association of Testing Authorities (NATA) accredited laboratories. Preservation techniques were selected to achieve maximum holding times for each parameter and samples stored in accordance with the laboratory requirements until delivery.

Samples for chemical analysis were chilled immediately and frozen as soon as possible. Frozen samples were packed into eskies with to ensure that they remained frozen until received by the local (Melbourne) laboratory.

Preserved infauna samples were stored in white plastic buckets and kept out of direct sunlight but did not require refrigeration or freezing.

All samples were transported with chain of custody (CoC) forms that detailed the sample identifications, sample type, date and time of sampling, and the analyses required.

2.6 SBRUVs imagery

2.6.1 Objectives

The primary objectives of the assessment of fish ecology SBRUVs imagery from winter and summer surveys, were to:

- Provide high-level information on the physical characteristics of surface sediments
- Provide high-level habitat classes for use in both benthic ecology and fish ecology studies
- Quantify coverage of benthos by different biota to allow seasonal comparison
- Identify potentially high biodiversity value habitats such as reefs, sponge beds or seagrass beds

2.6.2 Sampling

A single image of the benthic habitat was taken from the imagery collected during deployments at each fish ecology SBRUVs sampling location, during each season.

2.7 Image and sample analyses

2.7.1 Sediment sample storage and transport

All samples were preserved and handled in accordance with the requirements of the Australian and New Zealand Standards (AS/NZS 5667.12:1999 Water quality – sampling guidance on sampling of bottom sediments) and the National Association of Testing Authorities (NATA) accredited laboratories. Due to the remote nature of the survey location, the preservation techniques were selected to achieve maximum holding times for each parameter and samples stored in accordance with the laboratory requirements until delivery within the required holding times.

Samples for chemical analysis were chilled immediately and frozen as soon as possible. Frozen samples were packed into eskies to ensure that they remained frozen until received by the laboratory.

All samples were transported with chain of custody (CoC) forms that detailed the sample identifications, sample type, date and time of sampling, and the analyses required.

2.7.2 Image analysis

Image data used for statistical analyses

A total 325 still images were analysed in detail from the 95 survey 1 sampling locations for statistical analyses to identify different habitat types and biotopes. Images were selected that were representative of the different habitat types present at each site, typically between 5 and 10 images were analysed from each site.

Still images (photographs) were analysed to provide information on species distributions and abundance, and on substrates and habitats. A ten by ten grid (100 cells) was superimposed over each image using GIMP software (which keeps the grid at a fixed size relative to the original scale of the photo).

Grid cells had a unique ID so features could be located in each image to facilitate quality control and to confirm taxonomic identifications. In such cases, the analyst would provide the image reference number and cell reference to a senior scientist in the project team for the feature of interest.

Table 2-3. Biological categories used in image analysis

Taxa/morphotypes	Taxa/morphotypes	Taxa/morphotypes	Taxa/morphotypes
Algae	**Sponges (Porifera)**	**Bryozoans**	**Molluscs**
Algae brown (unknown)	Sponge_branching	Bryozoa	Bivalve (*Nemocardium thetidus*)
Algae_brown (*Carpoglossum confluens*)	Sponge_burrowing	Bryozoa (Bitectiporidae)	Bivalve (small/alive)
Algae_brown (*Cystophora sp.*)	Sponge_crater	Bryozoa (*Cryptopolyzoon* spp.)	Bivalve_Doughboy Scallop (*Mimachlamys asperrima*)
Algae_brown (*Cystophora torulosa*)	Sponge_cup-shaped	Bryozoa_encrusting	Chiton
Algae_brown (*Dictyopteris muelleri*)	Sponge_digitate	Bryozoa_Lace coral (*Cellaria* spp.)	Gastropod (*Conus anemone*)
Algae_brown (*Dictyota dichotoma*)	Sponge_encrusting	Bryozoa_Lace coral (*Orthoscuticella ventricosa*)	Gastropod_Cone shell (black)
Algae_brown (*Dictyota furcellata*)	Sponge_fistulose	Bryozoa_Lace coral (*Triphyllozoon* spp.)	Nudibranch
Algae_brown (*Ecklonia radiata*)	Sponge_flabelliform	Bryozoa_Lace coral_other	
Algae_brown (*Lobospira bicuspidata*)	Sponge_foliose		**Crustaceans**
Algae_brown (*Perithalia caudata*)	Sponge_globular	**Ascidians**	Barnacle
Algae_brown (*Zonaria sp.*)	Sponge_goblet	Ascidian (*Botrylloides sp*)	Crab (*Bellidilia undecimspinosa*)
Algae_brown (*Zonaria turneriana*)	Sponge_hollow	Ascidian (*Clavelina australis*)	Crab (*Ebalia intermedia*)
Algae_brown/yellow (filamentous)	Sponge_irregular	Ascidian (*Clavelina moluccensis*)	Crab (*Leptomithrax gaimardii*)
Algae_green (*Caulerpa brownii*)	Sponge_lamellate	Ascidian (*Herdmania grandis*)	Hermit Crab
Algae_green (Caulerpa trifaria)	Sponge_laminate	Ascidian (*Polycitor giganteus*)	Amphipod tubes (Unique habitat)
Algae_green (*Codium duthieae*)	Sponge_lobate	Ascidian (*Stolonica australis*)	
Algae_green (Dictyosphaeria sericea)	Sponge_massive	Brain ascidian (Sycozoa cerebriformis)	**Annelids**
Algae_green (*Ulva sp.*)	Sponge_plate-like	Stalked ascidian (*Sycozoa murrayi*)	Echiuran (*Ikeda* sp.)
Algae_red (ca. *Acrosorium sp*)	Sponge_ramose	Stalked ascidian (*Sycozoa pulchra*)	Polychaete_Fan worm
Algae_red (ca. *Gelidium sp*)	Sponge_spherical		Polychaete_Lugworm (Abarenicola haswelli)
Algae_red (ca. *Laurencia sp.*)	Sponge_stalked	**Echinoderms**	Polychaete_Other
Algae_red (ca. *Lophurella sp.*)	Sponge_tubular/pipe	Brittle star (*Ophiura kinbergi*)	
Algae_red (*Chrysymenia brownii*)		Feather star (*Antedon incommoda*)	**Fish**
Algae_red (Filamentous Wrack)	**Cnidarians**	Feather star (*Cenolia trichoptera*)	Fish _Tiger flathead (*Platycephalus richardsoni*)
Algae_red (Filamentous)	Anemone (*Anthothoe sp*)	Sea pen	Fish_Blenny (*Parablennius tasmanianus*)
Algae_red (*Gracilaria sp.*)	Anemone (Cerianthidae sp.)	Sea star (*Coscinasterias muricata*)	Fish_Goat fish (*Parupeneus heptacanthus*)
Algae_red (*Laurencia sp.*)	Anemone_Jewel (*Corynactis sp.*)	Sea star (*Luidia australiae*)	Fish_Goby
Algae_red (*Melanthalia obtusata*)	*Pseudogorgia godeffroyi*	Sea star (*Nectria ocellata*)	Fish_Gurnard (*Lepidotrigla mulhalli*)
Algae_red (Plocamium sp.)	Hydroid	Sea star (*Tosia neossia*)	Fish_Leatherjacket (*Acanthaluteres vittiger*)
Algae_red (*Plocamium sp.*)		Sea tulip (*Pyura spp*)	Fish_Leatherjacket (*Thamnaconus degeni*)
Algae_red (*Rhodoglossum sp.*)	**Seagrass**	Sea urchin (*Heliocidaris erythrogramma*)	Fish_Little Dragon Fish/Slender Seamoth

Taxa/morphotypes	Taxa/morphotypes	Taxa/morphotypes	Taxa/morphotypes
	Seagrass (*Heterozostera tasmanica*)	Sea urchin (*Phyllacanthus parvispinus*)	Fish_Wrasse
	Seagrass (Wrack)	Sea_urchin (*Microcyphus annulatus*)	
		Sea cucumber	

Table 2-4. Environmental categories used in image analysis

Parameter	Metric	Feature	Metric
Bedrock	% cover	Relief	1 = flat to 4 = rugged
Boulder/cobbles (>64 mm)	% cover	Stability	1 = consolidated/ stable to 5 = mobile
Gravel/pebbles (>4 mm)	% cover	Reef	Presence/absence
Rhodolith	% cover	Sediment veneer_shallow	Presence/absence
Shell_bivalve	% cover	Sediment veneer_deep	Presence/absence
Shell_scaphopod	% cover	Ripples (<10 cm)	Presence/absence
Shell_gastropod	% cover	Waves (>10 cm)	Presence/absence
Shell_fragments	% cover	Waves (>10 cm)	Presence/absence
Coarse sand	% cover	Tubes	Presence/absence
Fine sand	% cover	Burrows	Presence/absence
Mud/silt	% cover	Flocculation	Presence/absence
		Sediment streaks	Presence/absence
		Sand biscuits	Presence/absence

SBRUV imagery

Analysis of SBRUVs images from each season used the same basic approach to that of the drop-down and towed video still images, with a few modifications to allow consideration of the larger field of view and lower resolution of seabed features and biota.

Data on the following aspects were recorded from all images:

- Abundance of individuals (no. per m^2), recorded using the SACFOR abundance scale
- Per cent (%) coverage of colonies, beds and complex aggregations, recorded using the SACFOR abundance scale. Where half a grid cell or more was covered by a specific encrusting/massive growth form, then a count of 1 (%) was recorded
- Occurrence of seabed features (eg veneer, ripples, streaks, waves, profile) recorded as presence/absence
- Per cent (%) coverage of principal sediment components (fine, medium and coarse sand, geogenic gravel, shell gravel, shell (bivalve or gastropod), rock pavement (inferred below low relief mixed coarse sediments), emergent bedrock (reef)).

Survey 1 transect imagery and Survey 2 imagery

Imagery from the twenty 500 metre transects recorded in Survey 1 and imagery from Survey 2 were classified using the habitat types and biotopes identified through statistical analysis of survey 1 spot-site imagery (described above).

- The habitat types at each site and along each transect were plotted on the habitat map to provide additional data and refine mapped habitat distributions (where relevant) and to quantify small scale spatial variation in habitats.

The SACFORP abundance scale

- The Marine Nature Conservation Review SACFORP scale (Table 2-5) is a semi-quantitative abundance scale used widely in the UK to support the monitoring of marine habitats, communities and species since 1990 (https://mhc.jncc.gov.uk/media/1009/sacfor.pdf), having been developed in the 1950's (Strong and Johnson 2020). This scale is a development of the ACFOR scale developed by Crisp and Southward (1958). SACFORP is an acronym:
- S – Superabundant
- A – Abundant
- C – Common
- F – Frequent
- O – Occasional
- R – Rare
- P - Present
-

Table 2-5: SACFORP abundance scale

Per cent (%) cover	Growth form		Size of individuals/colonies				Density scale
	Crust/meadow	Massive/turf	<1 cm	1-3 cm	3-15 cm	>15 cm	
>80	S		S				>10,000 / m^2
40-79	A	S	A	S			1000-9999 / m^2
20-39	C	A	C	A	S		100-999 / m^2
10-19	F	C	F	C	A	S	10-99 / m^2
5-9	O	F	O	F	C	A	1-9 / m^2
1-5 or density	R	O	R	O	F	C	1-9 / 10 m^2
<1 or density		R		R	O	F	1-9 / 100 m^2
Present					R	O	1-9 / 1000 m^2
						R	<1/1000 m^2

2.7.3 Sediment samples

Infauna samples were sent for picking, sorting and identification by a taxonomic specialist at Infauna Data (Peterborough, Victoria). Infauna were identified to the lowest practical taxonomic level (to species level where possible or operational taxonomic unit (OTU). A reference collection was prepared to support comparison in future sampling.

All analyses were undertaken using standard methods at NATA-accredited laboratories.The following analytes were tested for by NATA-accredited laboratories where applicable:

- particle size distribution (PSD) analysis was undertaken using a combination of laser diffraction and sieving, with the results combined to provide a full PSD curve:
  - laser diffraction of particles sized from 0.022 µm to 1 mm
  - wet/dry sieving of sediments for the following sizes: <500 µm, 500 µm, 1 mm, 2 mm, 4 mm, 8 mm and >16 mm
- total metals (aluminium, antimony, arsenic, cadmium, chromium, cobalt, copper, iron, lead, mercury, manganese, nickel, selenium, silver, vanadium and zinc)
- nutrients (total phosphorus (TP) and total organic carbon (TOC)).

Additional samples were collected for QA/QC purposes. These included:

- sample duplicates
- a field (method) blank
- transport blank.

2.8 Data analysis

The following sections present methods for multiple interpretations of data for two main purposes:

i. *characterisation and identifying trends in baseline data*: as this is a characterisation, no factors (eg depth range) were pre-defined; rather, the analyses were used to objectively identify trends within the dataset. Multivariate statistical methods are described that identify (statistically-significant) groupings of similar samples based on comparisons between the data for each sample against all other samples. This approach was undertaken for each sampling method (eg subsea imagery, grab sample data, SBRUVs data) to allow direct comparability with future monitoring datasets collected using each method. Groupings were identified using alphabetical labels, defined at a level appropriate to the spatial scale of the Study Area, and then tested to determine significant difference. The characteristics of each grouping were defined, and their spatial distribution identified. This approach provided baseline data to allow direct comparison with subsequent studies – but focused at spatial scales relevant to the size of the Study Area (ie local scales). This approach provides more detail in mapping units.

ii. *spatial interpretation of data*: multivariate statistical analyses provided metrics to map data as mapping units relevant at regional to international scales. GPS positions were then used to present the mapping units across the survey array. This approach facilitates comparison with historic datasets and other datasets that may be collected in the region for broadscale comparison. Using broad mapping units tends to provide simpler interpretation of data, allowing interpretation of trends at much broader spatial scales. Examples include Folk sediment classifications and habitat classifications presented at higher classification levels (eg to substrate type only).

2.8.1 Image analysis data

Data derived from imagery were analysed for the purposes of habitat classification (see Section 2.8.3).

2.8.2 Sediment samples

Data were analysed using multiple approaches:

- Sediment quality was compared against relevant ANG (2018) guideline levels, where relevant
- The range of sediment types were characterised based on their particle size characteristics
- PSD data for each sample was described in terms of the Folk sediment classification, skewness, kurtosis and sorting. This information is useful for sediment mapping and to identify relationships between physical sediment characteristics and biological assemblages
- Infaunal biotopes (combining habitat and assemblage data) were characterised using a range of multivariate routines in PRIMER (v7) and presented spatially
- Infaunal biotopes and habitat classifications derived from video imagery were presented as separate habitat maps to provide an indication of the range and spatial distribution of different habitat types in the Study Area
- Total number of taxa were calculated per site to provide an indicator of relative biodiversity at each sampling site.

2.8.3 Habitat classification and mapping

Environmental and biological data derived from imagery and grab samples were imported into PRIMER (v7) for analysis. A number of multivariate statistical routines in PRIMER with PERMANOVA+ (Clarke and Gorley 2015, Anderson et al. 2008) were used to:

- identify significant groupings in the data (Cluster with SIMPROF)
- identify trends in the data (multi-dimensional scaling)
- identify the characteristics and significance of the groupings (SIMPER, PERMANOVA+)

- identify key aspects influencing distributions (Principal Components Analysis)
- investigate relationships between environmental and biological aspects (Bio-Env (BEST)).
- Habitat classifications (ie biotopes) were not simply defined by statistically-defined groupings in the data, as groupings can define variants or examples of a single biotope (eg there may be variability in abundance and species richness resulting in statistically-derived differences between several groups, though these groups still meet the criteria of a single biotope description). Therefore the environmental and biological characteristics of each statistically-derived grouping were compared (guided by Cluster analysis) to classify biotopes. The level at which biotopes were characterised (ie not using SIMPROF clusters, but high levels) was mainly driven by the requirement to map the data. If too many groups are used (eg SIMPROF clusters), then the maps become messy, confusing and difficult to interpret.
- Biotopes from data derived from imagery were classified using a ‘top down’ approach, where the substrate type(s) and depth ranges (ie infralittoral vs circalittoral) were defined first, and then biological assemblages associated with these habitat types characterised. This approach was better suited to the types of data derived from image analysis (eg high-level taxonomic descriptors, and a range of data types). Grab sample PSD and infauna data were analysed to identify and characterise infaunal biotopes using a ‘bottom-up’ approach, ie identifying groupings in the biological data, and then ‘backfilling’ the environmental and substrate information. This approach was more appropriate for the analysis of the infaunal data because of the characteristics of the dataset (236 invertebrate taxa and 135 samples).
- The habitat classifications for specific sampling positions were imported into a geographic information system (GIS) format for mapping. Habitat maps were derived by plotting SOTS spot-point and transect habitat data (ie benthic ecology survey data, SBRUVs data and existing SOTS geophysical survey line data) and data available from external datasets (eg Coastkit (DELWP 2021), Open Coasts habitats and fisher websites). The boundaries defined in habitat maps have been derived visually from interpretation of spot-point data groupings and categories, and through applying depth/bathymetry information (eg from charted depth contours and 5 m depth ranges plotted from the survey deployment data. This approach (identifying patterns by eye in GIS) inevitably results in some level of subjectivity, but provides a best estimate of the distribution of benthic habitats.

2.9 Quality Control

2.9.1 Image analysis

Ten per cent of the analysed images were selected for re-analysis by qualified and experienced RPS marine scientists. The images to be re-analysed were selected using the random number generator function in MSExcel. QA/QC failures, where identified, required detailed review and revision of the image in question and images of similar habitat types.

2.9.2 Infaunal samples

- Data received from infaunal taxonomic laboratories underwent an internal RPS QA/QC process to ensure taxonomic nomenclature was both current and accepted. The taxon list was uploaded to the World Register of Marine Species (WoRMS) ‘Match Taxa’ tool (https://www.marinespecies.org/aphia.php?p=match). In addition to checking spelling and current accepted nomenclature, this process also provided other key information such as Alpha IDs, authority and classification hierarchy.
- Once this process had been undertaken, the following data were removed from the dataset prior to analysis:
- Juvenile infauna (can occur in very high numbers, but due to the high mortality rates of settling stages and juveniles, are considered ephemeral)
- Non-infauna species
  - pelagic biota (eg ctenophores, calanoid copepods, chaetognaths)
  - fish (which are occasionally collected in grab samples)

- These aspects are excluded as they are either not infauna or not truly representative of the infaunal assemblage of the seabed habitat in the sample, and can skew the data analyses.

3 RESULTS

Survey 1 was completed between 17 November and 4 December 2020 while survey 2 was completed between 17 January and 16 February 2022. Both surveys were during the austral spring-summer period. The SBRUVs surveys were conducted in June (winter) and November (spring/summer) 2020.The sampling site positions for the benthic ecology survey and the SBRUVs surveys are presented in **Error! Reference source not found.** and depths in Figure 2-1.

3.1 Subsea imagery

Water depths recorded at drop video sites ranged from 16 m below sea level (bsl) at DV18b (survey 1) and CC06 (survey 2) to 54 m bsl at site VT8 (survey 1). Seabed was predominantly unconsolidated sand, shell, gravel, cobble and rhodolith. Seabed in shallower inshore areas (<25 m) was predominantly unconsolidated sandy sediment, with small areas of mostly low relief reef. Seabed in deeper offshore areas was also unconsolidated sediment, but with a larger proportion of coarse shell, gravel, cobble and rhodolith.

3.1.1 Statistically derived substrate categories

- Analysis of the substrate (%) data from survey 1 and survey 2 images was undertaken in PRIMER. Cluster analysis with SIMPROF based on Euclidean distance matrix from square-root transformed per cent data was used to identify significant groupings of substrate types. PERMANOVA+ was used to test the level of significance of the SIMPROF groupings, which were found to be significant (Pseudo-F = 75.796, P(perm) =0.001 in survey 1; Pseudo-F = 117, P(perm) =0.001 in survey 2).
- For easier interpretation of mapping (which was based on survey 1 data), higher-level groups were identified from the Cluster analysis (see dashed line in Figure 3-1). These higher level groups were also found to be significant in PERMANOVA+ (Pseudo-F = 213.45, P(perm) = 0.001). These groupings were then presented spatially across the Study Area (Figure 3-2). Note that multiple icons overlaid on the same sampling location indicates heterogeneity of substrates. The similarity per cent (SIMPER) routine in PRIMER was used to determine the survey 1 substrate components with the top 70 per cent contribution to the grouping (Table 3-1).
- Principal Component Analysis of survey 1 data (PCA, Figure 3-3) indicated that the main components influencing variability in environmental aspects across the Study Area were fine sand, coarse sand and shell fragments. Five main groups – B, E, F, H and I (comprising the greatest number of samples per group) were generally split into two main zones across the Study Area (Figure 3-2). Groups B,H and I were located in the shallower, sand zone, whereas groups E and F were mainly distributed in the deeper (>30 m) zone where rock pavement was inferred beneath sediment layers (analysis of geophysical data suggests this may be gravel, Fitzpatrick, 2022). The PCA showed that groups E and F were more similar to each other than the other three main groups, with group F having a slightly greater fine sand component than group E (Figure 3-3). Groups E and F had a greater whole bivalve shell component than groups B, H, and I – which were separated from each other by relative components of fine and coarse sand, with group H having a greater component of coarse sand than group C, and group I having a greater contribution of coarse sand than Group H. Group H was generally representative of sediments near reef habitat, with the exception of site S23, which was characterised by consolidated gravel/pebble substrates with coarse sand contributing to the sediment matrix.
- SIMPER analysis of image-derived sediment data from survey 1 identified that the groupings with the widest distributions were groups E, H and I. Group I (averaged square distance = 3.52) represented sediments in the shallower (<30 m) northern half of the Study Area. The greatest contribution to sediment composition was by shell fragments (50.02 %), coarse sand (15.15 %) and fine sand (11.87 %). Group H (average squared distance = 6.60) was characterised as reef (low and high profile) areas. The top 70 per cent of contributions to substrate composition to Group H were coarse sand (38.93 %), shell fragments (19.97 %) and gravel/pebbles (>4 mm). This group also had the greatest contribution of boulder/cobbles (>64 mm) (10.17 %) and bedrock (2.54 %) of all the groups. Group E (averaged square distance = 8.63) represents the sediments in the deeper, southerly part of the Study Area. The top 70 per cent contributors to those sediments were gastropod shells (41.64 %), bivalve shells (27.79 %) and coarse sand (14.64 %).

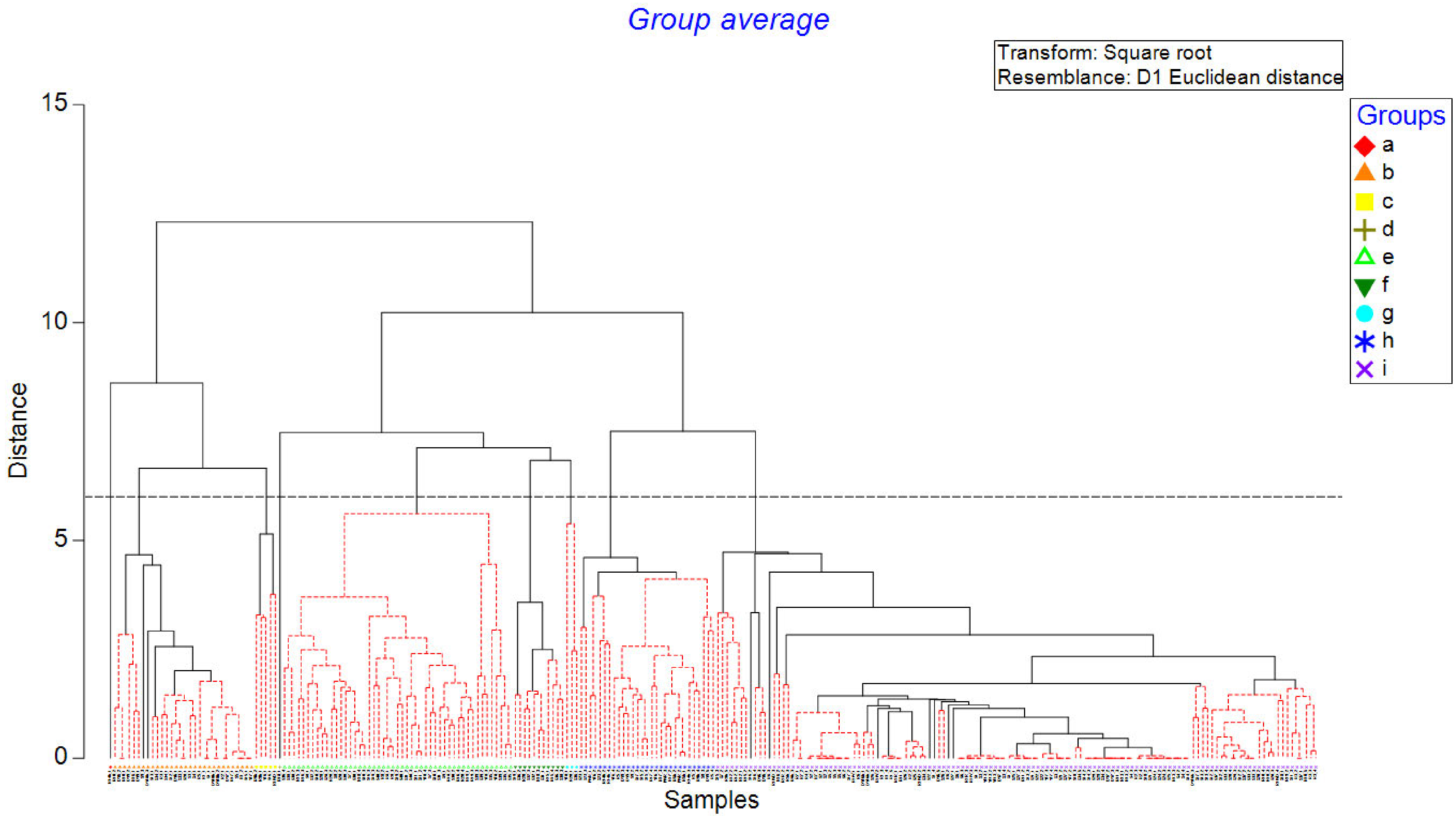


Figure 3-1: Cluster analysis of survey 1 subsea imagery sediment data. The dashed line defines the high-level cluster groups (see Table 3-1).

Table 3-1: Characteristics of high-level substrate groupings from survey 1 imagery data (see Figure 3-1). Groups A and D were represented by single samples only.

Group B (n = 33 images)			Group C (n = 7 images)			Group E (n = 58 images)			Group F (n = 16 images)		
Average squared distance = 5.90			Average squared distance = 10.62			Average squared distance = 8.63			Average squared distance = 3.84		
Component	%	Contrib%	Component	%	Contrib%	Component	%	Contrib%	Component	%	Contrib%
Shell fragments	12.4 ± 14.7	59.63	Gravel/ pebbles (>4mm)	5.0 ± 5.0	24.35	Shell - gastropod	5.6 ± 13.1	41.64	Shell fragments	29.4 ± 13.6	48.36
Fine sand	84.3 ± 17.1	17.86	Shell - bivalve	3.2 ± 4.3	18.39	Shell - bivalve	11.8 ± 10.9	27.79	Shell - bivalve	67.8 ± 14.2	19.37
Shell - bivalve	1.9 ± 2.7	15.4	Rhodolith	1.0 ± 2.2	9.42	Coarse sand	6.86 ± 5.9	14.64	Coarse sand	2.3 ± 1.8	15.7
Coarse sand	0.2 ± 0.9	2.83	Fine sand	45.0 ± 12.2	8.06	Shell fragments	75.5 ± 13.8	8.42	Shell - gastropod	0.4 ± 0.5	6.63
Shell - scaphopod	0.1 ± 0.3	1.58	Shell fragments	26.0 ± 8.9	6.61	Gravel/pebbles (>4mm)	0.3 ± 0.6	2.68	Rhodolith	0.3 ± 0.5	5.68
Shell - gastropod	0.1 ± 0.3	1.58	Shell - scaphopod	0.2 ± 0.5	1.88	Rhodolith	0.2 ± 0.4	1.77	Gravel/ pebbles (>4mm)	0.2 ± 0.4	4.26
Bedrock	0.0 ± 0.2	0.57	Shell - gastropod	0.2 ± 0.5	1.88	Fine sand	0.1 ± 1.0	1.66			
Rhodolith	0.0 ± 0.2	0.57				Shell - scaphopod	0.1 ± 0.7	1.4			

Group G (n= 3 images)			Group H (n = 41 images)			Group I (n = 165 images)		
Average squared distance = 10.68			Average squared distance = 6.60			Average squared distance = 3.52		
Component	%	Contrib%	Component	%	Contrib%	Component	%	Contrib%
Shell - gastropod	7.0 ± 11.3	51.56	Coarse sand	8.6 ± 7.9	38.93	Shell fragments	6.8 ± 8.6	50.02
Fine sand	28.3 ± 16.0	27.48	Shell fragments	3.8 ± 5.6	19.97	Coarse sand	89.9 ± 12.6	15.15
Gravel/ pebbles (>4mm)	1.7 ± 2.9	15.6	Gravel/ pebbles (>4mm)	1.1 ± 3.4	13.17	Fine sand	0.4 ± 2.5	11.87
Rhodolith	0.7 ± 0.6	3.12	Boulder/ cobbles (>64mm)	0.8 ± 2.2	10.17	Shell - bivalve	1.1 ± 1.2	6.68
Shell - bivalve	33.3 ± 5.8	2.24	Shell - bivalve	1.1 ± 1.4	5.43	Boulder/ cobbles (>64mm)	0.2 ± 1.5	6.01
			Fine sand	0.3 ± 1.2	4.05	Gravel/ pebbles (>4mm)	0.2 ± 0.6	5.11
			Rhodolith	0.2 ± 0.4	2.87	Shell - gastropod	0.2 ± 0.4	4.5
			Shell - gastropod	0.2 ± 0.4	2.87	Shell - scaphopod	0.0 ± 0.1	0.44
			Bedrock	0.2 ± 0.8	2.54	Rhodolith	0.0 ± 0.1	0.22

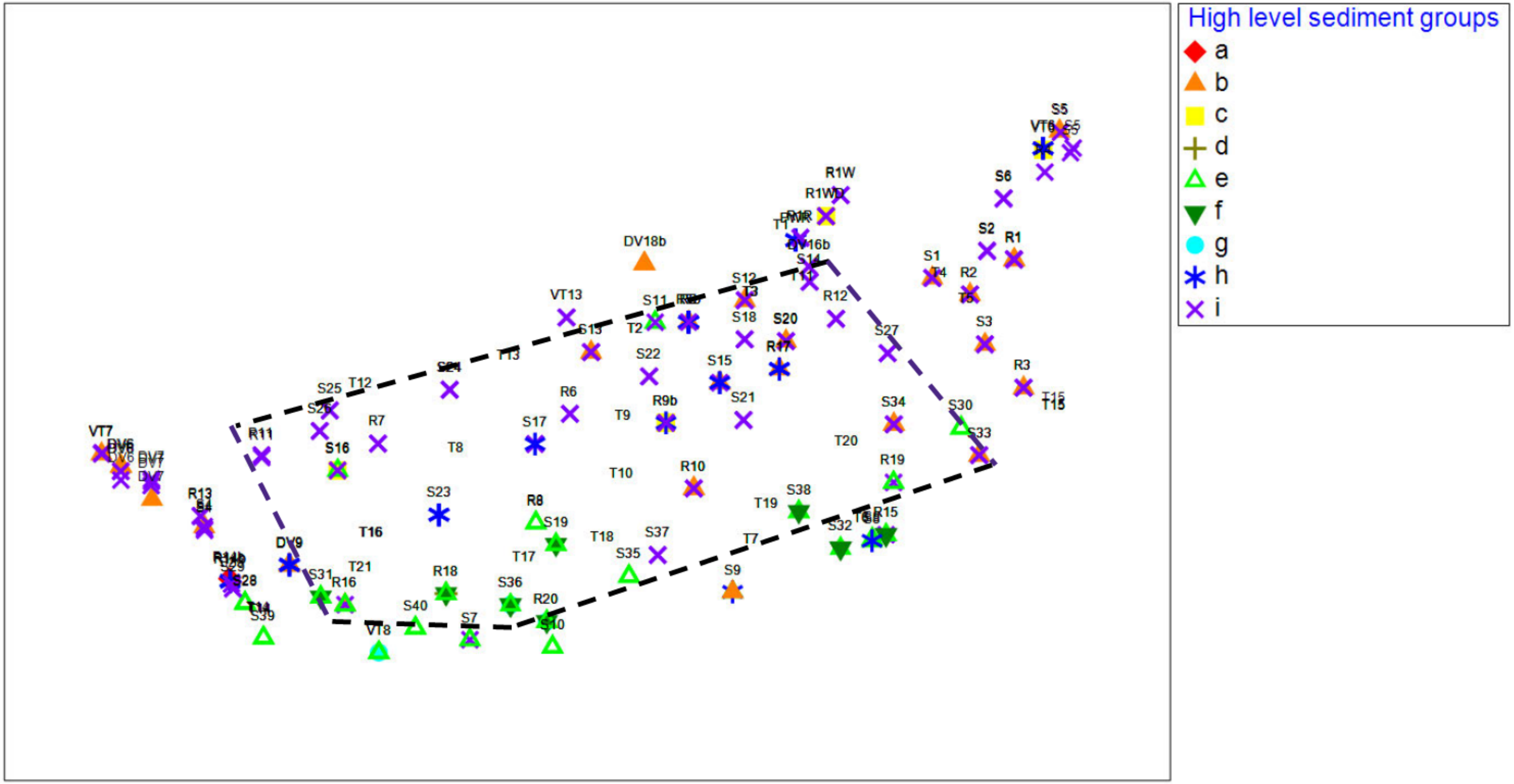


Figure 3-2: High-level sediment groups derived from PRIMER cluster analysis of survey 1 benthic images (see Table 3-1 for group characteristics). Dotted line = OWFA.

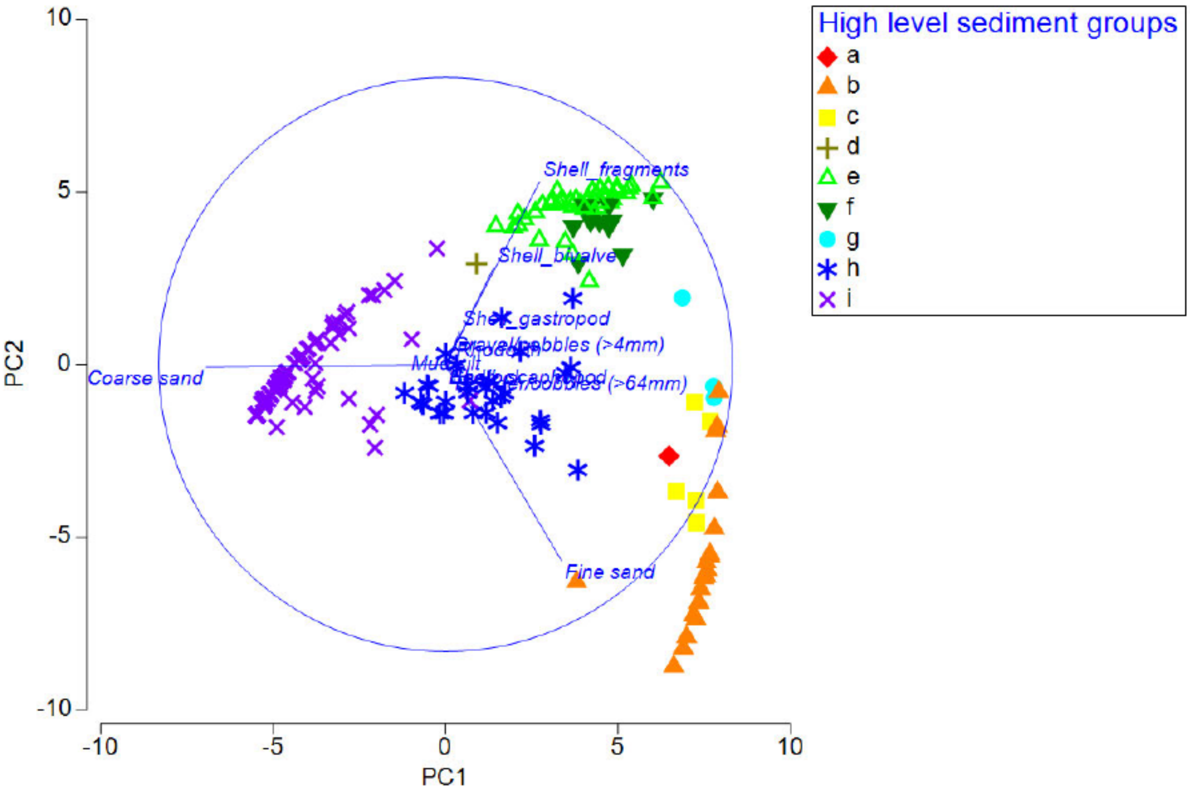


Figure 3-3: PCA plot of sediment groupings derived from the analysis of survey 1 imagery (see Table 3-1)

3.1.2 Benthic flora and fauna

- The most frequently-occurring epibiota in the images were red algae (mostly filamentous red macroalgae of seasonal occurrence), sponges and bryozoans, green and brown algae. These groups all occurred in 20 per cent or more of images (Table 3-2). Solitary and colonial ascidians were also common being present in 19 per cent of images. Seagrass (*Heterozostera tasmanica*) was identified in 11 per cent of images.

Table 3-2: Frequency of occurrence of epibiota in still images (survey 1)

Generic name	Class etc	% images
Red algae	Rhodophyta	52%
Sponges	Porifera	49%
Hard and soft bryozoans (lace corals)	Bryozoa	37%
Green algae	Chlorophyta	27%
Brown algae	Ochrophyta	23%
Solitary and colonial sea squirts	Ascidiacea	19%
Seagrass	Magnoliopsida	11%
Hydroids, sea-pens, corals	Cnidaria	7%
Crabs, shrimp, barnacles	Crustacea	7%
Sea stars, sea urchins, feather stars	Echinodermata	5%
Bivalves, gastropods	Mollusca	3%
Polychaete worms	Annelida	1%

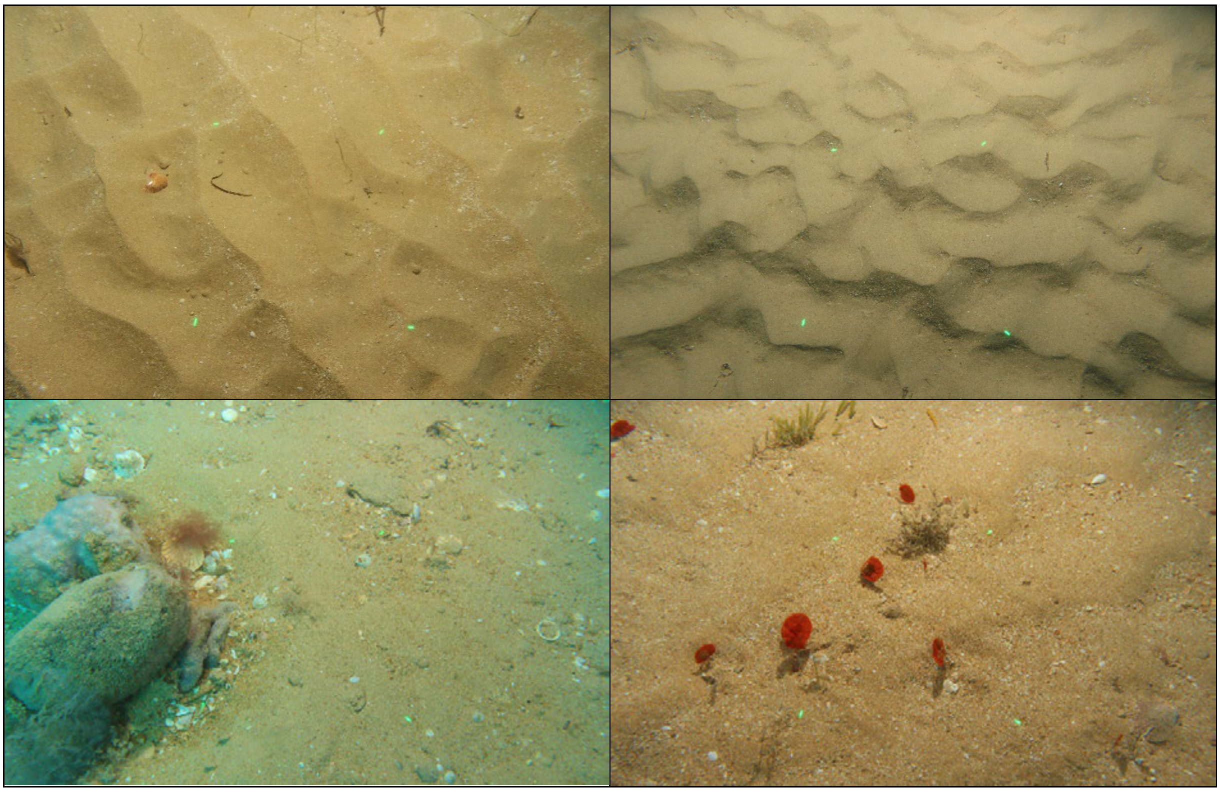
- Distribution of epibiota recorded in Survey 1 correlated with broad substrate types, and in particular low relief mixed coarse sediment over pavement (likely gravel), low profile reef and high profile reef. For example, the green alga *Caulerpa trifaria* was associated with high and low profile reef through the central and eastern License Area, whereas the green alga *Rhipiliopsis peltata* was associated with flat/low relief mixed coarse sediment in the southern central and eastern Study Area, in water depths of >30 m below sea level. Encrusting coralline red algae (e.g. *Lithothamnion*) were associated with all reef and unconsolidated hard substrate habitats, and nodules (rhodoliths) were occasionally observed. Distribution patterns of benthic fauna were also associated with the distribution of unconsolidated and consolidated hard substrate, in particular bryozoans, sponges and ascidians. The feather star, *Cenolia trichoptera*, was a characteristic species that occurred at high densities in some of the shallower high profile reefs in groups B, C, H and I. In contrast, the soft coral, *Pseudogorgia godeffroyi*, and the sea star, *Luidia australiae*, were more commonly associated with sandy habitats. Arborescent bryozoa, such as *Costaticella* sp. or *Orthoscuticella* sp. were recorded in both sand and hard substrate habitat, but was recorded more frequently in hard substrate habitat.
- The outcomes of the analysis of survey 1 biological assemblages associated with sediment groupings described in Section 3.1.1 are presented in Table 3-3. The results show that sediment groups generally associated with sandy habitat (such as groups B, C and I were characterised by biological assemblages with low average abundance (present or rare) and very low average similarity (3.91 to 12.47), indicating sparsely distributed epibiota. In contrast, the biological assemblages associated with hard substrates (e.g. groups E, F, G and H) were characterised by higher average abundances (rare to common, with no characterising taxa classified as ‘present’) and greater average similarities (32.33 to 47.61) indicating more frequently observed combinations of biota.
- Distributions of species or groups of biota that were identified in Section 2 as being representative of IMCRA marine bioregions or Victorian biounits were also identified. The following biota were recorded in the analysis of video survey imagery:
- seagrass (*Heterozostera tasmanica*), brown algae (*Ecklonia radiata*), the feather star *Cenolia trichoptera*, the sea star *Coscinasterias muricata* and the cnidarian *Pseudogorgia godeffroyi* (Figure 3-5)
- sponge beds (Figure 3-6).

Figure 3-4 shows that the seagrass *Heterozostera tasmanica* occurs between around 20 m and 25 m depth within the study area, and was most common in the southwest and north east. The distribution of seagrass may be limited by a combination of light availability (low inshore due to wave and current generated turbidity, and decreasing with depth) and bed shear stress (higher in shallower water and in the middle of the study area, Figure 1-4).

Figure 3-5 indicates that the seagrass *Heterozostera tasmanica* and the soft-coral *Pseudogorgia godeffroyi* were distributed in the shallower, sandier habitats in the northern part of the OWFA during survey 1. Some species, such as the feather star *Cenolia trichoptera* and the kelp *Ecklonia radiata* indicate where reefs occurred in the Study Area (Figure 3-5). Figure 3-6 shows the distribution of sponges was mainly associated with hard substrates (reef in shallower areas and unconsolidated hard substrates such as shell and rubble in deeper areas), with only sparse occurrence of sponges in the sand-dominated habitats. The distributions of the ascidian *Herdmania grandis* and a wide range of bryozoan species, like sponges, correlates with hard substrate habitat in deeper water (Figure 3-7). In contrast, the Figure 3-8 shows a range of biota, including echinoderms, ascidians, crabs, *Pseudogorgia godeffroyi*, polychaete worms and sea cucumbers were more likely associated with the shallower, sandy habitats.

Table 3-3: Characteristic taxa of sediment groups derived from subsea imagery (survey 1). Groups shown comprise >1 image.

Sediment group	Characterising taxa (top 70%)	Av. Abundance (SACFORP)	Contribution to group (%)
	Red algae (filamentous)	R	29.3
Group B	Arborescent bryozoan (eg *Costaticella*/*Orthoscuticella*)	R	14.5
(Plate 3-1)	Seagrass (*Heterozostera tasmanica*)	P	11.9
	Red algae (encrusting coralline)	P	8.7
Av. similarity = 3.91	Sponge (massive)	P	7.1
	Bryozoa 'ace of clubs' (*Lanceopora smeatoni*)	P	5.6
Group C	Arborescent bryozoan (eg *Costaticella*/*Orthoscuticella*)	F	35.5
(Plate 3-2)	Red algae (filamentous)	R	16.7
	Red algae (encrusting coralline)	R	14.5
Av. similarity = 12.47	Sponge (digitate)	O	10.4
Group E	Sponge (encrusting)	F	29.9
(Plate 3-3)	Hydroid (general)	F	23.9
Av. similarity = 31.55	Red algae (filamentous)	O	15.6
	Red algae (slimy)	R	6.3
Group F	Hydroid (general)	C	16.55
(Plate 3-4)	Red algae (filamentous)	C	15.68
	Green algae (*Rhipiliopsis peltate*)	F	13.76
Av. similarity = 47.61	Sponge (encrusting)	F	13.2
	Plate bryozoan (Bitectiporidae)	F	7.98
	Lace bryozoan (*Triphyllozoon* spp.)	O	7.24
Group G	Red algae (encrusting coralline)	C	55.8
(Plate 3-5)	Sponge (encrusting)	O	17.8
Av. similarity = 36.51			
Group H	Red algae (slimy)	C	25.8
(Plate 3-6)	Red algae (filamentous)	F	16.3
	Arborescent bryozoan (eg *Costaticella*/*Orthoscuticella*)	F	13.3
Av. similarity = 32.33	Sponge (encrusting)	F	12.2
	Green algae (*Rhipiliopsis peltate*)	R	4.9
Group I	Seagrass (*Heterozostera tasmanica*)	P	29.1
(Plate 3-7)	Hydroid (general)	R	25.6
Av. similarity = 5.97	Red algae (slimy)	P	12.0
	Red algae (filamentous)	P	11.4
Group J	Hydroid (general)	C	55.56
	Sponge (encrusting)	F	44.44
Av. similarity = 56.25			



.Plate 3-1: Example image of group B habitat and biota

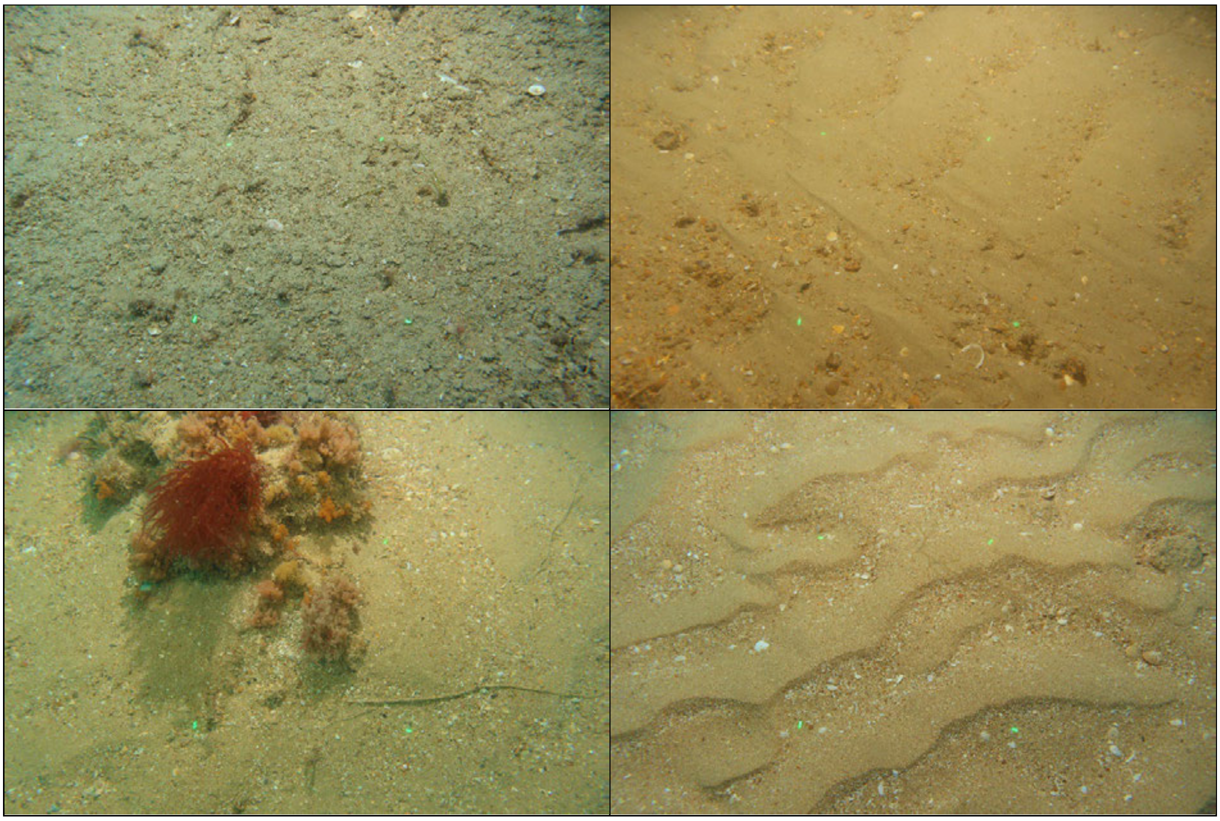


Plate 3-2: Example image of group C habitat and biota

Plate 3-3: Example image of group E habitat and biota

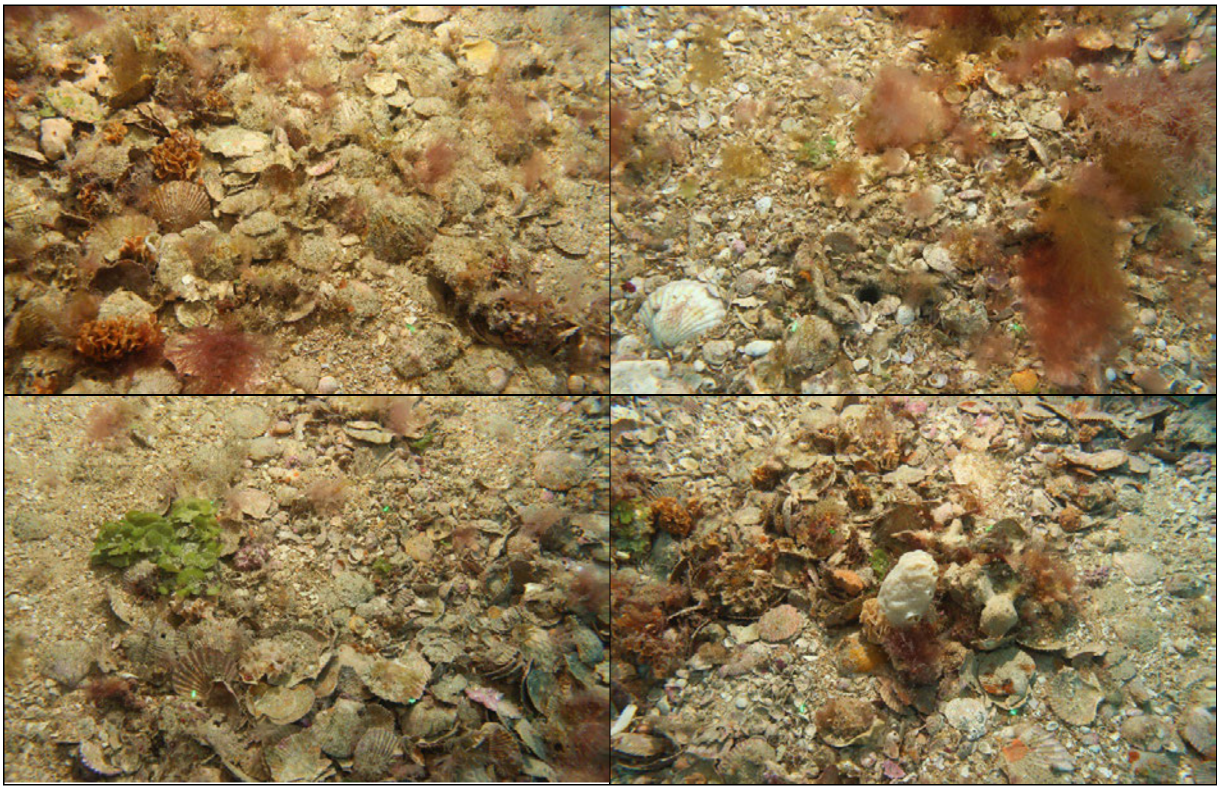


Plate 3-4: Example image of group F habitat and biota

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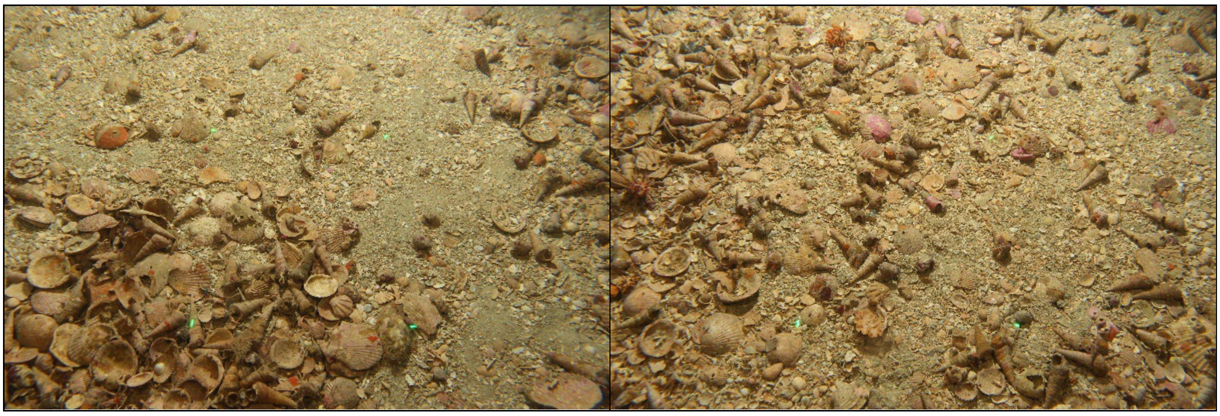

Plate 3-5: Example image of group G habitat and biota

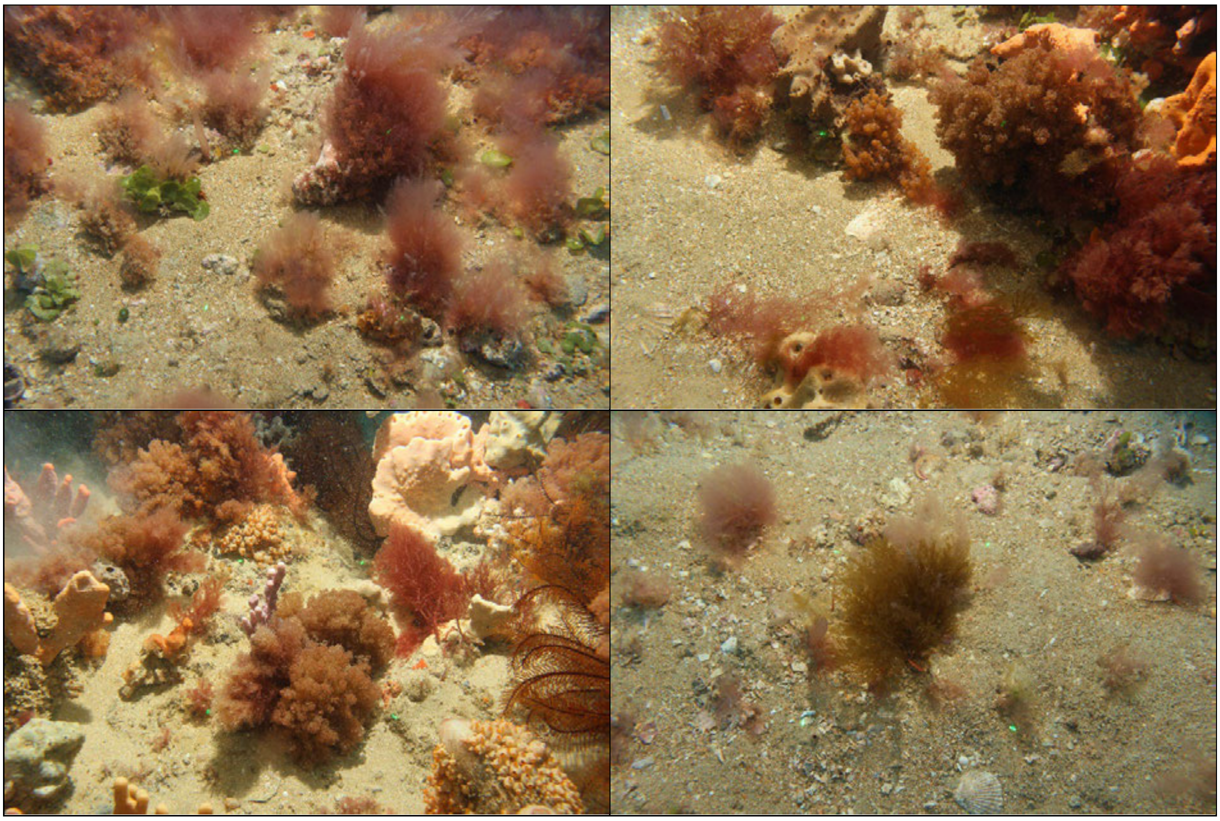

Plate 3-6: Example image of group H habitat and biota

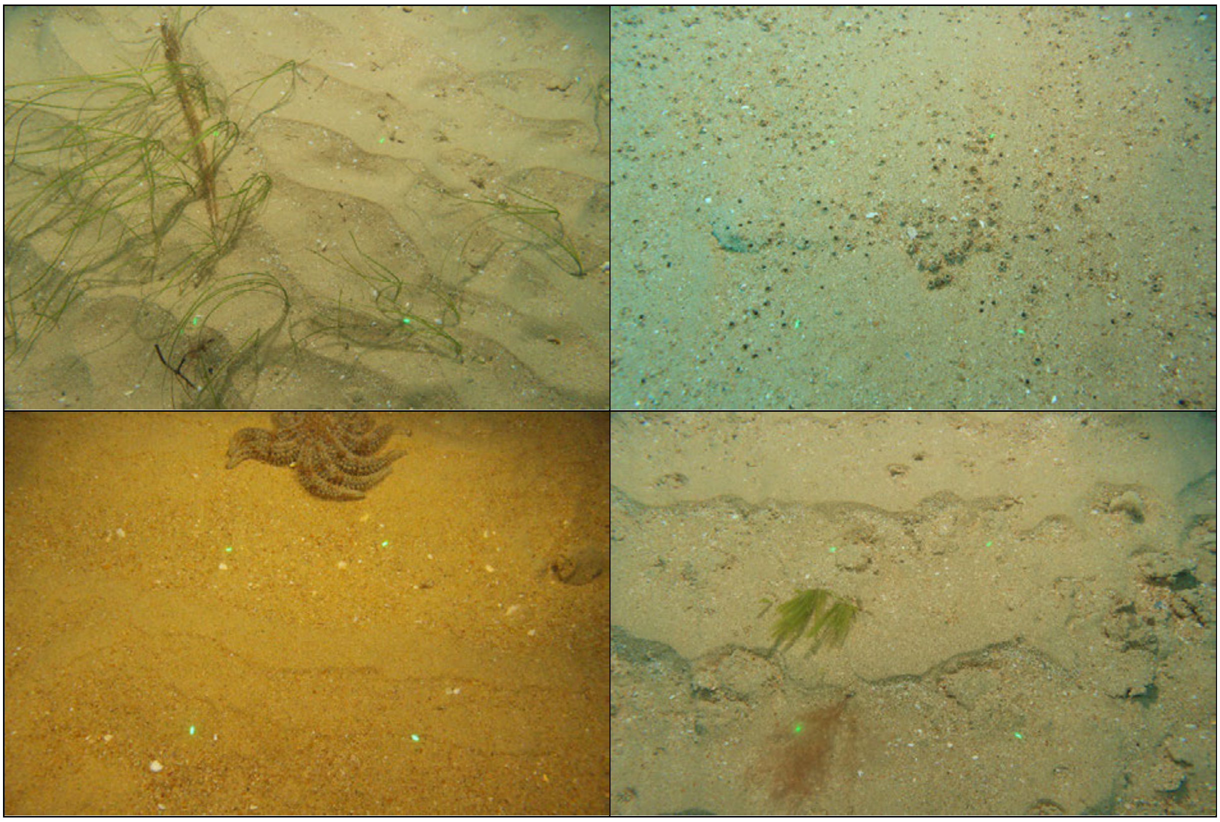

Plate 3-7: Example image of group I habitat and biota

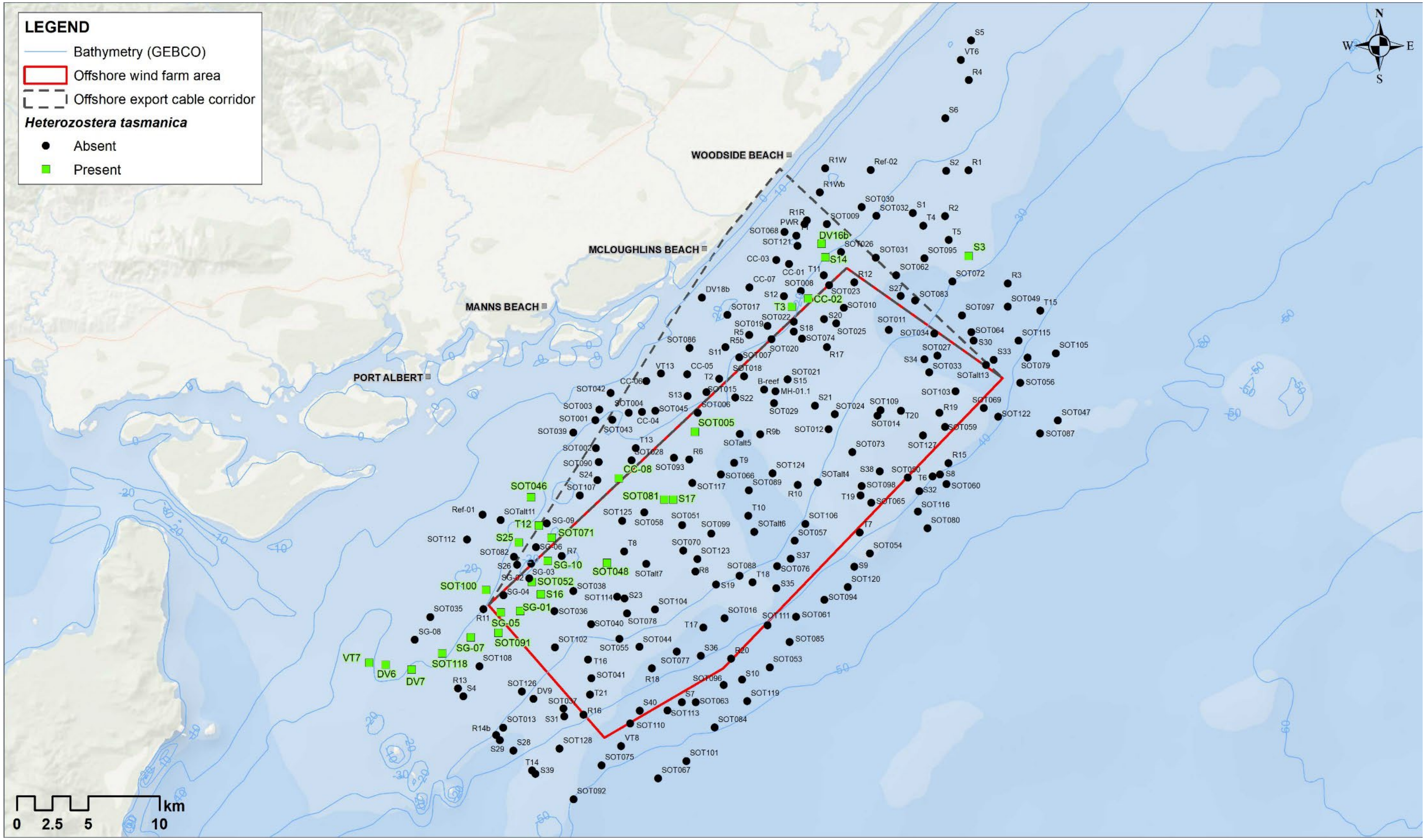

Figure 3-4: Occurrences of *Heterozostera tasmanica*, compiled from the subsea video and SBRUVs surveys

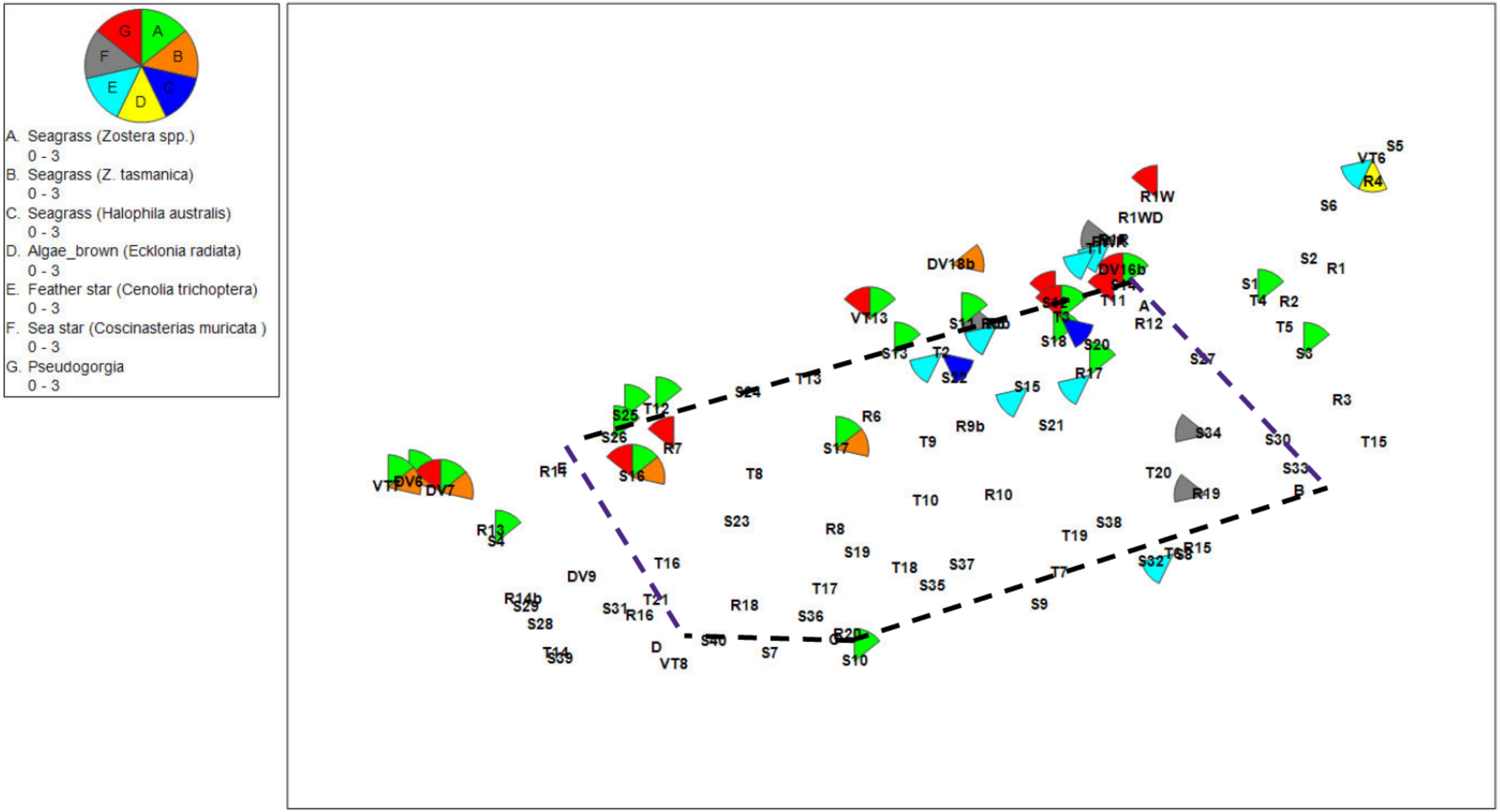

Figure 3-5: Spatial distribution (presence/absence) of survey 1 species that were representative of the region (refer to Section 1.3.1). Dotted line = OWFA.

[Hold: seagrass at S10 is an error please see Figure 3-4 for H. tasmanica distribution]

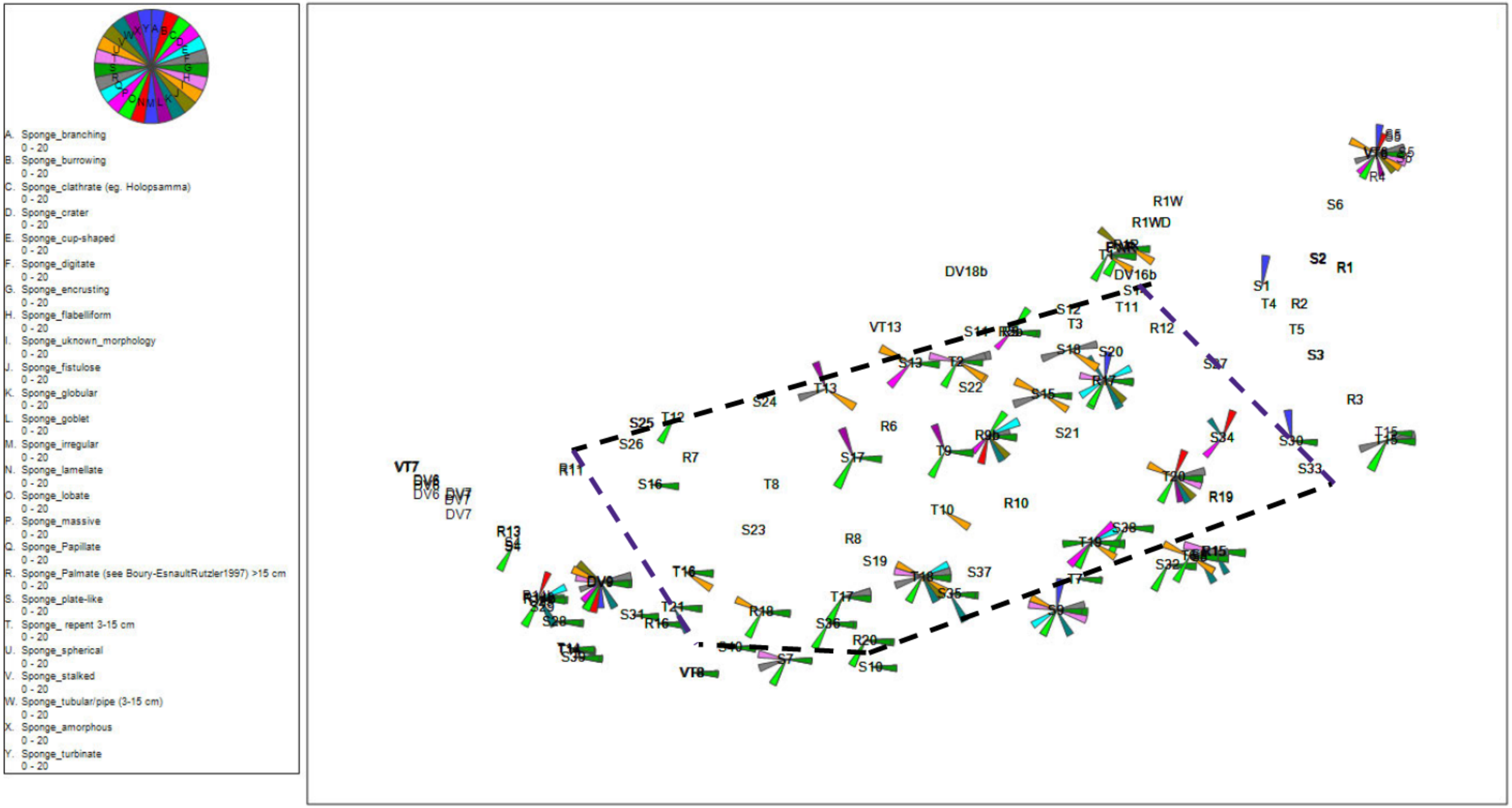

Figure 3-6: Spatial distribution of sponges across the Study Area from survey 1. Higher morphological diversities are indicative of reef areas. Dotted line = OWFA.

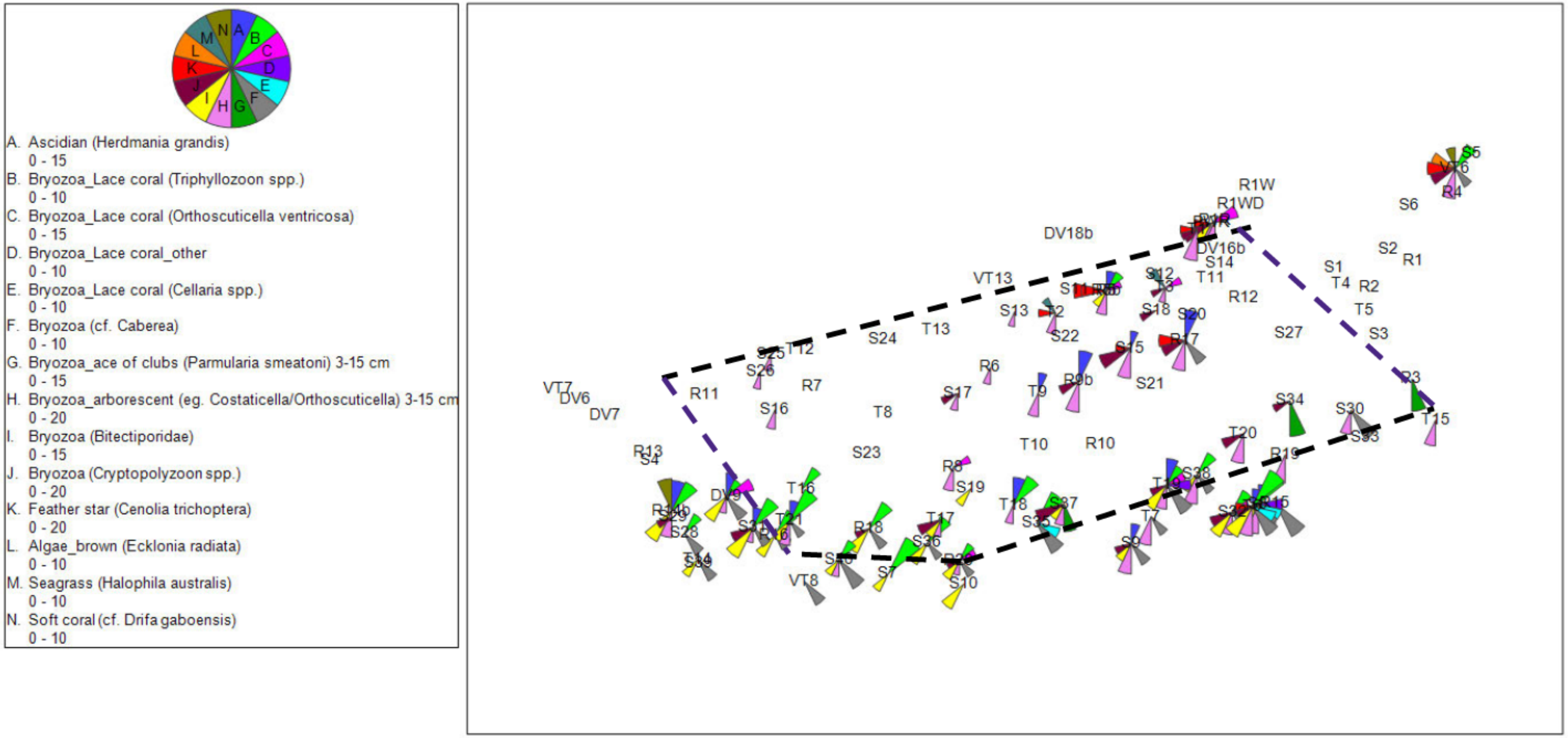

Figure 3-7: Spatial distribution of the ascidian *Herdmania grandis*, bryozoans, the feather star *Ceniola trichoptera*, the brown algae *Ecklonia radiata*, the seagrass *Halophila australis* and the soft coral *Drifa gaboensis* from survey 1 across the Study Area. Dotted line = OWFA.

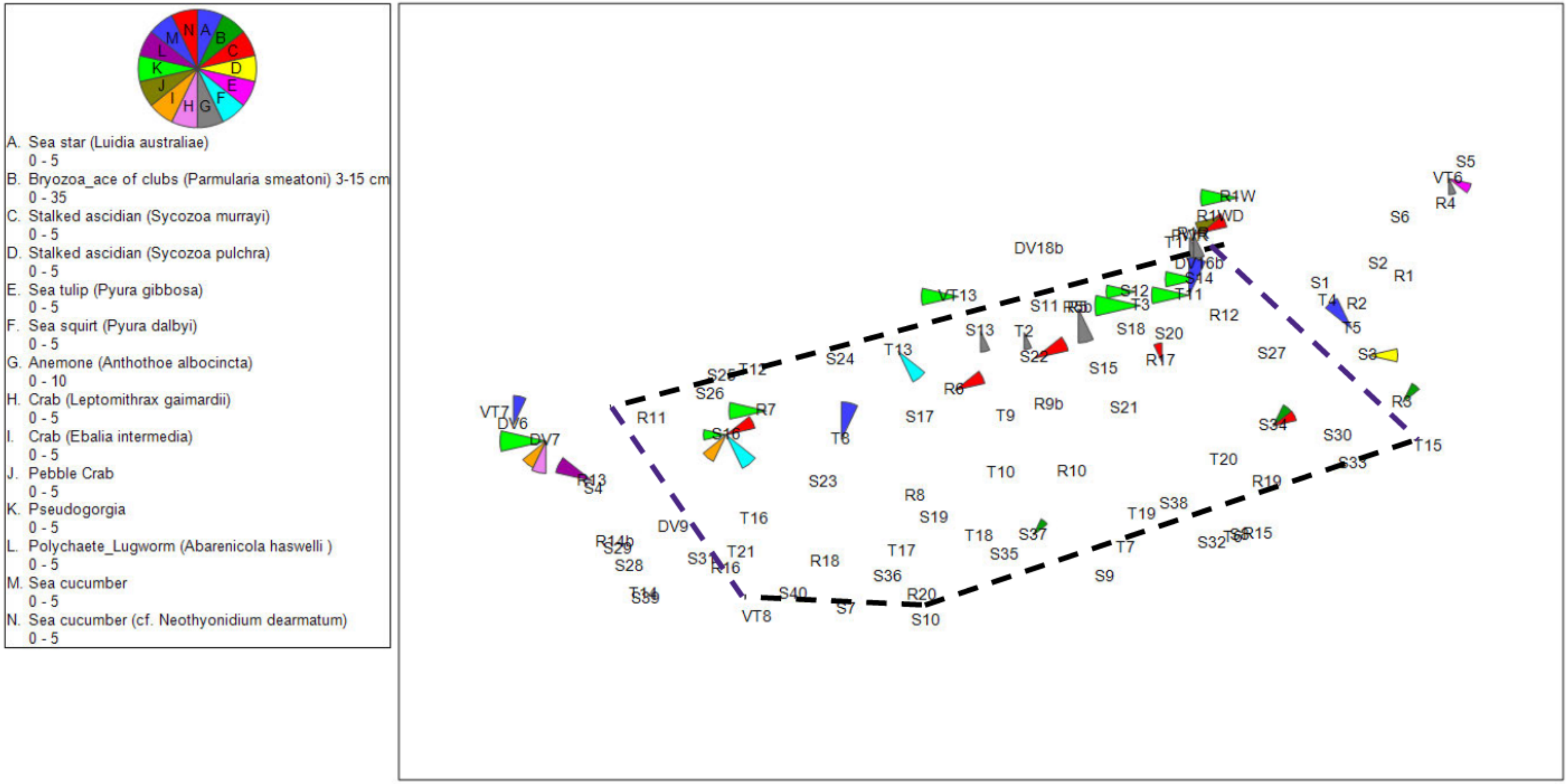

Figure 3-8: Spatial distribution of survey 1 biota associated with shallower sandy habitat across the Study Area. Dotted line = OWFA.

3.1.3 Spatial variability along and between transects

Survey 1 and survey 2 collected data from a total of 29 transects. Survey 1 included 21 transects, each 500 m long. There were six transects in the OECC (T1, T2, T3, T11, T12, T13), 8 in the OWFA (T8, T9, T10, T16, T17, T18, T19, T20) and 6 transects outside the Project Area (T4, T5, T6, T7, T14, T15 and T16).

Survey 2 included eight transects, each 2 kilometres long, all were within the OECC. Habitat (seabed type) data from each transect are included in Table 3-4. The table shows the percentage of images classified as each major seabed habitat type. Sites are ordered according to their depth range.

Mixed coarse sediment was the most common seabed type (34% of images), followed by sand (31%), coarse sediment (27%). Reef was the least common, occurring in less than 7% of images on average.

The data in Table 3-4 shows some clear patterns in the distribution of the main habitat types. Sand occurred in depths of 15 to 35 m and was the dominant seabed type along transects in the 15-20 m depth range and on some deeper transects. Coarse sediment (namely sand with shell fragments and gravel) was the dominant seabed type along transects in the 20-25 m depth range. Mixed coarse sediment, which comprised variable amounts of bivalve and gastropod shell, gravel, cobble and rhodolith, was dominant in areas over 30 m deep. Reef occurred mostly on transects less than 25 m deep, most commonly in the 20-25 m depth range, and was patchy. Reef was rare (mostly absent) beyond 30 m depth.

Most transects included three different habitat types, though transects beyond 30 m depth tended to have more homogeneous seabed (1 or occasionally 2 seabed types per transect).

Table 3-4. Seabed habitat types along transects – per cent images

Site Name	Depth	Sand	Coarse sediment	Mixed coarse sediment*	Reef
Average	-	31.0	27.3	34.8	6.9
CC-03	15-20 m	95.1	0.0	0.0	4.9
CC-05	15-20 m	20.8	64.2	0.0	15.1
CC-06	15-20 m	91.5	0.0	0.0	8.5
CC-07	15-20 m	97.7	2.3	0.0	0.0
T01	15-20 m	81.6	0.0	2.6	15.8
CC-01	20-25 m	100.0	0.0	0.0	0.0
CC-02	20-25 m	6.0	59.7	0.0	34.3
CC-04	20-25 m	8.3	75.0	0.0	16.7
CC-08	20-25 m	7.8	70.6	0.0	21.6
T02	20-25 m	0.0	40.8	55.1	4.1
T03	20-25 m	88.2	0.0	0.0	11.8
T08	20-25 m	100.0	0.0	0.0	0.0
T09	20-25 m	0.0	7.2	31.9	60.9
T10	20-25 m	0.0	100.0	0.0	0.0
T11	20-25 m	0.0	100.0	0.0	0.0
T12	20-25 m	17.3	42.3	40.4	0.0
T13	20-25 m	0.0	79.6	20.4	0.0
T04	25-30 m	83.7	16.3	0.0	0.0
T05	25-30 m	100.0	0.0	0.0	0.0
T16	30-35 m	0.0	0.0	100.0	0.0
T18	30-35 m	0.0	7.1	92.9	0.0
T20	30-35 m	0.0	8.3	88.3	3.3
T07	35-40 m	0.0	0.0	100.0	0.0
T17	35-40 m	0.0	0.0	100.0	0.0
T19	35-40 m	0.0	23.1	76.9	0.0
T21	35-40	0.0	0.0	100.0	0.0
T06	40-45 m	0.0	0.0	97.2	2.8
T14	40-45 m	0.0	0.0	100.0	0.0
T15	40-45 m	0.0	0.0	100.0	0.0

*This category comprises sand with a large portion of unconsolidated hard subtrates such as bivalve and gastropod shell, gravel, cobble/rubble and rhodolith

3.2 Grab sampling

Grab samples were recovered from 59 of the 60 planned sites in water depths ranging from 19 m to 50 m below sea level. Eighty samples were collected for chemical analysis (total organic carbon, total phosphorus, metals and metalloids). Ninety-six samples were collected for particle size distribution analysis.

3.2.1 Sediment quality

Sediment quality results are shown in **Error! Reference source not found.** with summary statistics provided below in Table 3-5.

Nutrients

Total phosphorus concentrations ranged from 95 mg P/kg to 1,270 mg P/kg with a median of 274 mg P/kg. (Table 3-5). Total phosphorus concentrations were highest in the deeper southwest portion of the study area (low bedshear, less winnowing) and lowest in the shallower northeast portion (higher bedshear).

Total organic carbon (TOC) concentrations were low and exhibited limited variation, ranging from 0.03% to 0.3%. Patterns in total organic carbon concentrations were similar to those for total phosphorus, being higher in the deeper southwest parts of the study area where bedshear and winnowing of sediments is lower .

Metals and metalloids

Maximum concentrations of metals were below ANZG (2018) default guideline values for all metals for which guidelines are available, with the exception of arsenic. One sample returned a zinc concentration of 512 mg/kg which was attributed to contamination by a flake of galvanising from the grab, with the replicate sample from that site having a low zinc concentration of 1.3 mg/kg.

Median arsenic concentration was 16.9 mg/kg, while the 80th percentile was 25.32 mg/kg, higher than the default guideline value (20 mg/kg) but well below the high guideline value (70 mg/kg). Total arsenic concentrations above the guideline value were recorded in 28 of the 80 samples, with these samples distributed across 22 of the 58 sites sampled. Arsenic concentrations correlated strongly with with iron (r^2 of 0.67) and manganese (r^2 of 0.61) and weakly with total phosphorus (r^2 of 0.16).

Table 3-5: Sediment quality concentrations in Project Area grab samples (n=80)

Parameter	Units	LoR	DGV	GV-high	Min	Median	80th percentile	Max
TP as P	mg/kg	2	N/A	N/A	95	274	437.6	1270
TOC	%	0.02	N/A	N/A	0.03	0.1	0.18	0.3
Al	mg/kg	50	N/A	N/A	340	595	992	1430
Sb	mg/kg	0.5	2	25	0.5	0.5	0.5	0.51
As	mg/kg	1	20	70	6.23	16.9	25.32	38.6
Cd	mg/kg	0.1	1.5	10	0.1	0.1	0.1	0.1
Cr	mg/kg	1	80	370	3.1	7.3	9.42	13
Cu	mg/kg	1	65	270	1	1	1	1.3
Co	mg/kg	0.5	N/A	N/A	0.5	0.5	0.5	0.6
Fe	mg/kg	50	N/A	N/A	2080	5270	7466	13900
Pb	mg/kg	1	50	220	1	1.2	1.8	7.6
Mn	mg/kg	10	N/A	N/A	12	32.5	41	79
Hg	mg/kg	0.01	0.15	1	0.01	0.01	0.01	0.01
Ni	mg/kg	1	21	52	1	1	1.5	2.5
Se	mg/kg	0.1	N/A	N/A	0.1	0.1	0.12	0.2
Ag	mg/kg	0.1	1	4	0.1	0.1	0.1	0.1
V	mg/kg	2	N/A	N/A	6.6	19.9	27.9	47.6
Zn	mg/kg	1	200	410	1	1.7	2.8	512

LoR = Limit of reporting

DGV = Default guideline value below which there is a low risk of unacceptable ecotoxicological effects occurring

GV-High = Upper guideline value, above which there is a high probability of adverse ecotoxicity effects

3.2.2 Particle size distributions

Laboratory particle size data can be found in **Error! Reference source not found.**. Data were square-root transformed and a resemblance matrix generated based on Euclidean distance. Cluster analysis with SIMPROF was used to identify unique groups of samples. PERMANOVA+ was undertaken to determine the significance of PSD SIMPROF groupings (Pseudo-F = 3.4105, P(perm) = 0.001). To facilitate spatial patterns in the sample distributions, higher-level groups were also identified from the survey data (Table 3-6). Identification of the spatial distributions of significant particle size groupings was required to allow direct comparison with spatial distributions of biota at a range of spatial scales for the purposes of identifying and characterising biotopes and potentially the spatial boundaries of different biotopes.

Sediments ranged from clean, moderately well sorted sand (group A) to very poorly sorted mixed sediment (eg group H). The spatial interpretation of these higher level groupings is presented in Figure 3-9, which is required for understanding baseline heterogeneity in particle size distributions across the Study Area. These groups were also found to be significant (PERMANOVA+ Pseudo-F = 7.0848, P(perm) = 0.001).

Table 3-6: Clay, silt, sand and gravel composition of particle size groups

Group	n	% Clay <0.004 mm	% Silt 0.004-0.063 mm	% Sand 0.063-4 mm	% Gravel 4-64 mm	Sorting
A	20	0.00 ± 0.00	0.08 ± 0.22	99.31 ± 1.91	0.61 ± 1.75	Moderately well sorted
B	1	0.04 ± 0.04	1.40 ± 1.40	73.56 ± 73.56	25.01 ± 25.01	Very poorly sorted
C	8	0.00 ± 0.00	0.99 ± 0.23	94.63 ± 3.51	4.38 ± 3.41	Poorly sorted
D	10	0.08 ± 0.14	1.52 ± 1.29	91.82 ± 2.62	6.58 ± 2.24	Poorly sorted
E	22	0.83 ± 0.37	5.57 ± 1.78	86.77 ± 5.4	6.83 ± 4.36	Poorly to very poorly sorted
F	12	0.00 ± 0.00	0.47 ± 0.63	97.75 ± 1.59	1.78 ± 1.24	Moderately to poorly sorted
G	17	0.06 ± 0.13	1.58 ± 1.20	93.87 ± 3.16	4.48 ± 2.75	Poorly sorted
H	6	0.61 ± 0.58	3.81 ± 2.76	72.78 ± 6.74	22.79 ± 6.82	Very poorly sorted

Folk sediment classifications of sediment samples are presented in Figure 3-10 to inform habitat classification and broad-scale mapping, and to allow direct comparison with historic datasets (where available). These figures show a similar pattern of fine sands in the north-east of the Study Area, transitioning to coarser, gravelly sands and sandy gravels in the south-west. They also show the within-site heterogeneity of sediment types at a number of sampling locations.

A principal component analysis (PCA) plot was prepared to show the relative effect of different particle size classes on the distribution of samples in the figure (labelled by high-level sediment descriptions in Figure 3-11). The PCA plot showed that the 0.125 mm (fine sand), 0.25 mm (medium sand) and 0.5 mm sediment size classes (coarse sand) had the greatest effect on relative distributions. For example, the transition from very coarse sand to coarse sand to medium sand followed the trajectory of the 0.25 mm vector. Sand was the dominant particle size in all groups (over 70 per cent).

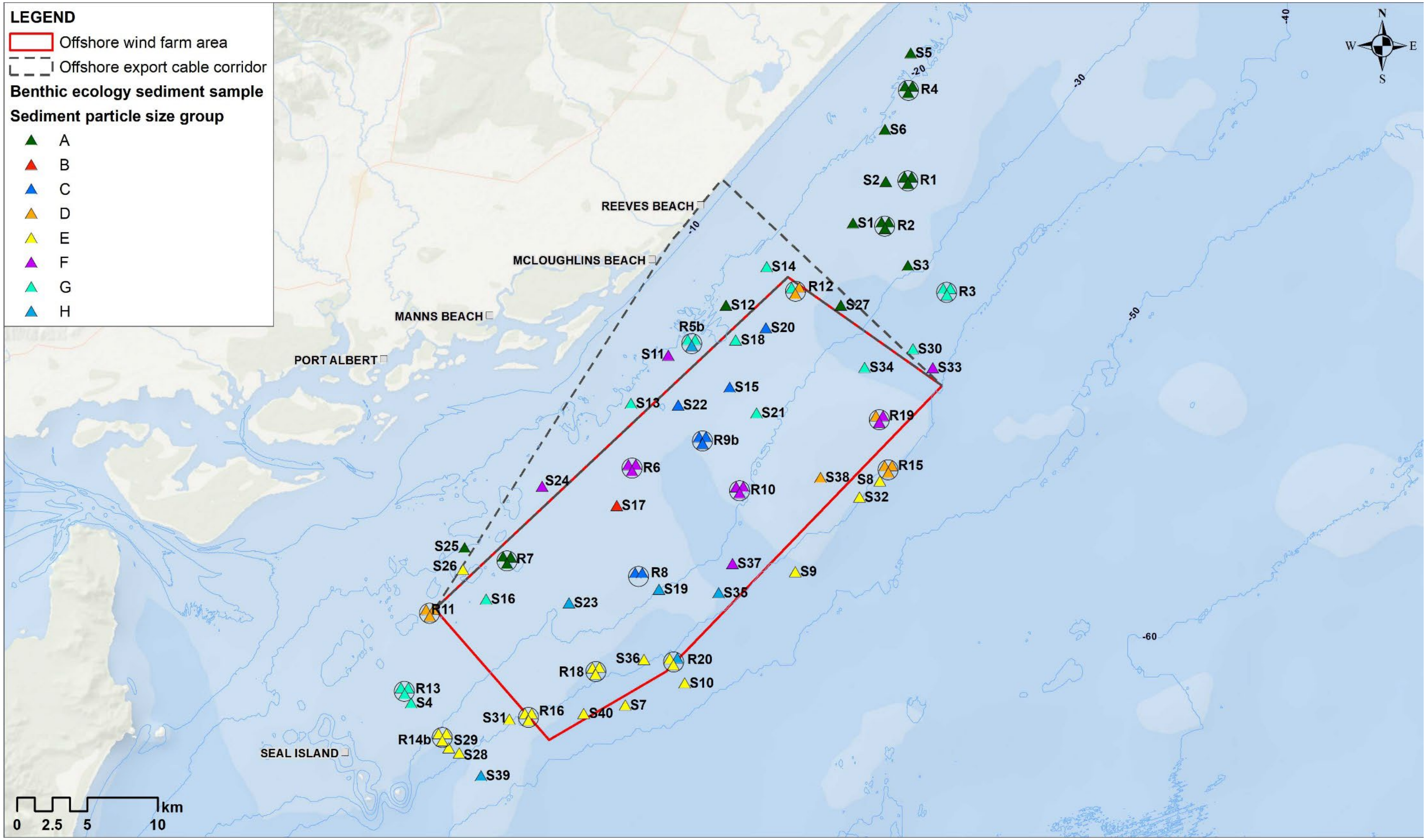

Figure 3-9: Sediment groupings based on grab sample PSD data. Circles around samples identify replicates collected at a single site (see Table 3-6).

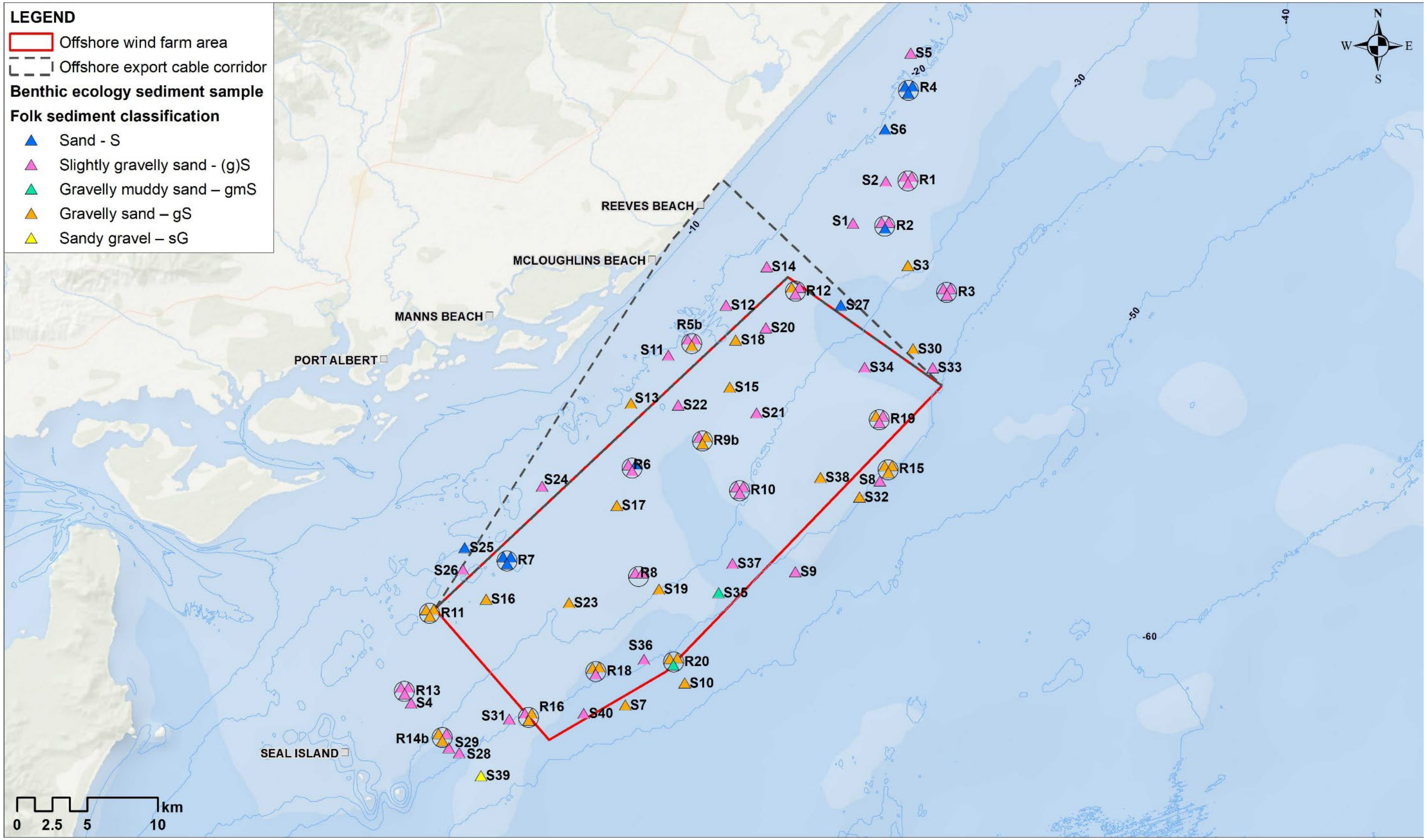

Figure 3-10: Folk sediment classifications of sediment particle size samples

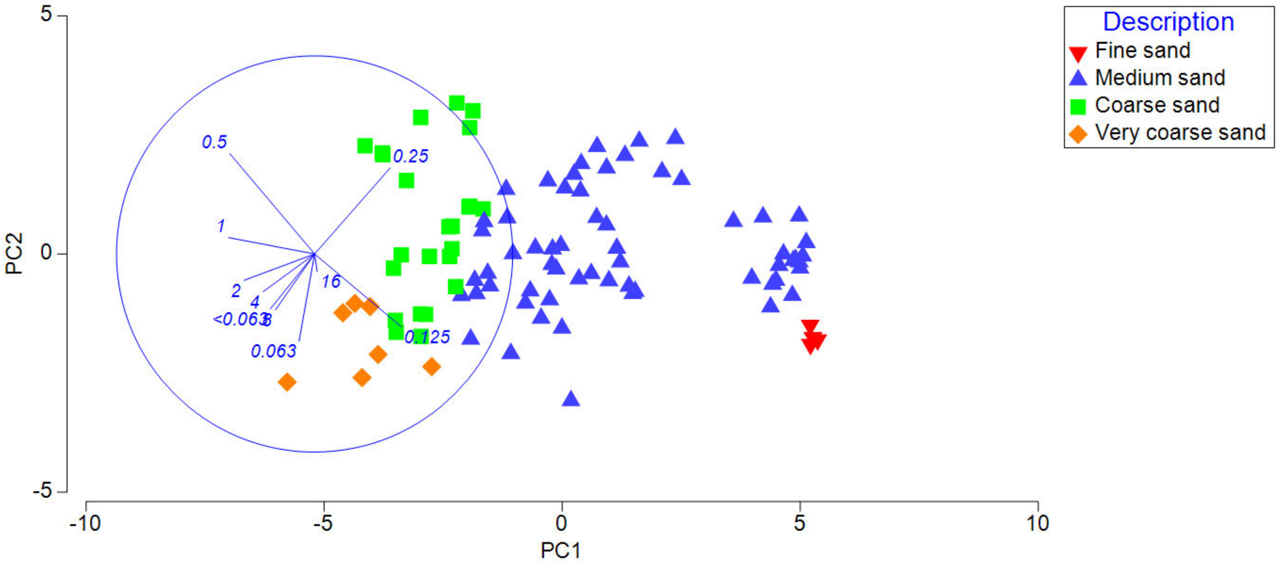

Figure 3-11: PCA plot of grab sample PSD data

3.2.3 Infauna

A total of 18,690 individuals representing 236 taxa were recorded from a total of 135 samples (=13.5 m^2 sampled area). The infauna across the Study Area comprised 82 molluscan taxa (OTUs), 77 arthropods, 53 annelids, 16 echinoderms, 2 cnidarians, and one taxon each of brachiopods, chordates, nematodes, nemerteans, phoronids, platyhelminths and sipunculans. Arthropoda (crustaceans) comprised 59 per cent of total infauna, annelida 31 per cent, molluscs 5.3 per cent, nematodes 2.2 per cent, echinoderms 1.1 percent. All other phyla comprised less than 1 per cent of the infauna. Over half (52 per cent) of the infauna collected came from just 11 taxa and one third of the infauna came from just four taxa. Corophiidae amphipods comprised 14 per cent of the infauna, Prionospio spp. (spionid worms) 9 per cent, Apseudomorpha (tanaid ampipods) 7 per cent and Paraonidae worms 4 per cent.

No FFG Act or EPBC Act listed species were identified in the infauna samples.

A species accumulation curve (Figure 3-12) shows that the curve flattened and tended towards a consistent gradient after around 50 samples and 190 taxa had been detected, with only 46 more taxa added by the remaining 35 samples. Further sampling would have detected only a small number of additional infauna taxa.

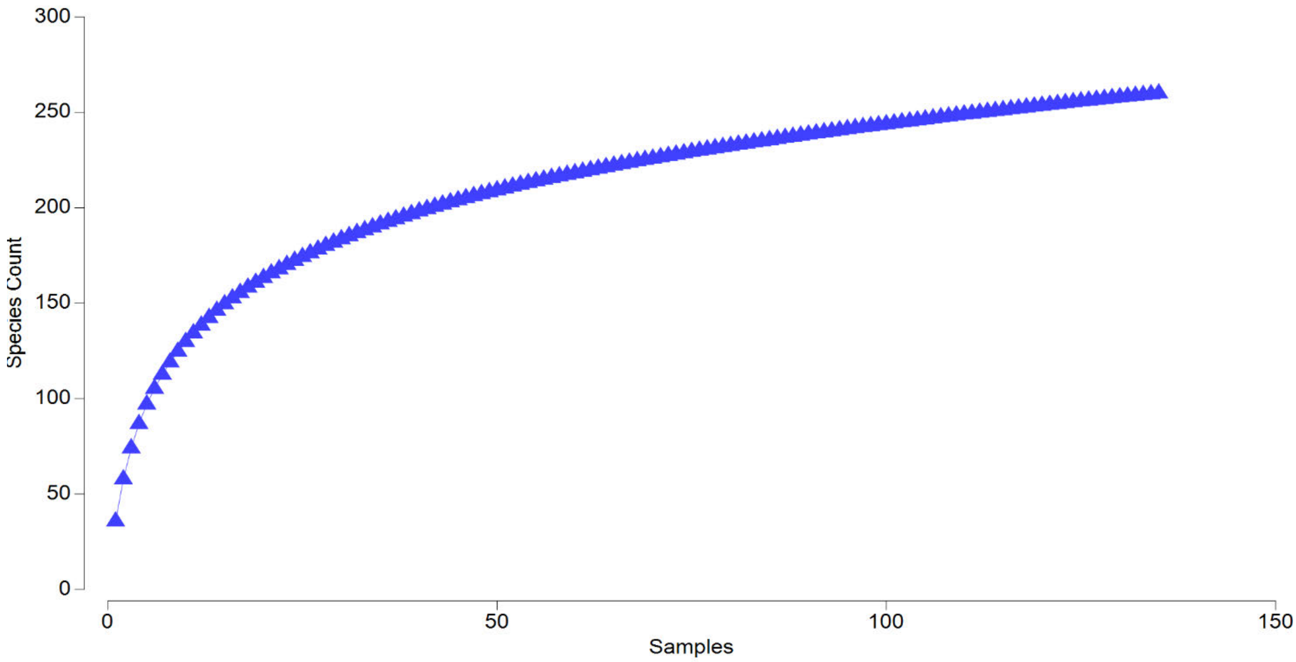

Figure 3-12: Species accumulation curve of cumulative species richness for a single infauna sample from all grab sample sites (N = 135), from 1000 random iterations.

The DIVERSE routine in PRIMER was used to calculate the total number of species (S), abundance (N), species richness (Margalef's d), Pielou's evenness (J'), Shannon-Weiner diversity (H') and Simpson's diversity (1-λ) for each infaunal sample (Clarke and Gorley 2015).

Infauna data were fourth root transformed, and a resemblance matrix generated using Bray-Curtis similarity. Cluster analysis with SIMPROF identified 31 groupings in the data. These groupings were tested using PERMANOVA+ and found to be statistically significant (Pseudo-F = 5.1621, P(perm) = 0.001). To facilitate the interpretation of patterns in spatial distributions when mapped, twelve broader groupings (A to L) were identified from higher branches in the cluster diagram (Table 3-7, Figure 3-13). These groupings were also found to be significantly different (Pseudo-F 7.3345, P(perm) = 0.001), and there were clear spatial trends in the distribution of the groups across the Study Area. For example, group J was distributed across the full width of the area in water depths of >30 m below sea level, including in the OWFA and both Reference Zones. Similarly, group G was distributed across the full width of the area but in water depths of around 20 m below sea level.

Two of the main groups (groups D and L) were dominated by annelids (polychaete worms, with all other groups dominated by arthropods (crustaceans). 'Groups' A and B were excluded from this assessment as they were outliers, comprising only a single sample each.

The number and per cent of each phylum contributing to each group varied, with e.g. Arthropoda contributing between 50 and 80 per cent of characteristic taxa in a group. The total number of taxa and total number of phyla defined as being in the top 70 % of taxa characterising a group were illustrative of whether sample groups were either relatively depauperate, or relatively diverse:

- groups C, D, and E had between 5 and 8 characterising taxa, representing only two phyla
- groups H and L had between 9 and 11 characterising taxa, representing three phyla
- groups F and G had a moderate number of characterising taxa (12 and 8, respectively), but with a more diverse number of phyla represented (5 and 4 phyla, respectively)
- groups I, J and k had between 20 and 26 characterising taxa, representing 6, 4 and 5 phyla, respectively.

As illustrated in Table 3-7, the characteristic taxa vary between groups, which provide useful information on the type of habitat they represent. For example, the caprellidae (skeleton shrimp), which are identified as characteristic in groups H, J and K, inhabit epibiota that extend into the water column, such as hydroids and macroalgae. Nereidid polychaetes (e.g. group I), however, are characteristic of often mobile sand habitats. Urohaustoriid amphipods and the infaunal bivalve *Gari livida* (the purple sunset shell) are also found in sandy sediments (e.g. groups C, F, G and I). Fibulariid echinoderms (pea urchins, e.g. group L) live within coarse sand or gravelly sediments.

Table 3-7: Characteristic taxa of infaunal groups from grab sampling data. Groups shown comprise >1 image.

Sediment group	No. samples	Characterising taxa (top 70%)	Phylum	Family	Av. Abundance (ind./0.1 m^2)	Contribution to group (%)
C	3	Urohaustoriidae	Arthropoda	Urohaustoriidae	4.67	22.44
		Nemertea	Nemertea	N/A	2.33	18.49
Av. similarity = 43.33		Amaryllididae	Arthropoda	Amaryllididae	1.00	17.43
		Paranthuridae	Arthropoda	Paranthuridae	3.00	7.53
		Crangonidae	Arthropoda	Crangonidae	0.67	6.11
D	2	Birubius spp.	Arthropoda	Phoxocephalidae	4.00	12.19
		Cirratulidae	Annelida	Cirratulidae	4.00	10.25
Av. similarity = 47.20		Capitellidae	Annelida	Capitellidae	1.50	8.62
		Lumbrineridae	Annelida	Lumbrineridae	1.50	8.62
		Orbiniidae	Annelida	Orbiniidae	1.50	8.62
		Prionospio spp.	Annelida	Spionidae	1.50	8.62
		Syllidae B	Annelida	Syllidae	1.50	8.62
		Travisiidae	Annelida	Travisiidae	3.50	8.62
E	2	Prionospio spp.	Annelida	Spionidae	8.50	18.28
		Birubius spp.	Arthropoda	Phoxocephalidae	5.00	18.28
Av. similarity = 54.57		Corophiidae	Arthropoda	Corophiidae	2.00	14.54
		Cirratulidae	Annelida	Cirratulidae	1.50	12.23
		Platyischnopidae	Arthropoda	Platyischnopidae	1.00	12.23

Sediment group	No. samples	Characterising taxa (top 70%)	Phylum	Family	Av. Abundance (ind./0.1 m^2)	Contribution to group (%)
F	24	Prionospio spp.	Annelida	Spionidae	14.21	11.82
		Birubius spp.	Arthropoda	Phoxocephalidae	2.88	9.34
Av. similarity = 44.20		Corophiidae	Arthropoda	Corophiidae	14.25	8.48
		Nemertea	Nemertea	N/A	2.71	7.36
		Nematoda	Nematoda	N/A	3.63	6.69
		Cumacea A	Arthropoda	N/A	1.42	6.26
		Apseudomorpha spp.	Arthropoda	N/A	1.83	5.35
		Urohaustoriidae	Arthropoda	Urohaustoriidae	1.63	4.62
		Gari livida	Mollusca	Psammobiidae	1.33	3.46
		Paranthuridae	Arthropoda	Paranthuridae	2.13	2.97
		Cirratulidae	Annelida	Cirratulidae	1.17	2.93
		Syllidae A	Annelida	Syllidae	1.08	2.67
G	26	Urohaustoriidae	Arthropoda	Urohaustoriidae	5.31	12.83
		Gari livida	Mollusca	Psammobiidae	4.50	12.08
Av. similarity = 41.80		*Prionospio* spp.	Annelida	Spionidae	7.42	10.12
		Nemertea	Nemertea	N/A	1.54	8.81
		Paranthuridae	Arthropoda	Paranthuridae	2.31	8.56
		Birubius spp.	Arthropoda	Phoxocephalidae	2.00	8.42
		Corophiidae	Arthropoda	Corophiidae	2.77	6.28
		Platyischnopidae	Arthropoda	Platyischnopidae	2.04	5.40
H	2	Corophiidae	Arthropoda	Corophiidae	46.00	11.04
		Apseudomorpha spp.	Arthropoda	N/A	11.50	10.07
Av. similarity = 34.93		Cylindroleberidae	Arthropoda	Cylindroleberidae	38.00	9.45
		Syllidae A	Annelida	Syllidae	4.50	6.91
		Birubius spp.	Arthropoda	Phoxocephalidae	4.50	6.91
		Caprellidae	Arthropoda	Caprellidae	2.50	6.91
		Cumacea A	Arthropoda	N/A	4.50	6.91
		Phoronida	Phoronida	N/A	2.50	6.91
		Maldanidae	Annelida	Maldanidae	1.50	5.81
I	10	Corophiidae	Arthropoda	Corophiidae	35.20	6.80
		Nemertea	Nemertea	N/A	6.50	5.73
Av. similarity = 48.80		Apseudomorpha spp	Arthropoda	N/A	7.10	5.27
		Cirratulidae	Annelida	Cirratulidae	4.50	5.24
		Prionospio spp.	Annelida	Spionidae	9.10	4.98
		Birubius spp.	Arthropoda	Phoxocephalidae	3.50	4.74
		Nematoda	Nematoda	N/A	7.20	4.72
		Tanaidomorpha spp.	Arthropoda	N/A	17.40	4.35
		Cumacea A	Arthropoda	N/A	4.60	3.95
		Platyischnopidae	Arthropoda	Platyischnopidae	4.30	3.63
		Pasiphaeidae	Arthropoda	Pasiphaeidae	1.40	2.59
		Capitellidae	Annelida	Capitellidae	1.70	2.25
		Urohaustoriidae	Arthropoda	Urohaustoriidae	2.40	2.23
		Flabelligeridae	Annelida	Flabelligeridae	1.90	2.10
		Liljeborgiidae	Arthropoda	Liljeborgiidae	1.30	2.09
		Phoronida	Phoronida	N/A	1.50	2.03
		Ampeliscidae	Arthropoda	Ampeliscidae	2.00	2.00
		Anomura	Arthropoda	N/A	1.20	1.93
		Gari livida	Mollusca	Psammobiidae	1.50	1.92
		Nereididae	Annelida	Nereididae	0.80	1.89

Sediment group	No. samples	Characterising taxa (top 70%)	Phylum	Family	Av. Abundance (ind./0.1 m^2)	Contribution to group (%)
J	40	Corophiidae	Arthropoda	Corophiidae	40.80	5.49
		Prionospio spp.	Annelida	Spionidae	19.33	4.89
Av. similarity = 52.31		Apseudomorpha spp.	Arthropoda	N/A	24.90	4.54
		Paraonidae	Annelida	Paraonidae	14.20	4.29
		Syllidae B	Annelida	Syllidae	6.60	3.44
		Nematoda	Nematoda	N/A	4.93	3.36
		Syllidae A	Annelida	Syllidae	7.43	3.06
		Tanaidomorpha spp.	Arthropoda	N/A	9.93	3.04
		Birubius spp.	Arthropoda	Phoxocephalidae	3.28	3.03
		Nemertea	Nemertea	N/A	6.23	3.00
		Sabellidae	Annelida	Sabellidae	5.55	2.81
		Ampeliscidae	Arthropoda	Ampeliscidae	4.13	2.70
		Melitidae	Arthropoda	Melitidae	4.05	2.68
		Caprellidae	Arthropoda	Caprellidae	7.33	2.58
		Paranthuridae	Arthropoda	Paranthuridae	2.65	2.35
		Dexaminidae	Arthropoda	Dexaminidae	3.98	2.26
		Tiron spp.	Arthropoda	Synopiidae	3.73	2.20
		Thelepodinae	Annelida	Terebellidae	3.75	2.12
		Amaryllididae	Arthropoda	Amaryllididae	4.05	2.02
		Cumacea A	Arthropoda	N/A	2.35	1.97
		Anomura	Arthropoda	N/A	2.58	1.93
		Capitellidae	Annelida	Capitellidae	2.38	1.66
		Orbiniidae	Annelida	Orbiniidae	1.63	1.57
		Podoceridae	Arthropoda	Podoceridae	3.73	1.53
		Synopia spp.	Arthropoda	Synopiidae	2.48	1.41
		Leptostraca spp.	Arthropoda	N/A	3.00	1.35

Sediment group	No. samples	Characterising taxa (top 70%)	Phylum	Family	Av. Abundance (ind./0.1 m^2)	Contribution to group (%)
K	13	Prionospio spp.	Annelida	Spionidae	18.31	5.18
		Corophiidae	Arthropoda	Corophiidae	7.31	4.89
Av. similarity = 52.24		Syllidae A	Annelida	Syllidae	9.38	4.87
		Amaryllididae	Arthropoda	Amaryllididae	7.38	4.36
		Nemertea	Nemertea	N/A	4.00	4.21
		Dexaminidae	Arthropoda	Dexaminidae	4.54	3.96
		Paraonidae	Annelida	Paraonidae	3.62	3.58
		Anomura	Arthropoda	N/A	5.08	3.51
		Melitidae	Arthropoda	Melitidae	5.31	3.35
		Syllidae B	Annelida	Syllidae	5.85	3.30
		Nematoda	Nematoda	N/A	2.00	3.22
		Galatheoidea	Arthropoda	N/A	12.92	3.12
		Isopoda spp.	Arthropoda	N/A	4.92	2.72
		Tanaidomorpha spp.	Arthropoda	N/A	2.31	2.29
		Stenetriidae	Arthropoda	Stenetriidae	5.00	2.10
		Leptostraca spp.	Arthropoda	N/A	1.46	2.09
		Apseudomorpha spp.	Arthropoda	N/A	3.23	2.03
		Platyhelminthes	Platyhelminthes	N/A	1.31	1.89
		Tiron spp.	Arthropoda	Synopiidae	1.92	1.71
		Caprellidae	Arthropoda	Caprellidae	17.00	1.71
		Sabellidae	Annelida	Sabellidae	1.38	1.64
		Liljeborgiidae	Arthropoda	Liljeborgiidae	3.08	1.55
		Hesionidae	Annelida	Hesionidae	1.46	1.54
		Capitellidae	Annelida	Capitellidae	1.23	1.53
L	11	Syllidae B	Annelida	Syllidae	3.27	12.06
		Onuphidae	Annelida	Onuphidae	3.91	10.01
Av. similarity = 40.54		Prionospio spp.	Annelida	Spionidae	1.55	7.32
		Syllidae A	Annelida	Syllidae	2.00	7.19
		Gnathiidae	Arthropoda	Gnathiidae	1.82	7.18
		Corophiidae	Arthropoda	Corophiidae	0.91	6.83
		Cirratulidae	Annelida	Cirratulidae	1.18	5.10
		Glyceridae	Annelida	Glyceridae	1.45	4.19
		Melitidae	Arthropoda	Melitidae	0.91	4.18
		Fibulariidae	Echinodermata	Fibulariidae	1.27	3.06
		Oweniidae	Annelida	Oweniidae	1.09	3.04

The total number of individuals per Phylum for each of the twelve groupings is presented in Table 3-8. Arthropoda (which includes crustaceans and pycnogonids) was the dominant phylum in eight of the twelve groups, and most abundant phylum overall (with 11,042 individuals, or 59.1 per cent of the total number of individuals identified). Annelids (polychaete worms) were the most abundant phylum in three of the twelve groups, second most abundant in eight of the twelve groups, and second most abundant overall (with 5,793 individuals, or 31.1 per cent of total individuals). The third most abundant phylum was the mollusca, with a total of 999 individuals (5.3 per cent of total individuals).

The number of samples per grouping has also been included in the table to allow a relative assessment of the total number of individuals per grouping against the number of samples. For example, 10,499 individuals (56.2 per cent of the total individuals recorded) were identified from 40 samples in group J (29.6 per cent of the total number of samples). This allowed determination of whether the biological assemblage of each grouping were likely to be sparse (ie lower % of total individuals than % of total samples in group) or abundant. Table 3-8 also provides an estimate of the number of individuals per square metre of sea bed, to allow direct comparison with other studies and to support environmental impact assessment.

The mean, minimum and maximum value for each DIVERSE metric or index (S, N, d, J', H' and 1-λ) was then calculated for each of the twelve groups (A to L) derived from Cluster analysis (Table 3-9). Lowest species richness and diversity scores were recorded for group A (d = 1.4, J' = 1.0 and H' = 0.7), which consisted of a single sample (R13.5) with two individuals (N = 2) from two species (S = 2). With the exception of group A, mean Shannon-Weiner diversity scores were recorded within the range of 2.5 to 3.5. The greatest average number of taxa (S = 54), abundance (N = 268.8) species richness and diversity scores (d = 9.6, J' = 0.8 and H' = 3.2) were recorded from group J. The infaunal assemblages of groups A to L are discussed further in Section 3.6.2.

The mean (±SE) values for species richness (S), abundance (N), Margalef's species richness (d) and Shannon-Weiner diversity (H' (log^e)) were also calculated for each of the five SBRUVs broad habitat classifications (sand, sand with patchy epibiota, mixed sediments, pavement with veneer and reef) at each 1 m depth increment at which infaunal samples were collected (rounded down to the nearest metre). This approach was used to investigate trends in assemblages across broad habitat types represented broadly in the area (as identified in both the subsea video and SBRUVs datasets). The results are presented in Figure 3-14. Species richness, Margalef's species richness and Shannon-Weiner showed similar patterns with depth, with values increasing from 19 m below sea level to peak values at around 35-40 m, with a slower decline in values with increasing depth – though a decline was less clear for Shannon-Weiner diversity (Figures 3-11 A, C and D). Values tended to be higher in the 35 to 50 m depth range than the 19 to 35 m depth range. Values for each broad habitat type tended to roughly align with this distribution. Abundance (N) did not follow this basic pattern – values were generally much lower in the 19 to 35 m depth range than in water depths of >35 m, and an increase in abundance from 19 to 35 m was not evident. A steeper decline in abundance from 35 to 50 m water depth was also observed.

PERMANOVA also identified a significant difference in the infaunal assemblages between 5 m depth ranges over the 19 to 50 m depth range (ie <20 m, 20–24 m, 25–29 m, 30–34 m, 35–39 m, 40–44 m and >45 m; Pseudo-F = 6.5593, P(perm) = 0.001). Subsequent pairwise comparisons indicated that the 20–24 m and 25–29 m groups were the only groups significantly different (t = 1.6452, P(perm) = 0.003) from each other for depth ranges shallower than 35 m; all other comparisons between groups >35 m depth were significant. To facilitate interpretation, cluster analysis of average similarity between/within groups (an output from PERMANOVA pairwise comparison) is presented in Figure 3-15. This figure shows the two main clusters of infaunal assemblages from depths less than and greater than 35 m.

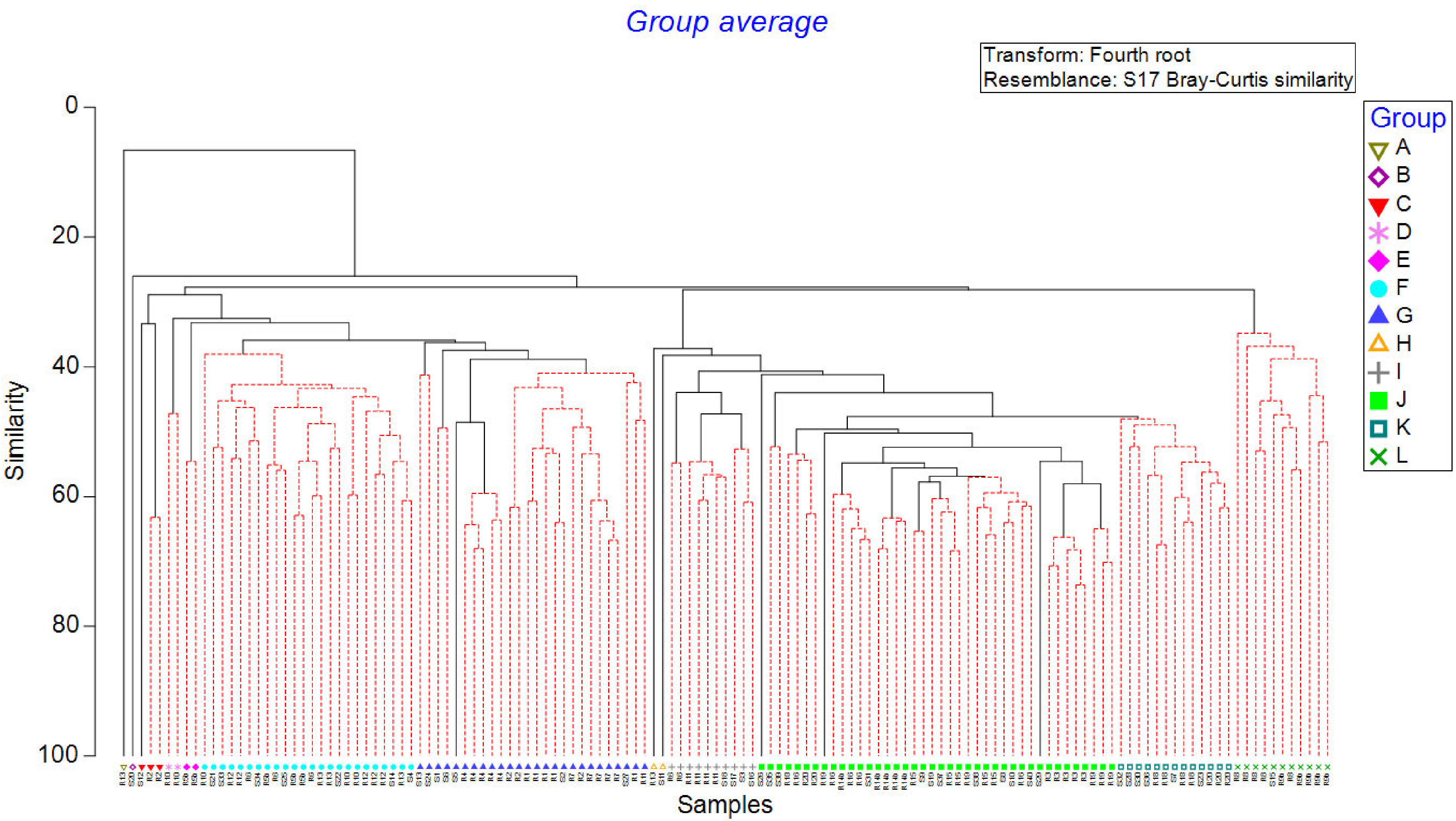

Figure 3-13: Cluster analysis of infauna data

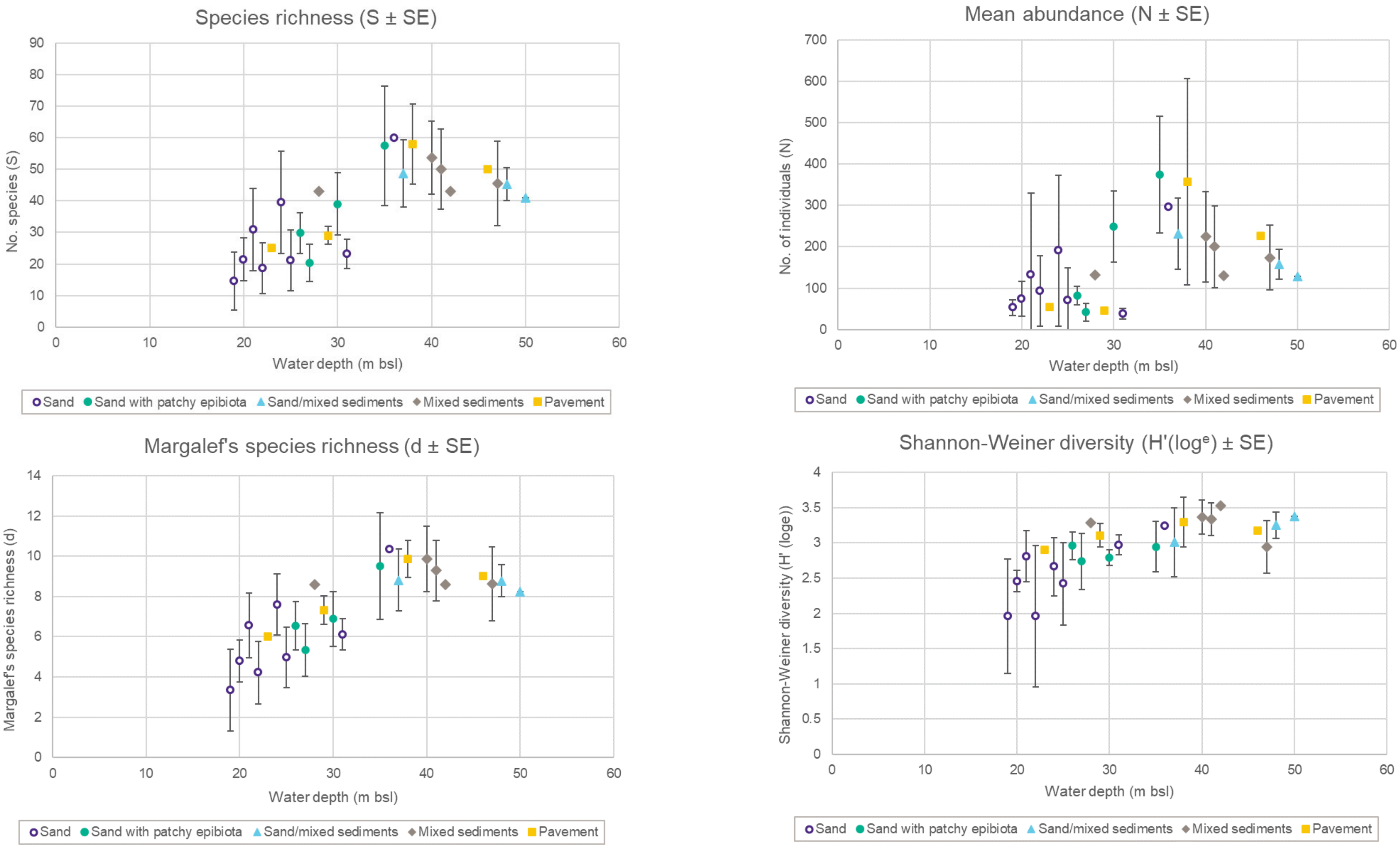

Figure 3-14: Mean ±SE species richness (A), abundance (B), Margalef's species richness (C) and Shannon-Weiner diversity (D) for broad habitat types by water depth (m bsl)

Table 3-8: Number of individuals per Phylum for each infaunal grouping

Phylum	A	B	C	D	E	F	G	H	I	J	K	L	Row total	% total no. of individuals
Annelida	0	23	10	36	23	612	400	111	357	3,261	732	228	5,793	31.0
Arthropoda	2	11	49	23	41	882	613	300	1,134	6,506	1,356	125	11,042	59.1
Sipuncula	0	0	0	1	0	13	5	2	1	24	6	1	53	0.3
Mollusca	0	21	0	5	1	92	323	11	107	373	51	15	999	5.3
Echinodermata	0	2	0	2	0	14	17	4	3	81	55	26	204	1.1
Phoronida	0	0	0	0	0	5	1	5	15	12	0	5	43	0.2
Platyhelminthes	0	0	0	0	0	1	0	0	0	19	17	0	37	0.2
Nematoda	0	2	2	1	0	87	13	5	72	197	26	8	413	2.2
Cnidaria	0	0	2	4	0	12	20	3	4	14	22	4	85	0.5
Brachiopoda	0	2	0	1	0	0	0	0	0	7	5	1	16	0.1
Chordata	0	0	0	0	0	0	0	0	0	5	0	0	5	0.0
Column total	2	61	63	73	65	1,718	1,392	441	1,693	10,499	2,270	413	18,690	
% total no. of individuals	0.0	0.3	0.3	0.4	0.3	9.2	7.4	2.4	9.1	56.2	12.1	2.2		
No. of samples	1	1	3	2	2	24	26	2	10	40	13	11	135	
% of total samples	0.7	0.7	2.2	1.5	1.5	17.8	19.3	1.5	7.4	29.6	9.6	8.1		
Mean no. individuals per sample	2.0	61.0	21.0	36.5	32.5	71.6	53.5	220.5	169.3	262.5	174.6	37.5		
Estimated no. of individuals per m^2 of seabed	**20**	**610**	**210**	**365**	**325**	**716**	**535**	**2205**	**1693**	**2,625**	**1,746**	**376**		

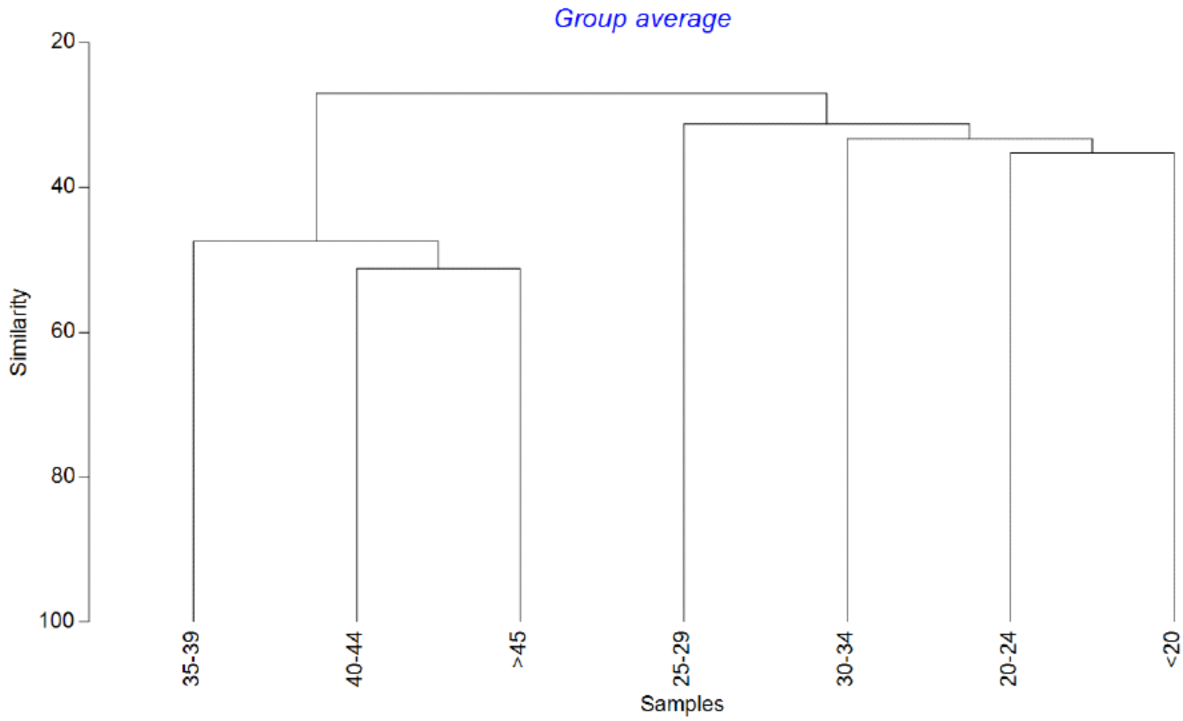

Figure 3-15: Cluster analysis of PERMANOVA similarity of infauna data between 5 m water depth ranges

Table 3-9: Species richness, abundance and diversity indices for high-level infauna groups

Grouping		S	N	Margalef's d	Pielou's J'	Shannon H'	Simpson's 1-λ
A (1 sample)		**2.0**	**2.0**	**1.4**	**1.0**	**0.7**	**1.0**
B (1 sample)		**28.0**	**62.0**	**6.5**	**0.9**	**3.0**	**0.9**
C (3 samples)	Max	12.0	33.0	3.8	0.9	2.3	0.9
	Average	**11.7**	**23.3**	**3.4**	**0.9**	**2.3**	**0.9**
	Min	11.0	18.0	3.1	0.9	2.2	0.9
D (2 samples)	Max	25.0	44.0	6.3	1.0	3.0	1.0
	Average	**22.5**	**36.5**	**6.0**	**0.9**	**2.9**	**1.0**
	Min	20.0	29.0	5.6	0.9	2.9	1.0
E (2 samples)	Max	13.0	39.0	3.7	0.9	2.4	0.9
	Average	**12.5**	**32.5**	**3.3**	**0.9**	**2.2**	**0.9**
	Min	12.0	26.0	3.0	0.9	2.1	0.9
F (24 samples)	Max	33.0	238.0	7.8	1.0	3.2	1.0
	Average	**24.3**	**74.3**	**5.6**	**0.8**	**2.6**	**0.9**
	Min	14.0	21.0	3.4	0.3	1.0	0.3
G (26 samples)	Max	30.0	185.0	6.4	1.0	3.0	1.0
	Average	**18.9**	**55.1**	**4.6**	**0.8**	**2.4**	**0.9**
	Min	8.0	20.0	1.9	0.3	0.8	0.3
H (2 samples)	Max	39.0	263.0	7.3	0.7	2.6	0.9
	Average	**38.0**	**221.0**	**6.9**	**0.7**	**2.5**	**0.8**
	Min	37.0	179.0	6.5	0.7	2.5	0.8
I (10 samples)	Max	51.0	319.0	8.7	0.9	3.2	1.0
	Average	**40.2**	**175.8**	**7.8**	**0.8**	**3.0**	**0.9**
	Min	31.0	63.0	5.9	0.6	2.4	0.8

Grouping		S	N	Margalef's d	Pielou's J'	Shannon H'	Simpson's 1-λ
J	Max	76.0	711.0	13.5	0.9	3.7	1.0
(40 samples)	Average	**54.0**	**268.8**	**9.6**	**0.8**	**3.2**	**0.9**
	Min	36.0	101.0	7.3	0.5	2.0	0.7
K	Max	2.0	2.0	1.4	1.0	0.7	1.0
(13 samples)	Average	**28.0**	**62.0**	**6.5**	**0.9**	**3.0**	**0.9**
	Min	12.0	33.0	3.8	0.9	2.3	0.9
L	Max	11.7	23.3	3.4	0.9	2.3	0.9
(11 samples)	Average	**11.0**	**18.0**	**3.1**	**0.9**	**2.2**	**0.9**
	Min	25.0	44.0	6.3	1.0	3.0	1.0

Spatial distributions of taxa commonly associated with sediments are presented in Figure 3-16. Assemblages characterised by *Gari* spp. and Urohaustoriidae (groups C, F, G and I) were associated with the sandy sediments in the northern, shallower sections of the Study Area (e.g. indicated by the yellow arrow in the figure). Infaunal assemblages characterised by Venerid bivalves were recorded in the south-west of the Study Area (blue arrow). Figure 3-17 shows diverse, mainly crustacean, infaunal assemblages associated with unconsolidated hard substrate habitat (mixed coarse sediments (shell) with rock pavement inferred beneath) and particulate sediments adjacent to reef habitat.

The samples from the 19 replicate sites were also analysed separately using Cluster analysis with SIMPROF to determine potential within- and between-site heterogeneity (Figure 3-18). All five infaunal samples were grouped together (ie infaunal assemblages were homogeneous) at 8 sites:

- R3 (fine sand habitat with shell with a water depth of 37 m)
- R4 (fine sand habitat with a water depth of 20 m)
- R6 (mixed sediment habitat with a water depth of 26 m)
- R7 (fine sand habitat with a water depth of 21 m)
- R8 (mixed sediment habitat with a water depth of 27 m)
- R9b (rock pavement with a sediment veneer, with a water depth of 27 m)
- R11 (coarse shelly sand with a water depth of 21 m)
- R15 (mixed sediment habitat with a water depth of 41 m).

Samples from seven sites (R1, R2, R5b, R12, R14b, R16 and R20) were split over two groups at each site, whereas four sites (R10, R13, R18 and R19) were the most heterogenous ('patchy') as the five replicate samples were distributed between three SIMPROF groups each.

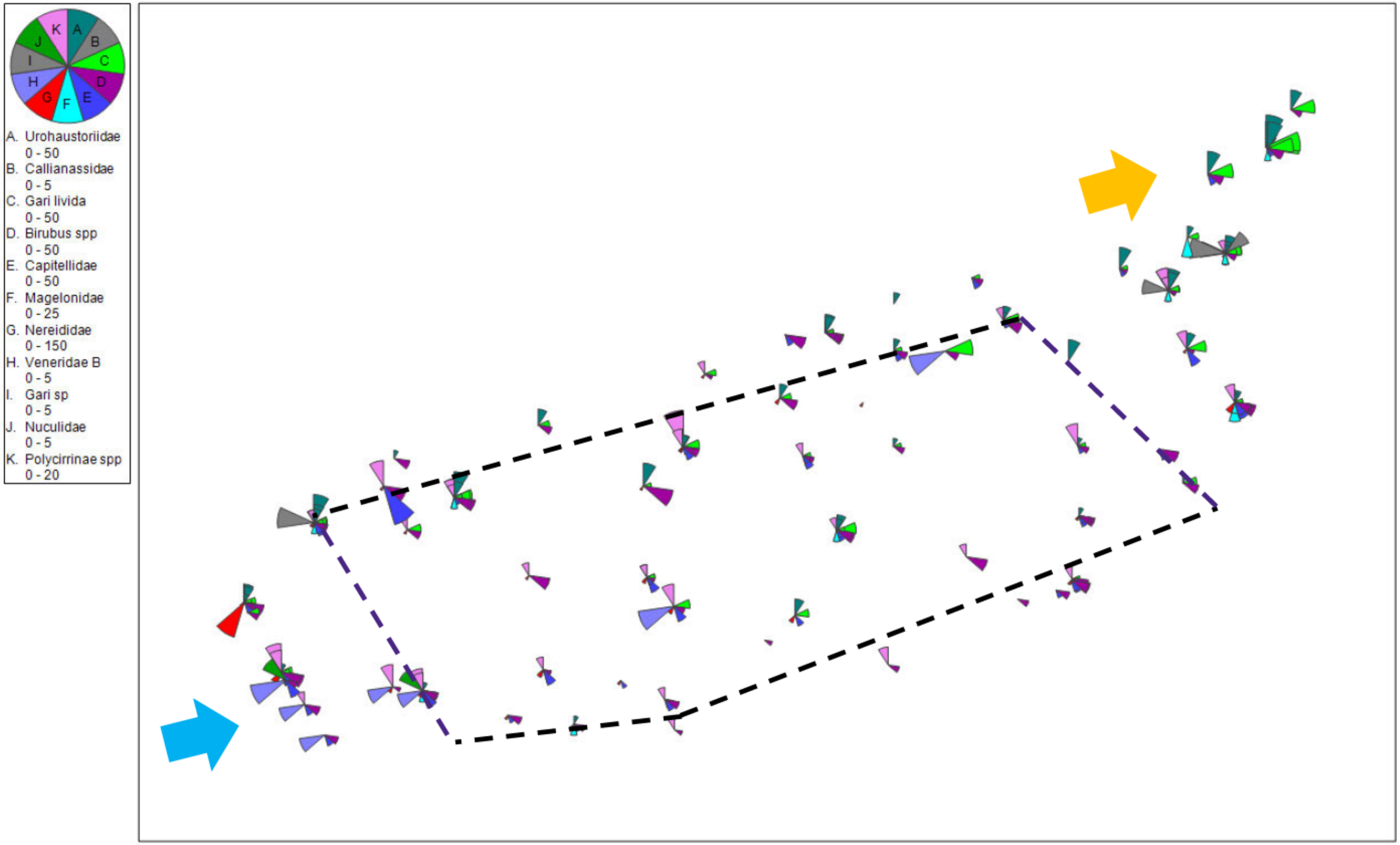

Figure 3-16: Example of spatial distributions of infauna taxa associated with areas of fine sands (orange arrow) and mixed coarse sediments (shell) with rock pavement inferred beneath (blue arrow). Dotted line = OWFA.

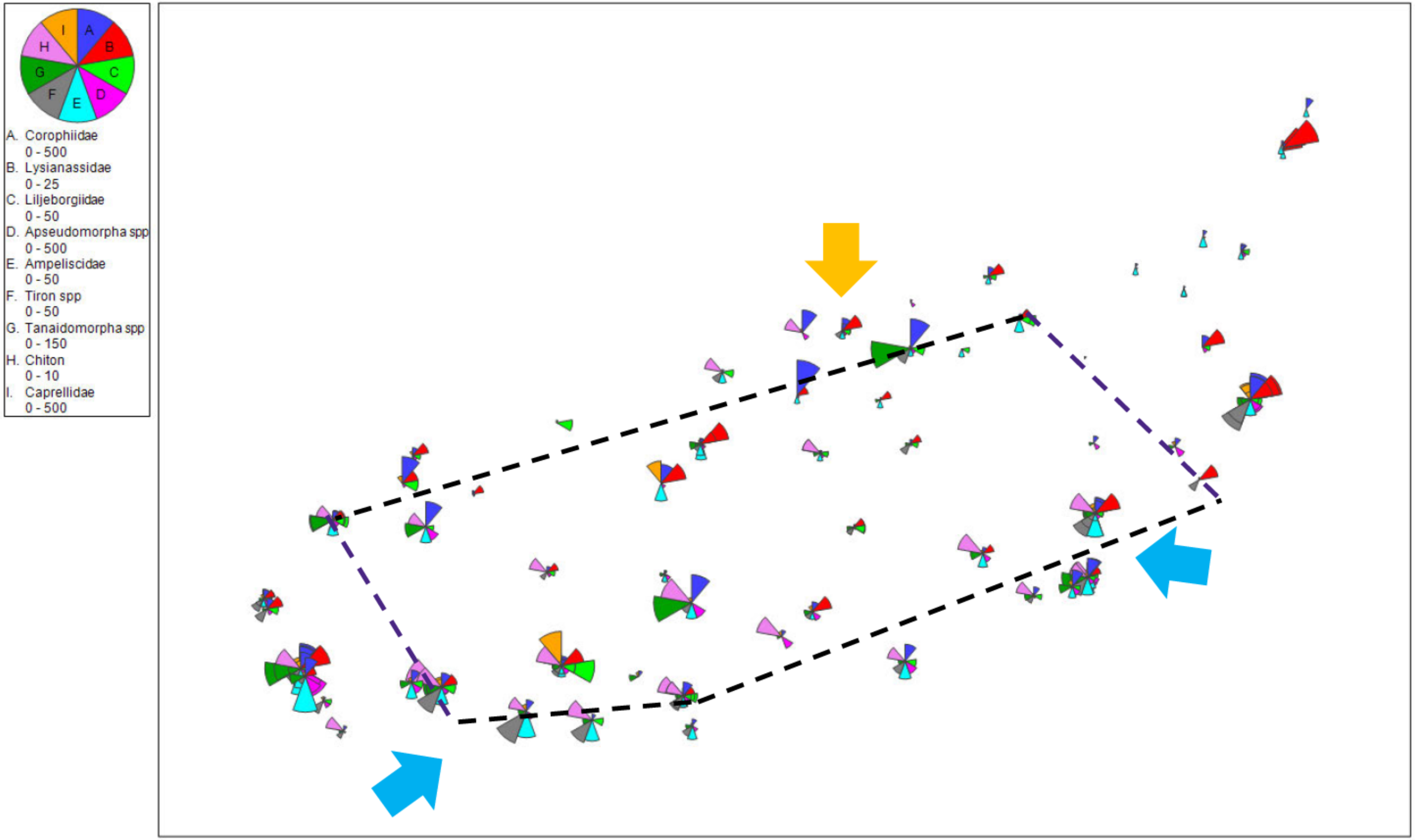

Figure 3-17: Examples of taxa associated with areas of patchy reef (orange arrow) and rock pavement with sediment veneers (blue arrows). Dotted line = OWFA.

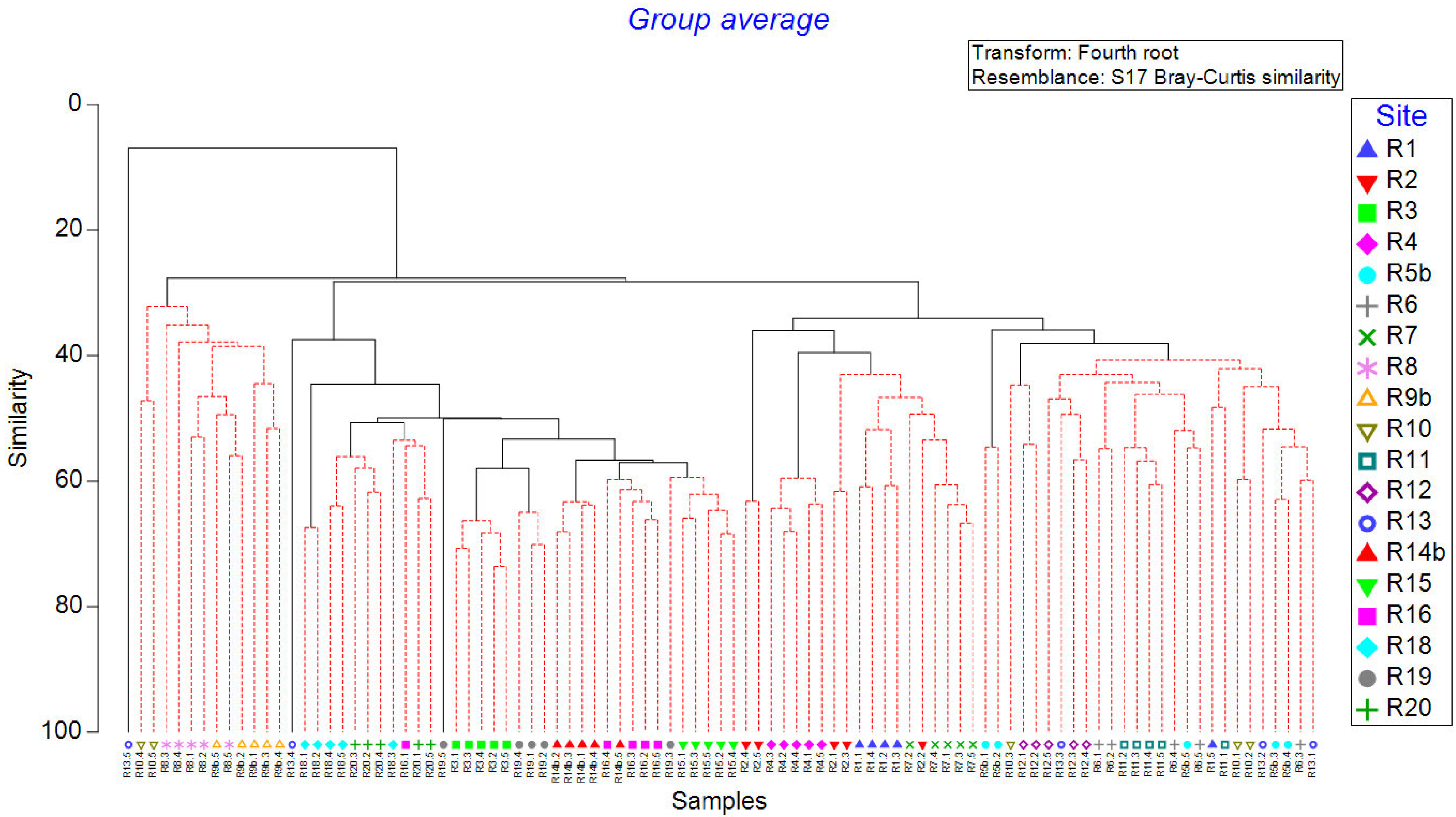

Figure 3-18: Cluster analysis with SIMPROF of infauna replicate site data

3.3 Analysis of SBRUVs imagery

3.3.1 SBRUVs surveys

The following five broad benthic habitat classes were defined from analysis of the SBRUVs imagery from summer data when ambient light was highest:

- sand – flat or mobile fine to coarse sand, with sparse or no conspicuous epibiota (Plate 3-8)
- mixed sediments – generally flat substrate comprising a range of different sediment grain sizes (sand, gravel, shell, pebbles, cobbles and occasionally boulders) (Plate 3-9)
- pavement with veneer – flat/low profile seabed comprising a veneer of sediment (much of which was mixed coarse sediment – shell, rubble) over an inferred hard layer (likely gravel, Fitzpatrick, 2022) and patchy epibiota (Plate 3-10).
- sand with patchy epibiota – discontinuous patches of large epibiota (seagrass, sponges, lace corals, large/foliose forms of bryozoa (eg Bitectiporidae), macroalgae, invertebrate complexes estimated to be >10 cm) interspersed by sandy sediment (excluding thin veneers). Examples of this habitat comprising large faunal assemblages (eg sponges, bryozoa, hydroids) were often observed surrounding reef habitat, and are likely to represent a transitional habitat between reef and adjacent substrate habitats (Plate 3-11)
- reef – emergent rock substrate or shell/rubble accumulations with high densities of diverse epibiota. Observed as low profile reef (< 0.5 m high) or higher profile reef (> 1 m high, often patchy with sediment patches) (Plate 3-12).

Each SBRUVs image from the summer survey was characterised by one of the five classes (Figure 3-19). Sand habitats were generally found broadly across the Study Area in shallower water depths (< 35 m), and most commonly at < 25 m (see Section 3.3.2). Mixed substrates were sparsely represented, with the only aggregation of sites occurring in the eastern side of the OWFA along the 35 m depth contour. Pavement with veneer was more broadly represented, generally occurring at water depths of > 25 m – noting that this habitat largely comprises mixed coarse sediments including hard shell/rubble in many places. Sand with patchy epibiota was relatively limited in its distribution, mainly occurring adjacent to reef or pavement with veneer habitat. Reef (including shell/rubble accumulations) with high densities of diverse epibiota occurred at 18 sites from the shallower to deeper portions of the site, mostly in the eastern part of the Study Area.

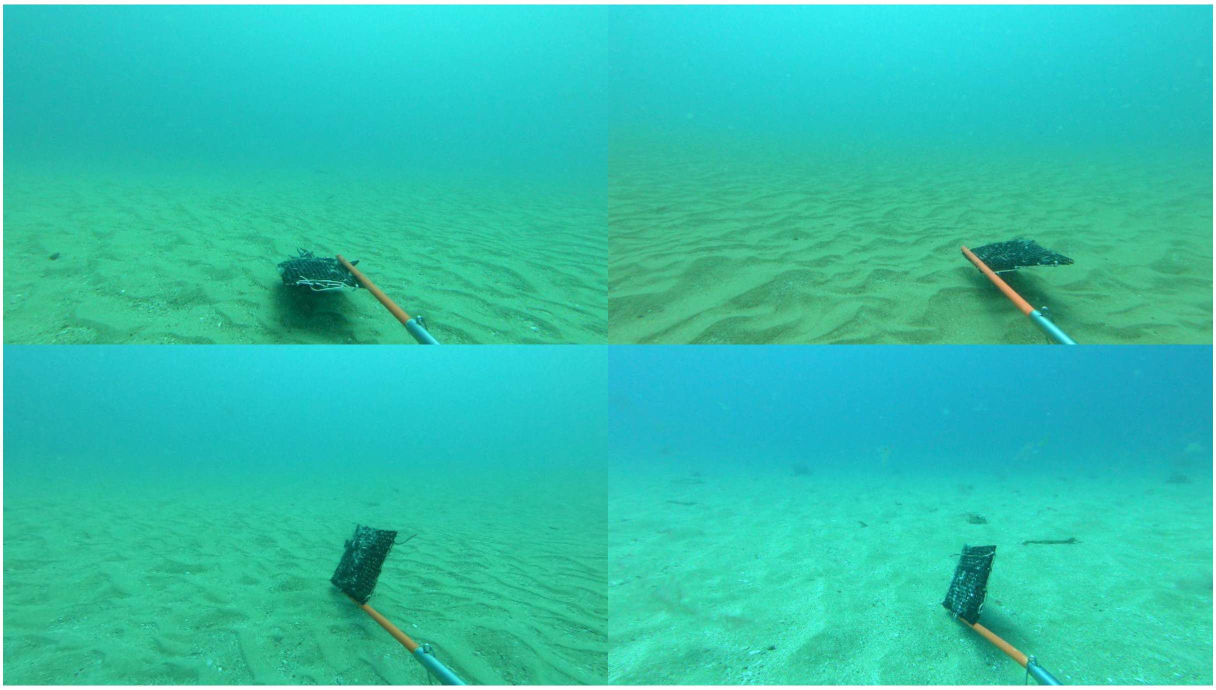

Plate 3-8: Sand

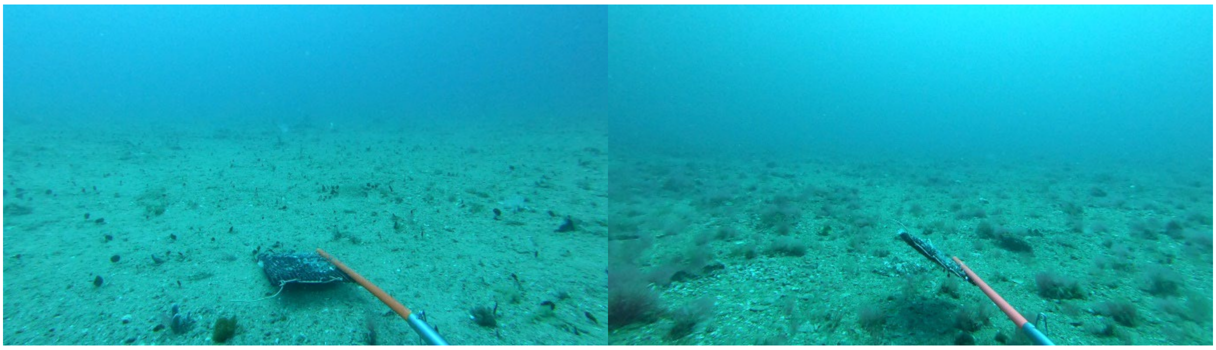

Plate 3-9: Mixed sediments

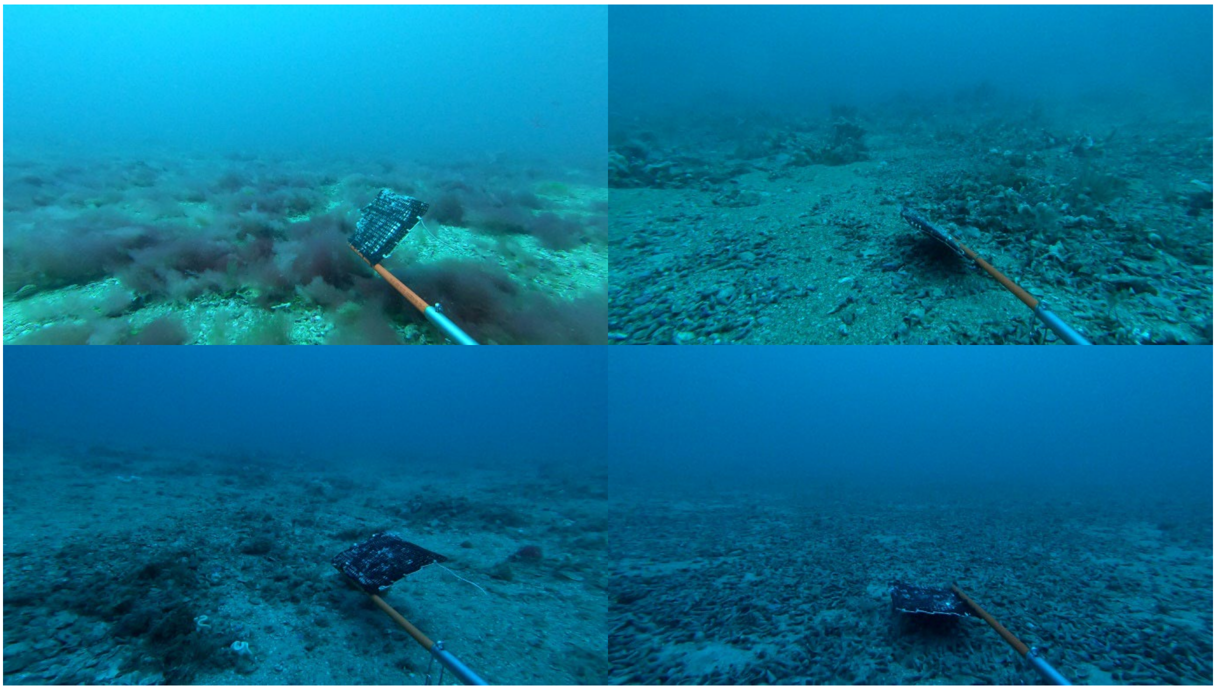

Plate 3-10: Pavement with veneer (mixed coarse sediments)

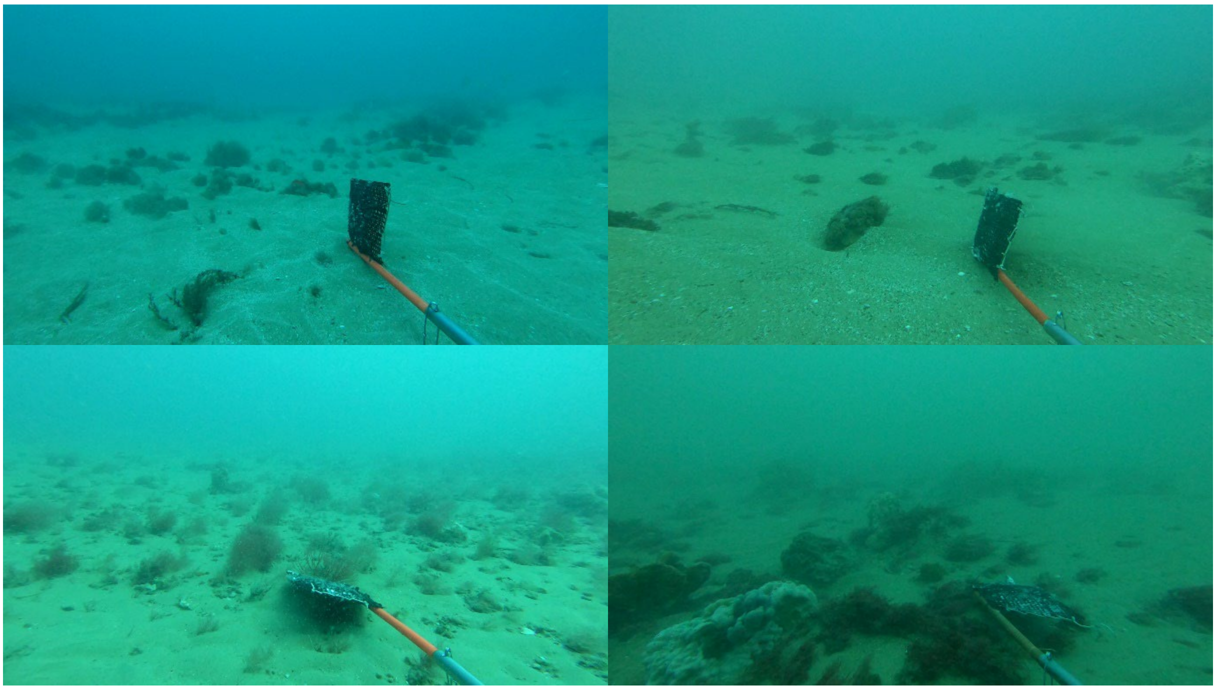

Plate 3-11: Sand with patchy epibiota

Plate 3-12: Reef

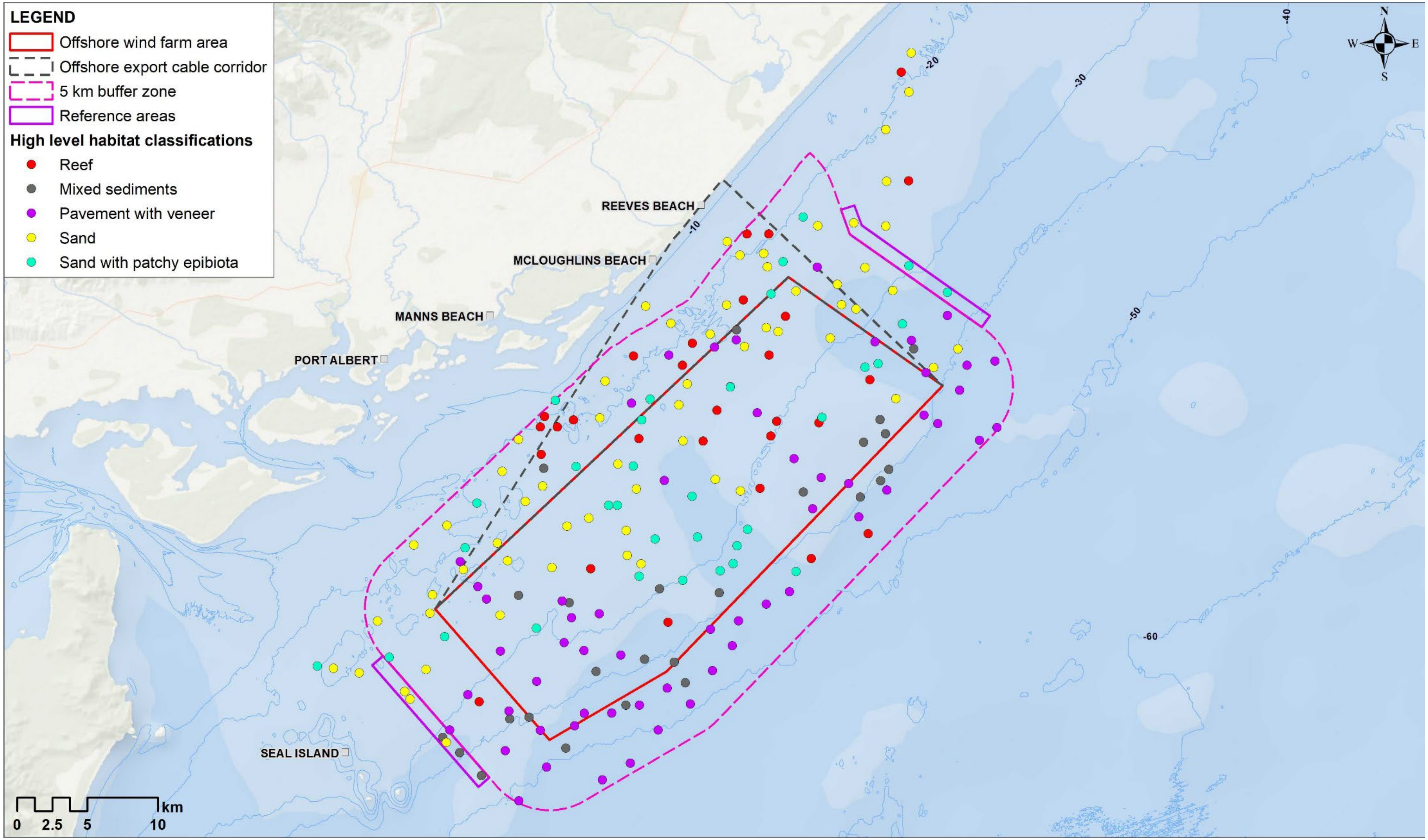

Figure 3-19: High-level habitat classes from summer SBRUVs surveys

3.3.2 Temporal variability

Benthic biota

Marine macrophytes – namely seaweeds, kelps and seagrass – were selected for analysis to identify trends in the distribution of biota that were likely to exhibit seasonal cyclicity. Ascidians were also included in this analysis as organisms that are unlikely to exhibit seasonal cyclicity (eg large long lived biota) or mobile benthic epibiota that occur in the same habitat as macroalgae (eg crinoids on high profile reefs).

Winter distributions of marine macroalgae were generally to the north and central east of the OWFA, in areas where patchy reef was recorded (Figure 3-20). Ascidians were recorded across the Study Area, generally in water depths of less than 40 m. Flat laminar brown macroalgae (eg *Zonaria* spp) was recorded across the central OWFA, in the 2 m to 35 m depth range.

Summer distributions were distinctly different to winter distributions (Figure 3-21). Crinoids were recorded at more sites, though still in the < 25 m depth range. Seagrass was more abundant, with greatest abundance recorded in the north-west and central north of the OWFA. The most notable difference was the distribution of red macroalgae, which was rare in winter, but distributed from the central west of the OWFA to the south-east, mainly within the 25–39 m depth range, an area with mixed coarse sediments. Red algae are known to occur in spring-summer blooms on unconsolidated hard substrate (shell, rubble) right around Bass Strait in euphotic depths, particularly along the north coast of Tasmania (CEE 2011, Lucieer et al 2007). Other macroalgae were distributed across the OWFA in shallower depths (ie generally <35 m below sea level).

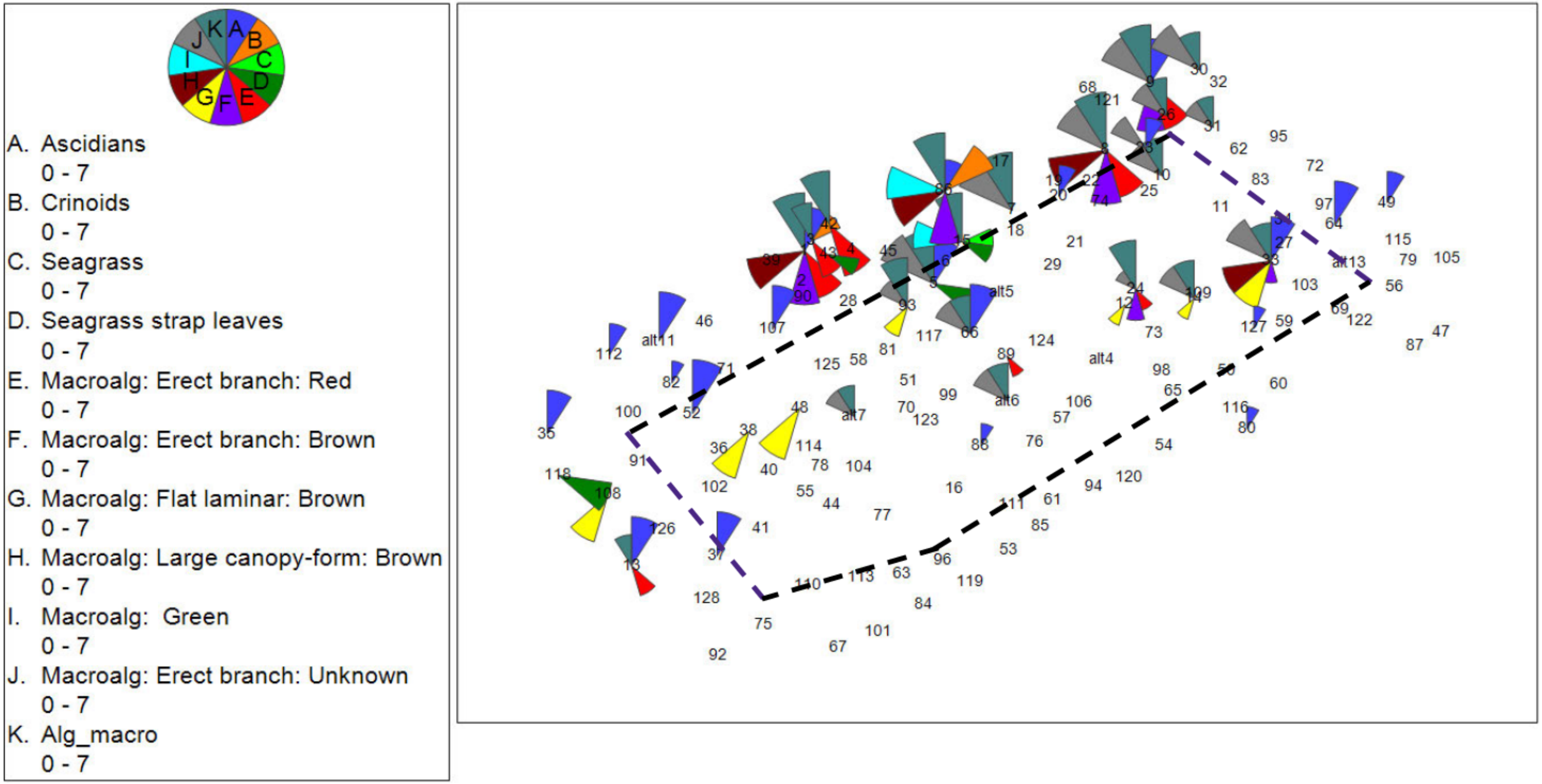

Figure 3-20: Abundance of ascidians, crinoids, seagrass and macroalgae (0 = not recorded to 7 = superabundant (SACFOR scale)) from the SBRUVs winter survey. Dashed line = OWFA.

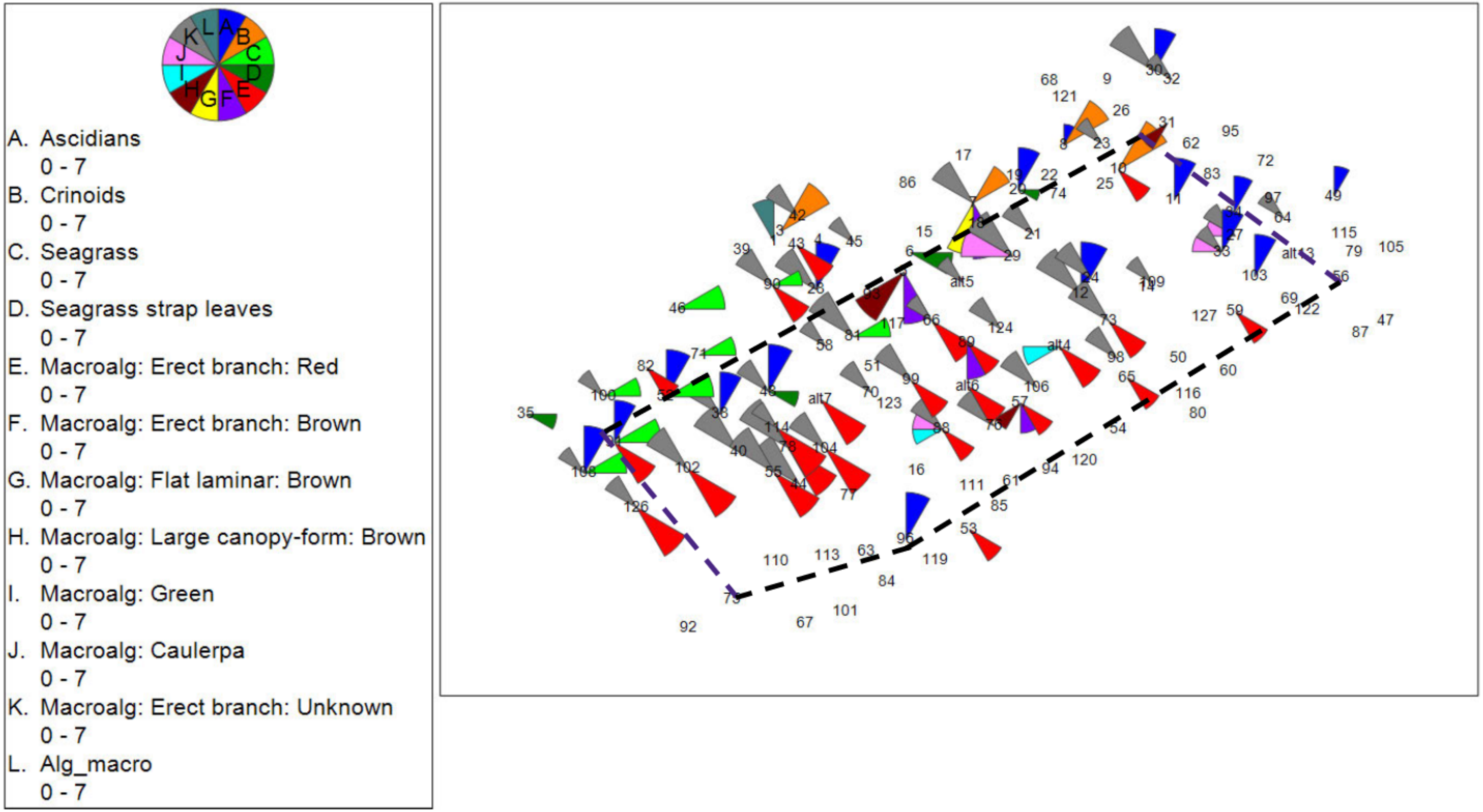

Figure 3-21: Abundance of ascidians, crinoids, seagrass and macroalgae (0 = not recorded to 7 = superabundant (SACFOR scale)) from the SBRUVs summer survey. Dashed line = OWFA.

3.4 Biodiversity

The Commonwealth Marine Area (CMA) is a matter of national environmental significance (MNES) protected under Part 3 of the EPBC Act. As such, a number of indicators can be used in the evaluation of potential impacts from the project on benthic values and sensitivities in the CMA, which will provide key risks to:

- representativeness
- ecological integrity and functioning
- biodiversity
- quality
- conservation values.

This section presents the results of an assessment of relative biodiversity (ie number of species recorded per ‘sample’) from benthic imagery and infaunal samples. In this study, biodiversity refers to the total number of taxa, morphotypes, colonies and biological complexes (dense assemblages of sessile epibiota) per site.

The total number of epibiota taxa identified in images at each site is presented in Figure 3-22. Shallower sandy habitats (<30 m) had the lowest number of taxa, ranging from zero (bare sand) to 9 taxa per site (ie. sand with sparse epibiota). More epibiota taxa were identified in deeper habitats (>30 m, 9 to 19 taxa per site) with more unconsolidated hard substrate such as shell and rubble that provides attachment for epibiota. Reef also supported a wide range of epiobiota. It is worth noting that the total taxa scores at reef sites and those otherwise dominated by macroalgae are likely to be underestimated due to the crowding effect of large/dense epibiota.

Equivalent analysis of infaunal data identified up to an average of 69 taxa per 0.1 m^2 grab sample (out of a possible 234 taxa in the dataset (Figure 3-23). As with the subsea imagery, shallower areas (<30 m) had lower diversity (1-30 taxa) while deeper areas (>30 m) had higher diversity (40-69 taxa). However, more diverse sites were scattered throughout the Study Area, including in shallower depths.

The sum of the average number of epibiota and infauna biota per site are combined in Figure 3-24. The figure clearly shows the difference in number of taxa between the areas known to be dominated by mobile sand habitat (ie in the north east of the study area, in water depths of < 35 m below sea level and areas dominated by unconsolidated hard substrates (shell, rubble) in the southwest in water depths of > 35 m below sea level.

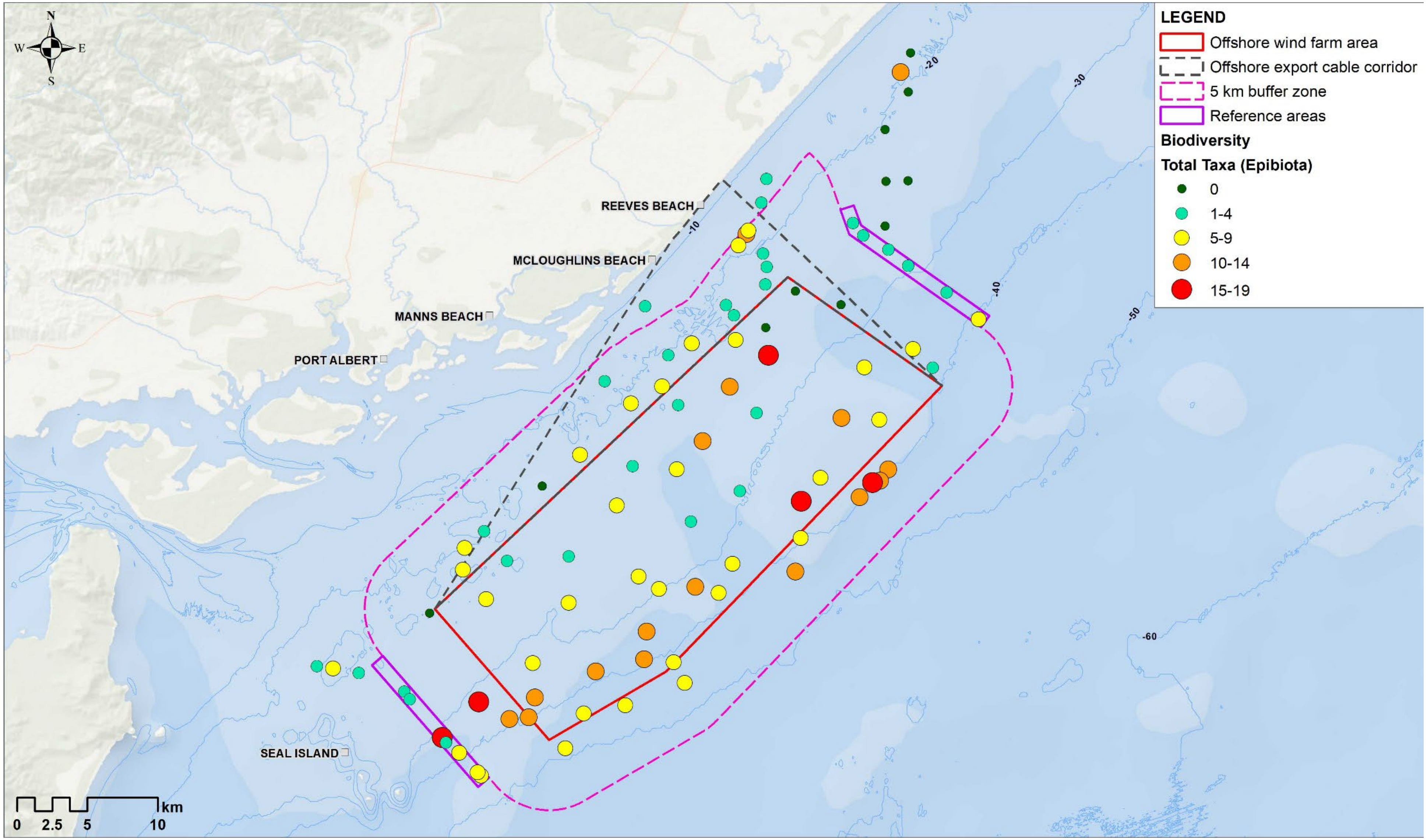

Figure 3-22: Average number of epibiota operational taxonomic units (OTUs) per site

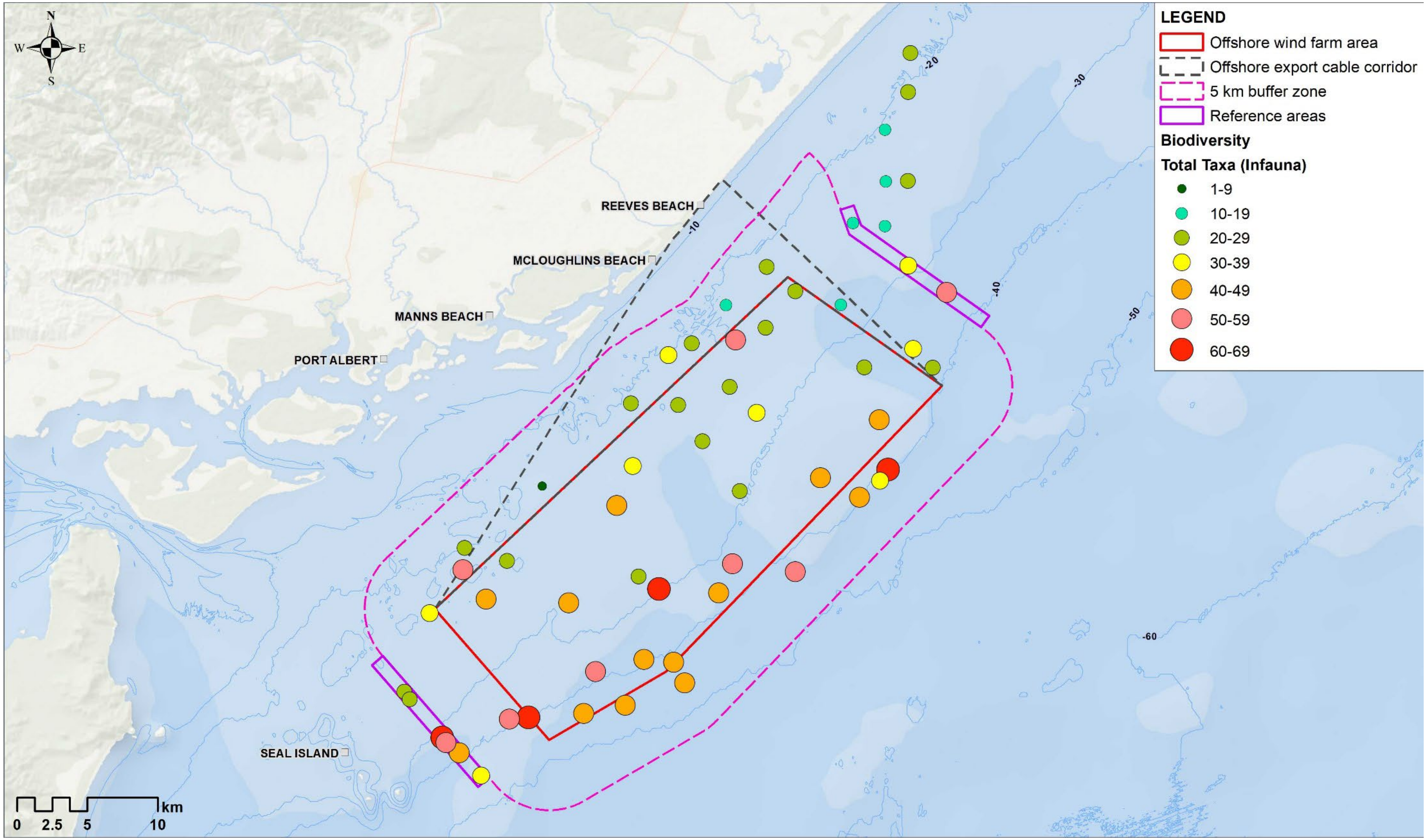

Figure 3-23: Average number of infaunal taxa per site (biodiversity)

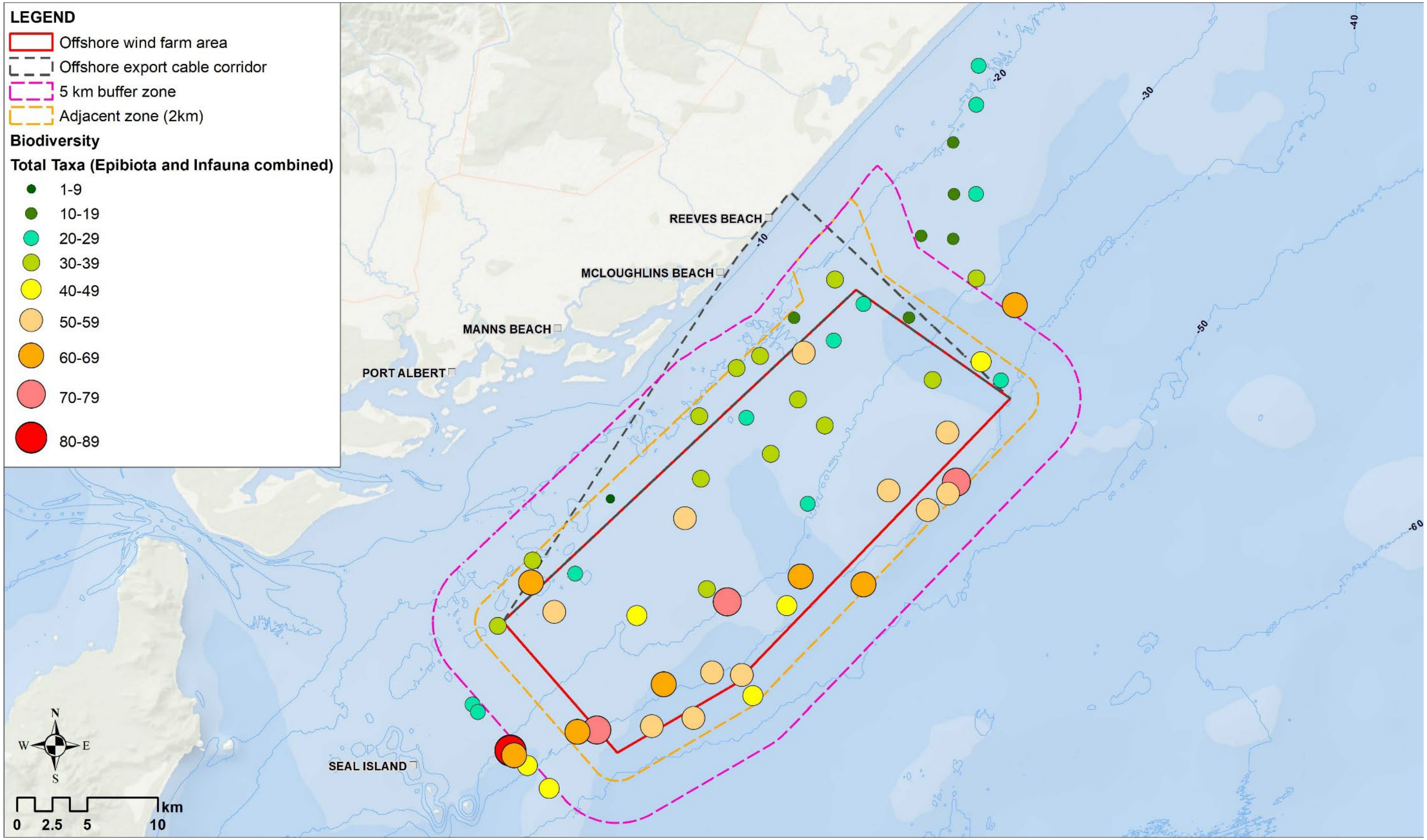

Figure 3-24: Combined average number of epibiota and infauna per site

3.5 Habitat classification and mapping

3.5.1 Habitats and biotopes derived from imagery

The site classifications based on substrate type identified in images presented in Section 3.1.1 were further analysed to derive more detailed habitat/biotope classifications using a 'top down' approach, ie defining habitats in each image based on substrate and depth first, and then defining sub-groups using biological data. This was achieved by applying the pre-defined groupings (from the substrate data) to the biological data, and running the similarity per centages (SIMPER) routine in PRIMER. This provided the top 70 per cent of taxa characterising each grouping. The 34 biotope classifications derived from the analysis of subsea imagery are listed in Table 3-10 and presented in Figure 3-25. Full characterisation of each epibiota biotope is presented in **Error! Reference source not found.**.

To optimise the applicability of the habitat map, the 34 biotope classifications were recombined into 22 biotopes by removing 'infralittoral' and 'circalittoral' from the description (so the same biotopes could occur in both infralittoral and circalitorral depths).The spot-point data and bathymetry were used to provide a habitat map (Figure 3-26). This habitat map presents both higher-level broad habitat classifications (described in the legend on the left side of the figure) and more detailed spot-point biotope classifications (described in the legend on the right side of the figure). Both are important aspects of the habitat map. The broad habitat classifications provide a full-coverage estimate of the habitat types across the Study Area, which is important for both planning and subsequent impact assessment. The spot-point habitat classifications are important for highlighting that the high-level classifications are likely to be comprised of a mosaic of habitat types at smaller spatial scales.

The habitat map (Figure 3-26) includes the outcomes of the analysis of both benthic ecology survey 1 and survey 2 data. The outcomes of survey 2 resulted in the reclassification of one habitat type, where 'sand with patchy seagrass and epibiota' was reclassified to 'sand with patchy epibiota and seagrass' due to the lower density and abundance of seagrass recorded in survey 2 than conservatively estimated from survey 1. Outcomes were otherwise generally consistent with survey 1 mapping.

The following broad habitat types were defined for mapping the seabeds of the Project Area:

- Bivalve shell and coarse sediments on pavement (mixed coarse sediments) with turf epibiota (eg Plate 3-3)
- Coarse sediment with patchy epibiota
- Coarse sediment with sparse epibiota
- High profile reef with crinoids and large epibiota (eg Plate 3-12-)
- High profile reef with dense macroalgae and sponges
- Low profile reef with patchy epibiota (eg Plate 3-2)
- Mixed sediments with abundant red macroalgae (eg Plate 3-6)
- Patchy low profile reef with high density large epiobiota
- Pavement (mixed coarse sediment) with patchy epibiota
- Pavement (mixed coarse sediment) with sparse epibiota
- Pavement with veneer (mixed coarse sediment) and sparse epibiota (eg Plate 3-10)
- Rippled sand with no conspicuous/sparse epibiota (eg Plate 3-8)
- Sand with patchy epibiota and seagrass (eg Plate 3-1)
- Screw shell on coarse sand with sparse epibiota.

Table 3-10: Benthic habitat classifications defined from subsea video (equivalent CBiCs codes in brackets)

Infralittoral (< 30 m depth)					Circalittoral (> 30 m depth)			
Sand (ba5.23)	Coarse sediment (ba5.13)	Mixed sediments (ba5.43)	Pavement (ba3)	Reef (ba3)	Sand (ba5.25)	Coarse sediment (ba5.14)	Pavement (ba4)	Reef (ba3)
Infralittoral rippled sand with no conspicuous epibiota (**ba5.232**)	Infralittoral coarse sediment with Amphipod tubes	Infralittoral mixed sediments with abundant red macroalgae (**ba3.198**)	Infralittoral pavement with sand and sparse epibiota	Patchy Infralittoral low profile reef with high density large epibiota	Circalittoral rippled sand with no conspicuous epibiota (**ba5.253**)	Circalittoral screw shell on coarse sand with sparse epibiota (**ba5.442**)	Bivalve shell and coarse sediments on circalittoral pavement with turf epibiota	Circalittoral low profile reef with patchy epibiota
Infralittoral rippled sand with sparse epibiota (**ba5.232**)	Infralittoral coarse sediment with ascidians, patchy biota and amphipod (?) tubes		Infralittoral pavement with coarse sediment veneer and sparse epibiota	Low profile reef with patchy epibiota	Circalittoral rippled sand with sparse epibiota (**ba5.253**)	Circalittoral coarse sediment with sparse epibiota **(ba5.14)**	Circalittoral pavement with coarse sediment veneer and sparse epibiota (**ba4.13**)	
Infralittoral rippled sand with sparse epibiota (ascidians)	Infralittoral coarse sediment with patchy biota		Infralittoral pavement with coarse sediment veneer and patchy epibiota	Infralittoral low profile reef with crinoids and large epibiota	Circalittoral sand with patchy epibiota and seagrass (**ba5.83**)	Circalittoral coarse shelly sand with ophiuroids	Circalittoral screw shell on rock pavement with sparse epibiota (**ba5.442**)	
Infralittoral sand with patchy epibiota	Infralittoral coarse sediment with sparse ascidians, sea stars and gastropods		Infralittoral pavement with thin sand veneer and large patchy epibiota	Infralittoral high profile reef with crinoids and large epibiota		Circalittoral coarse sediment with patchy epibiota	Circalittoral pavement with coarse sediment veneer and patchy epibiota	
Infralittoral sand with patchy epibiota and seagrass	Infralittoral coarse sediment with sparse biota			Infralittoral high profile reef with dense macroalgae and sponges		Circalittoral coarse sediment with abundant turf epibiota	Circalittoral pavement with coarse sediments and sparse epibiota	
	Infralittoral coarse sediment with sparse seagrass and epibiota (**ba5.83**)					Abundant sponges on circalittoral coarse sediments		

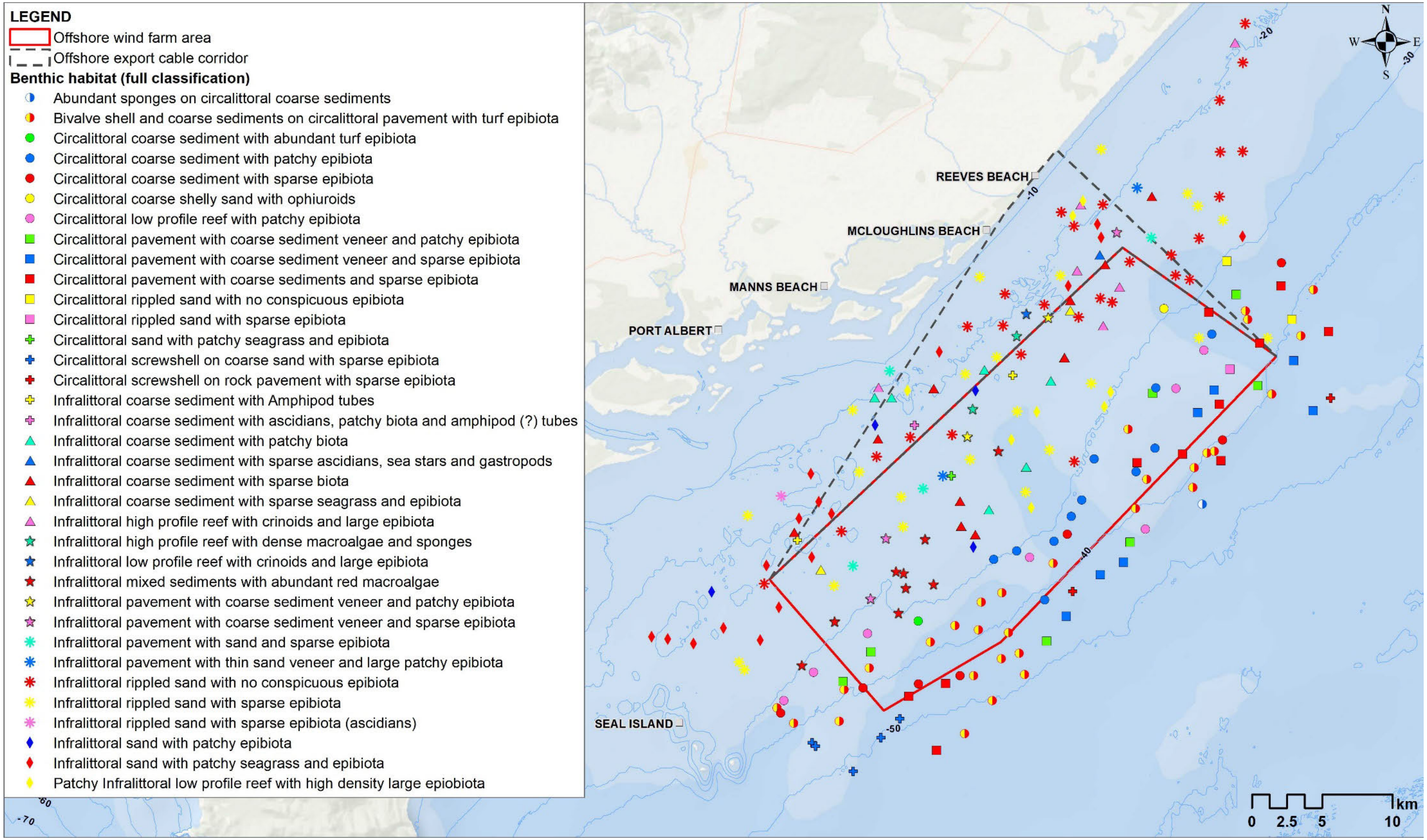

Figure 3-25: Benthic habitat map derived from subsea imagery – detailed habitat classifications

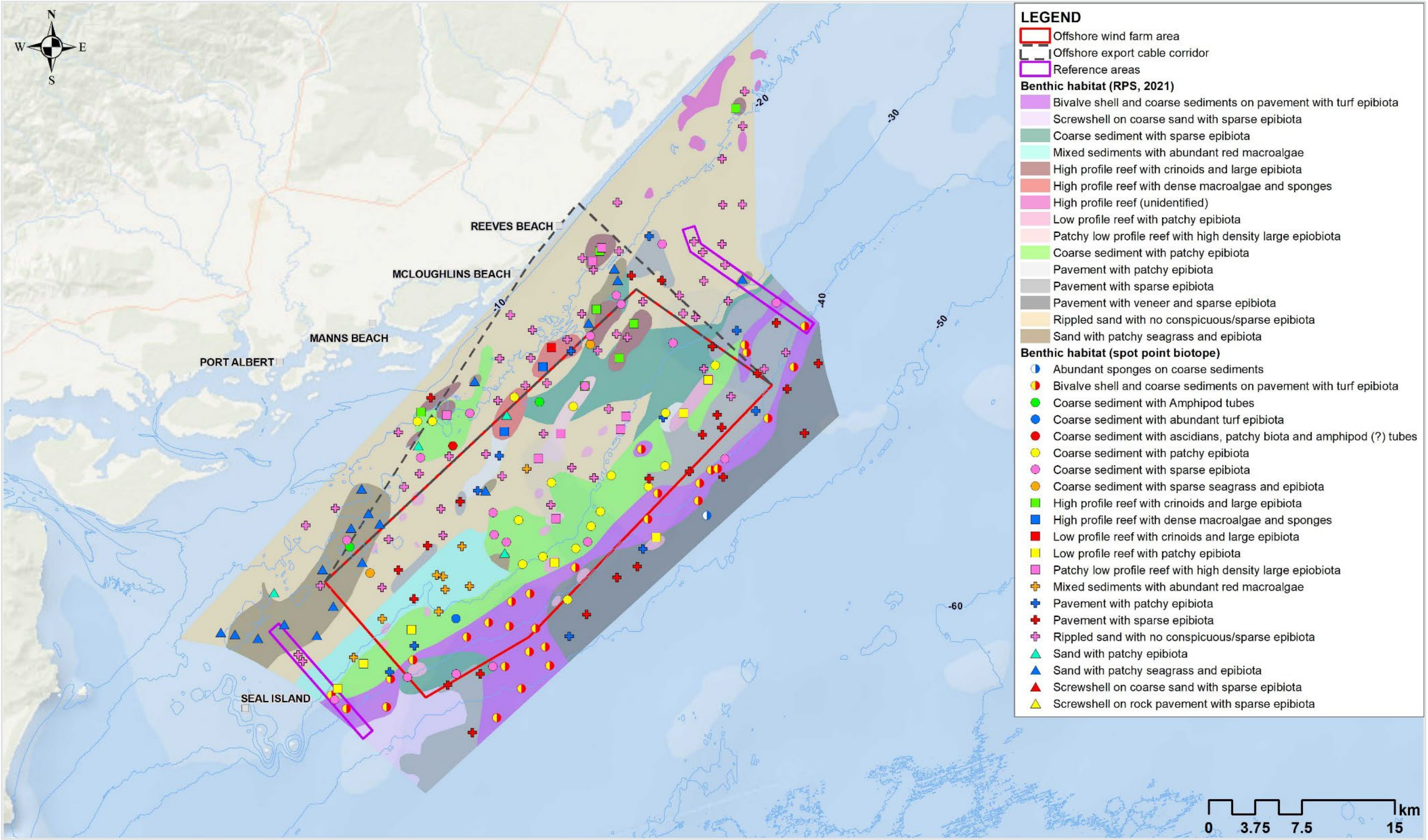

Figure 3-26: Benthic habitat map based on subsea imagery from survey 1 (November/December 2020) and survey 2 (January/February 2022) showing broad trends over large spatial scales (simplified habitat classification) overlaid with spot-point classifications to indicate potential for heterogeneity at smaller spatial scales

Note that pavement with sediment veneer habitats are likely to represent sediment over gravel, rather than pavement.

3.5.2 Biotopes derived from grab sampling

The twelve habitat classifications defined from grab sampling data (sediment particle size distribution and infauna) are listed in Table 3-11 and presented spatially in Figure 3-27.

The range of infauna biotopes was greater in the 20-30 m depth range (~10 biotopes) than in waters over 30 m depth (~3 biotopes). Biotopes in the 20 m to 30 m depth range mostly had low (sparse) infauna abundances with limited diversity. While fewer biotopes occurred in deeper water, they comprised a more diverse range of infauna with higher abundances.

Table 3-11: Benthic habitat classifications from grab sampling (equivalent CBiCs codes in brackets)

Infralittoral		Circalittoral	
Sand (ba5.23)	Coarse sediment (ba5.13)	Sand (ba5.25)	Mixed sediments (ba5.44)
Very sparse amphipods and ostracods in infralittoral sand (Sample R13.5)	Sparse annelids and amphipods in infralittoral coarse sediment (Group E)	Sparse annelids and amphipods in circalittoral sand (Group D)	Diverse amphipods and annelids (including nereids) in circalittoral mixed sediments (Group J)
Sparse amphipods, isopods and crangonid shrimp in infralittoral sand (Group C)	Diverse amphipods, annelids, cryptic crustaceans, phoronids and sunset shells in infralittoral coarse sediments (Group I)	Sparse annelids, amphipods, tanaids, sunset shells and cumaceans in circalittoral coarse sand (Group L)	Diverse amphipods, annelids and cryptic crustacea in circalittoral mixed sediment (Group K)
Sparse amphipods, annelids and sunset shells in infralittoral coarse sand (Group F)	Diverse annelids with amphipods and infaunal echinoderms in infralittoral coarse sediment (Sample S20)		
Infaunal bivalves with sparse amphipods and annelids in infralittoral coarse sand (Group G)			
Amphipods, tanaids, ostracoda, annelids, caprellids, cumaceans and phoronids in infralittoral sand (Group H)			

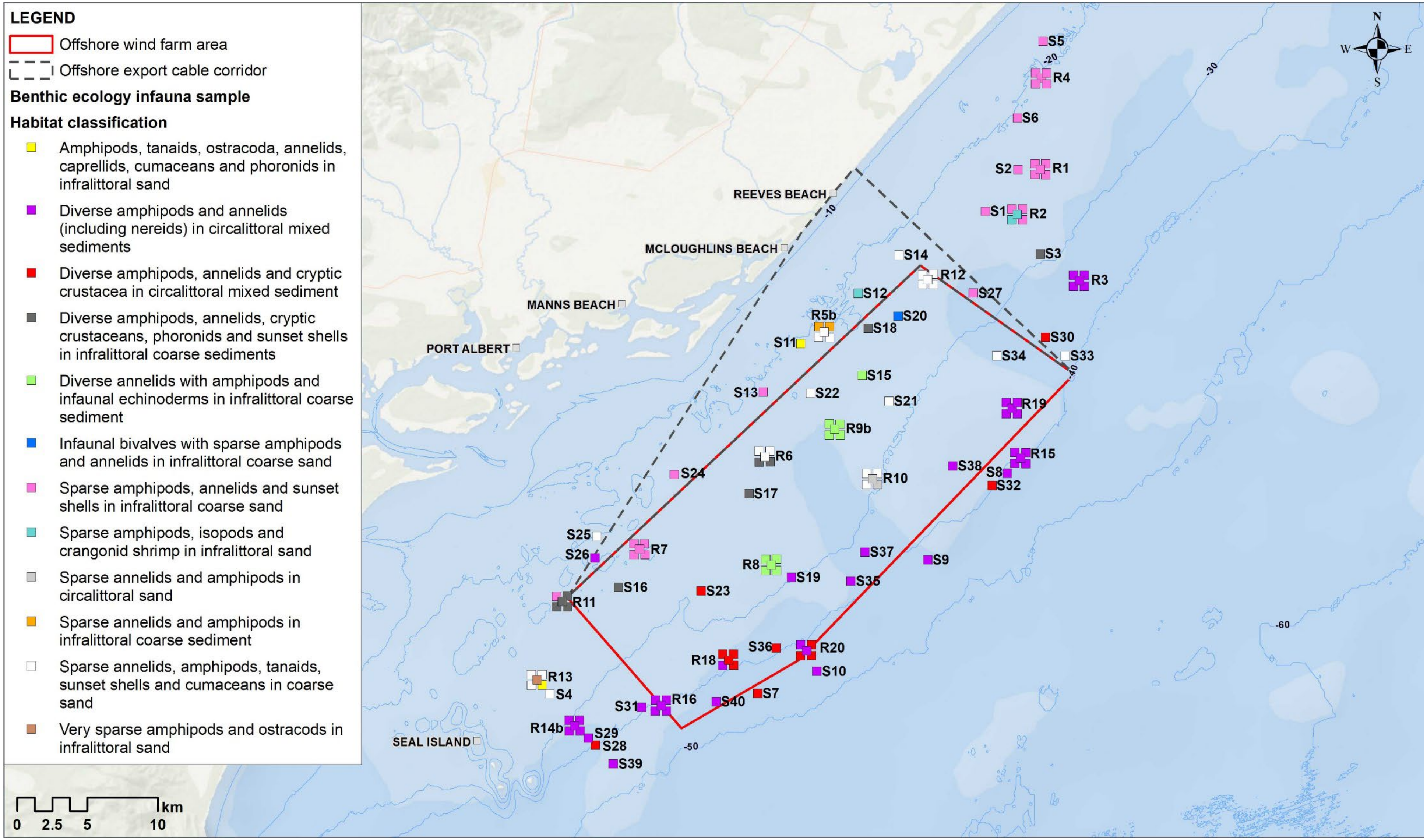

Figure 3-27: Habitat classifications based on grab sampling data

4 DISCUSSION

4.1 Characteristic environmental aspects

- Environmental characteristics varied across the Study Area. The bathymetry profile varies from more gently sloping in the northeast to more steeply sloping in the southwest. Most seabed in the the OWFA is in the depth range 25 to 35 m, with smaller areas in the range 20-25 m (inshore) and 35 to 45 m (offshore). The deepest part of the OWFA is in the southwest corner (~45 m below mean sea level).
- Subsea imagery (including SBRUVs imagery) identified mobile sands in the north-eastern part of the Study Area, with patchy high and low profile reefs distributed across the Study Area mostly in the 20–25 m depth range, with small areas of low profile reef recorded in the deeper habitat. Bivalve shell beds occurred extensively across the deeper portions of the Study Area, and New Zealand screw shell (*Maoricolpus roseus*) beds were recorded in the deeper south-west corner.
- Sediment quality results indicated clean sediments with little anthropogenic influence such as elevated nutrient or metal levels. Concentrations of total organic carbon were low (<0.3 per cent) but highest in the deeper parts of the study area where less winnowing of fine sediment would be expected. Concentrations of total phosphorus showed a similar pattern. Concentrations of metals were below the default guideline values for sediments in Australia with the exception of arsenic. Arsenic was above the default guideline value at under half the sites sampled. Marine sediments around Australia often exhibit arsenic levels above guidelinevalues (NAGD 2009, DEC 2006, Davies 1979). Arsenic concentrations were positively correlated with iron and manganese concentrations. Previous studies have shown that iron formations and iron-rich sediments can contain very large concentrations of natural arsenic (Tanaka, 1988). Therefore the source of arsenic is likely to be geological.
- Particle size distribution data identified that sediment types across the Study Area ranged from sand to gravelly sands to sandy gravels. Sediments were finest in the north-east, with coarse shell and mixed coarse sediment distributed across the flat/low profile seabed in the deeper areas (>35 m below sea level). Sediments in depth ranges <35 m below sea level were dominated by sands. These findings align with survey data available on the DELWP Coastkit website (https://mapshare.vic.gov.au/coastkit/), which identifies seabed substrates in shallower parts of the Study Area as being comprised of fine/muddy sands, sands, coarse and mixed sediments.
- Principal Coordinates Analysis showed that the 0.125 mm, 0.25 mm and 0.5 mm sediment size classes had the greatest effect on distributions of infauna assemblages.

4.2 Characteristic species

- High profile hard substrate reef assemblages are considered to have higher local environmental value as they are less likely to have been subject to periodic inundation (burying) with sediment than low profile reefs, and hence a more diverse and stable epibiota assemblage (NSR Consultants 2001, Butler et al. 2002). The three dimensional structure provided by epibiota on reef is attractive to a wide range of mobile fish and invertebrate species, and these are often targeted by recreational and commercial fishing. Mapping the distribution of these habitats allows the potential planning of turbine arrays and micrositing to avoid potential permanent impacts.
- A wide diversity of sponge morphotypes was identified on reef as well as on unconsolidated hard substrates in deeper water (shell, rubble etc).
- A wide diversity of bryozoans was identified, particularly in deeper habitats, consistent with hard skeletons from bryozoans comprising a major proportion of sediments in eastern Bass Strait (James et al 2008).
- Seagrasses are known to occur in infralittoral benthic habitats of the region, in water depths of less than 30 m. The current study has provided key information on the distribution of seagrass (*Heterozostera tasmanica*) in the Study Area. *Heterozostera tasmanica* occurred patchily at depths between 20 and 25 m depth, where observed it showed a sparse growth form in patches rarely more than a few metres extent. Sediment is likely to be mobilised relatively frequently in the depths where *H. tasmanica* occurs and these beds are likely to be dynamic.

- The depth and sediment related patterns documented by this study are similar to that documented previously by Coleman et al (1997) and Heislers and Parry (2007). Both these studies also found that infauna diversity was higher in poorly sorted, heterogeneous sediments found in deeper water with less wave disturbance, and lower in well sorted sandy sediments found in shallower water with higher wave disturbance.
- Infaunal diversity documented in this study is comparable to that documented further east by Colemean et al 1997. Coleman et al (1997) also sampled infauna using a 0.1 m2 Smith-Macintyre grab (likely the very same grab used in this study), though samples were sieved through 0.5 mm mesh, half the size of the 1 mm mesh used in this study. Coleman et al (2007) documented 803 species and 60258 individuals in samples totalling 10.4 m^2. This study documented 236 species and 18690 individuals from an area of 13.5 m^2. Due to the different mesh size, it is not possible to compare species numbers based on area sampled.
- Infaunal diversity in Bass Strait and in particular eastern Bass Strait is generally considered to be high (Coleman et al, 1997, Heislers and Parry, 2007). Southern Australia in general has high biodiversity and endemicity of marine species, particularly of algae and invertebrates (CoA, 2015).
- Infauna were generally dominated by arthropods (eg crustaceans) and annellid (polychate) worms with relatively few molluscs and other taxa. Similar patterns have been documented by Colemean et al (1997) and Heislers and Parry (2007). Taxa characteristic of sand and mixed sediments were identified during the study, and are described in relevant biotope descriptions.

4.3 Benthic habitats and communities

The benthic habitats of the Project Area comprised five overarching (high level) seabed types:

- sands
- sands with patchy epibiota
- mixed sediments (coarse sediment)
- inferred pavement with a sediment veneer (mixed coarse shell, rubble, gravel and sand)
- rocky reefs (low and high profile).

Of these seabed types, sands were the dominant habitat type in water depth less than 30 m, and pavement with veneer (flat or low relief hard substrate) was generally the dominant habitat type in water depth greater than 30 m. These findings align with survey data available on the DELWP Coastkit website (https://mapshare.vic.gov.au/coastkit/), which identifies seabed substrates in the Study Area as being comprised of the following CBiCs habitat level 3 classifications (with habitat code):

- infralittoral fine sand (ba5.23)
- rippled fine sand (ba5.232)
- sublittoral sand and muddy sand (ba5.2)
- sublittoral coarse sediment (ba5.14)
- sublittoral mixed sediments (ba5.4).

Minor areas of patchy reef were recorded through the centre of the OWFA, and along the northern boundary. The results showed that these habitats were well represented in the Study Area. The regularity of their distribution (and geophysical data collected within and adjacent to the OWFA; Fugro 2020) indicated that these sediment types are likely to continue well beyond the reference zones.

Broad habitat classifications are a useful tool for identifying connectivity in benthic habitats across a Study Area. However, these high-level classifications do not provide the level of detail required to be able to assess key aspects such as ecological integrity, function and biodiversity. To this end, 34 low-level biotopes were characterised from the subsea imagery data (drop-down and towed video imagery), and a further 12 biotopes characterised from grab sample data. The characterisation of these biotopes includes defining substrate type, water depth range and biological assemblage (characteristic taxa). These biotopes were further refined to develop a habitat map for the Study Area.

The following broad habitat types were defined for mapping the seabeds of the Project Area:

- Bivalve shell and coarse sediments on pavement (likely gravel) with turf epibiota. The epibiota component of this habitat classification was characterised by encrusting sponges, hydroids, red and green macroalgae and bryozoans (arborescent, foliaceous (bitectiporidae), finely branching and lace corals). The infaunal assemblage was characterised by crustaceans (amphipods, tanaids, isopods, anomurans, leptostracans and cumaceans) and polychaetes being the dominant characterising phyla, with nemerteans (ribbon worms) and nematodes also recorded. The highest average infaunal species richness and Shannon-Weiner diversity scores were recorded for this habitat.
- Coarse sediment with patchy epibiota. Red and green macroalgae, hydroids, bryozoans (arborescent, bitectiporidae and *Adeona grisea*), brown macroalgae and lobate sponges were characteristic components of the epibiota assemblage of this habitat type. The infaunal assemblage comprised of polychaetes, crustaceans (tanaids and amphipods), nemerteans, nematodes, caridean prawns and echinoderms (brittlestars).
- Coarse sediment with sparse epibiota. Epibiota assemblages were characterised by hydroids, encrusting sponges, bryozoans (ace of clubs (*Lanceopora smeatoni*), lace coral and bitectiporidae), green and red macroalgae. Infauna comprised polychaetes, crustaceans (amphipods, tanaids, cumaceans, isopods and leptostracans), nemerteans and nematodes.
- High profile reef with crinoids and large epibiota. Characteristic epibiota included red macroalgae, arborescent bryozoans, *Cryptopolyzoon* sp. (a bryozoan), hydroids, echinoderms (the feather star *Cenolia trichoptera*), sponges (encrusting, lobate and digitate), ascidians, seagrass (*Heterozostera* spp.). The infaunal assemblage associated with this habitat were found to have relatively low species richness and the lowest Shannon-Weiner diversity scores of the habitats identified. The assemblage was dominated by polychaetes, with crustaceans (amphipods, tanaids, isopods, ostracods, crabs and cumaceans), nemerteans, nematodes, phoronids, gastropod and a razor shell species also characterising this habitat.
- High profile reef with dense large macroalgae (such as *Ecklonia radiata* and *Sargassum sp*) and sponges. Epibiota were characterised by echinoderms (the feather star *Cenolia trichoptera*), red macroalgae and arborescent bryozoa. Infaunal assemblages were characterised by polychaetes and crustaceans (amphipods, isopods, tanaids, crabs, cumaceans and ostracods) and nemerteans.
- Low profile reef with patchy epibiota. Sponges (encrusting, digitate, lobate, spherical, fistulose and globular), hydroids, green and red macroalgae, arborescent bryozoans and doughboy scallops (*Mimachlamys asperrima*) comprised the epibiota assemblage. No infaunal samples were collected in this habitat (habitat boundaries were defined following the survey).
- Mixed sediments with abundant red macroalgae. Red and green macroalgae characterised this habitat. Crustaceans (isopods, amphipods, squat lobsters, tanaids and snapping shrimp), polychaetes and echinoderms (brittle stars) were characteristic of the infaunal community.
- Patchy low profile reef with high density large epiobiota. The epibiota assemblage was characterised by bryozoans (arborescent and *Cryptopolyzoon* sp.), red algae, green macroalgae, encrusting sponges and ascideans (*Herdmania grandis*). Polychaetes, crustaceans (amphipods, isopods and ostracods), echinoderms (brittle stars) and nemerteans comprised the infaunal assemblage.
- Pavement with patchy epibiota. Hydroids characterised the epibiota, whilst nematodes, nemertea, crustaceans (amphipods, isopods, tanaids and cumaceans) and polychaetes were characteristic of the infaunal assemblage.
- Pavement with sparse epibiota. Hydroids, red algae and arborescent bryozoans were characteristic. Characteristic infauna included polychaetes, crustaceans (predominantly amphipods, with tanaids, cumaceans and ostracods) nematodes and nemerteans.
- Pavement with veneer and sparse epibiota. Arborescent bryozoa and sponges (lobate and encrusting) characterised this habitat, with crustaceans (amphipods, tanaids, isopods, hermits crabs and leptostracans), polychaetes, bivalves and sea spiders characteristic of the infaunal assemblage.
- Rippled sand with no conspicuous/sparse epibiota and diverse infauna. This habitat comprised relatively coarse, mobile sands, characterised by sand ripples (<10 cm in height), with either no conspicuous or sparse sessile epibiota. Biota, when present, included the soft coral *Pseudogorgia godeffroyi*, ascidians, hydroids, sea stars (e.g. *Luidia australiae*, *Coscinasterias muricata*), bryozoans, and occasional seagrass, sponges, sea pens, macroalgae and scallops. Also present were the tubes or siphons of infaunal organisms (likely polychaetes, amphipod crustaceans and bivalves). Rays were more

frequently recorded in this habitat. The infaunal assemblage associated with this habitat was relatively diverse, with the second highest average number of species and average Shannon-Weiner diversity score. This habitat was mostly recorded in the infralittoral zone (<30 m) and was characterised by deep sediments. Infauna were dominated by crustaceans (mainly amphipods, isopods – include several elongate forms and ostracods), annelids and molluscs (sunset clams and trough shells/duck clams), with cnidarians (burrowing anemones), sipunculans (unsegmented annelid worms), ribbon worms (nemerteans) and nematodes also represented.

- Sand with patchy epibiota and seagrass. This habitat was characterised by sand habitat with low density patches of epibiota and seagrass (*Heterozostera* spp.). Other conspicuous epibiota include species commonly recorded in sand habitats, such as the soft coral *Pseudogorgia godeffroyi*. and hydroids. As identified by the habitat map (--Figure 3-26), this habitat type is not likely to be consistent over large areas, but interspersed by other habitat types (e.g. 'rippled sand with no conspicuous or sparse epibiota' and 'coarse sediment with amphipod (?) tubes' (See Plate 3-7, top right panel)) – likely due to variations in hydrography and sediment transport at local spatial scales. However, spatial mapping has considered that seagrass above-ground biomass distributions can be variable over time in order to adopt a more conservative approach. Infaunal assemblages were characterised by crustaceans (amphipods, ostracods, elongate isopods and pebble crabs), annelid polychaetes and molluscs, but in contrast to e.g. the rippled sand habitat, the ratio between crustacean taxa and polychaete taxa it lower (ie crustaceans are less dominant), there are more molluscan taxa (sunset clams, trough shells/duck clams and razor shells), and echinoderms (Fibulariidae, which are small infaunal urchins and sand dollars) and phoronids replace cnidarians and sipunculans in the other characteristic taxa represented.
- Screw shells on coarse sand with sparse epibiota. Epibiota characterising this habitat include encrusting sponges, hydroids and red filamentous algae. Characteristic taxa identified from infaunal sampling identified that this habitat was dominated by the New Zealand screw shell (*Maoricolpus roseus*), with polychaetes, amphipods, anomurans (hermit crabs and squat lobsters) and bivalve molluscs comprising other characteristic taxa. The lowest average infaunal species richness and second lowest Shannon-Weiner diversity were recorded for this habitat type.
- The results of survey 2 provided additional context to the area of 'sand with patchy epibiota and seagrass' habitat to the west of the OWFA and OECC, particularly with respect to habitat heterogeneity and the likely distributions of seagrass above-ground biomass.

4.4 Seasonal variability

- The outcomes of the current study have indicated that biological assemblages (particularly marine macroalgae) have seasonal variability in their abundance and composition. As commonly found in temperate marine habitats globally, the results of the BRUVs image analysis align with known seasonal cycles of growth and dieback of marine macroalgae in temperate waters, with increased growth and coverage during the summer, and dieback prior to the winter. Subsequently, there is likely to be annual cycles of settlement, growth and mortality for mobile fauna – which follow the growth and dieback cycles of their food sources and changes in availability of their habitat (eg periodic inundation of hard substrate by mobile sediments).

4.5 Longer term stability

- The current study, Fitzpatrick (2022) and Fugro G&G data (2020) have shown that there are some low sand waves at locations in the north and east of the area, and the coarse, rippled nature of the sand waves suggests that they are being moved by seabed currents. This indicates that low relief benthic habitats in the vicinity of these sand waves are likely to be periodically inundated as they migrate. Information from local fishers indicates that this is likely to be the case in the Study Area (RPS 2021a).
- Filter-feeding communities of high profile reef and areas of low profile reef in water depths of greater than 30 m appeared to be well established because most sessile organisms/colonies were relatively tall and the assemblages were relatively diverse. This indicates that these habitats are likely to be exposed to less frequent sediment movement.
- The detail provided in the habitat classifications defined in this study allow some level of prediction to be made around what changes to a biotope would result from a specific impact factor. For example, if a predicted impact results in a consequential impact on the characteristics of the biotope (eg change in

substrate from sand to rock armour (hard substrate)), then the outcome may feasibly be a change to one of the other defined biotopes in the Study Area. Where that was to be the case, then an assessment of the relative impact or consequence to biodiversity and ecological function of the change from one biotope to another may be undertaken. In the example given, the assessment of potential impact can be informed by a determination of the potential difference in biodiversity and ecological function from eg 'Sand with patchy epibiota and seagrass' to 'Low profile reef with patchy epibiota' (see Section 4.3 for detail on these habitats) *at relevant spatial scales*. This is an important aspect for supporting effective impact assessment.

- The results of this study suggest that most of the benthic communities (excluding diverse high and low profile reefs) are adapted to high to intermediate levels of perturbation due to sediment movement. This is reflected in the relatively high abundance/density and diversity of filter-feeding organisms on exposed hard substrates. It also indicates that the persistence of these communities in the region is dependent on their ability to quickly recolonise exposed hard substrates as they become available.

4.6 Species or communities listed under the EPBC Act or FFG Act

No benthic EPBC Act listed species were identified during the surveys. No evidence of the Giant Kelp Marine Forests of South-East Australia Threatened Ecological Community was recorded and this community is not know from the area historically.

The Commonwealth Marine Area is a listed matter of national environmental significance, protected under Part 3 of the EPBC Act. The broad range of ecological values of the marine area require a robust assessment of potential risks to ecological integrity, ecological function and biodiversity. The study approach – and approach used to identify, characterise and map benthic habitats across the Study Area – provides information to inform a robust assessment of potential impacts to relevant values and sensitivities. The use and application of hierarchical habitat classification schemes allows assessment of ecological integrity, function and biodiversity (the values of the CMA). The characteristic environmental components and biological assemblages of biotopes provide data on a wide range of appropriate biological and physical (e.g. substrate components) indicators suitable for environmental impact assessment.

The FFG Act listed seagrass *Heterozostera tasmanica* was recorded at multiple locations. No other FFG Act listed species were recorded during the study.

5 CONCLUSIONS

The benthic ecology study showed that the sediments in the Study Area were generally dominated by (often mobile) sand in the shallower (<30 m depth range) with scattered low- and high-profile rocky reef. Sediments were generally finer in the east than in the west. The seabed in waters deeper than 30 m were generally dominated by flat, low relief mixed sediments comprising sand and mixed coarse sediments including shell, gravel/rubble and some rhodolith. Flat or low profile rock pavement was inferred beneath these sediments. New Zealand screw shell beds were identified in places in deep water.

Sand habitats generally supported very sparse to sparse infauna, with no conspicuous to patchy epifauna. Areas of rocky reef supported medium to high density macroalgae and/or filter-feeder communities. Infaunal taxa were characteristic of the sediment types recorded at the sample sites. Sediment quality results indicated clean sediments with little anthropogenic influence.

Shallower areas (<30 m) generally had lower species diversity of infauna and epibiota, while deeper areas (>30 m) had higher species diversity. More epibiota taxa were identified in deeper habitats with more unconsolidated hard substrate, such as shell and rubble, that provides attachment for epibiota.

No EPBC Act listed benthic species or threatened ecological communities were identified within the Study Area. The FFG Act listed seagrass *Heterozostera tasmanica* was recorded between 20 and 25 m depth throughout the Study Area. Descriptions of local marine bioregions and IMCRA biounits indicated that species, assemblages and habitats are likely to be represented in the broader region.

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