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Marine Natural Values Study (Vol 2)

Marine Protected Areas of the Otway Bioregion

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August 2012

EXECUTIVE SUMMARY

Along Victoria's coastline there are 30 Marine Protected Areas (MPAs) that have been established to protect the state's significant marine environmental and cultural values. These MPAs include 13 Marine National Parks (MNPs), 11 Marine Sanctuaries (MSs), 3 Marine and Coastal Parks, 2 Marine Parks, and a Marine Reserve, and together these account for 11.7% of the Victorian marine environment. The highly protected Marine National Park System, which is made up of the MNPs and MSs, covers 5.3% of Victorian waters and was proclaimed in November 2002. This system has been designed to be representative of the diversity of Victoria's marine environment and aims to conserve and protect ecological processes, habitats, and associated flora and fauna. The Marine National Park System is spread across Victoria's five marine bioregions with multiple MNPs and MSs in each bioregion, with the exception of Flinders bioregion which has one MNP. All MNPs and MSs are "no-take" areas and are managed under the *National Parks Act (1975) - Schedules 7 and 8* respectively.

This report updates the first Marine Natural Values Study (Plummer *et al.* 2003) for the MPAs in the Otway bioregion on the west coast of Victoria and is one of a series of five reports covering Victoria's Marine National Park System. It uses the numerous monitoring and research programs that have increased our knowledge since declaration and aims to give a comprehensive overview of the important natural values of each MNP and MS.

The Otway bioregion extends from Cape Jaffa in South Australia to Apollo Bay in Victoria, past the limit of state waters and to the western Bass Strait islands. It has a cool temperate climate and waters, with localised nutrient rich coastal upwellings. Its high wave energy coastline has sandy beaches, with volcanic headlands in the west and limestone cliffs in the east. The biota consists of cosmopolitan, southern and western temperate species that are well adapted to the colder, rough water conditions. It has a large number of fish and plant species, and particularly diverse red algae flora. It contains two large MNPs, Discovery Bay and Twelve Apostles, extending to the state water limit, and two small MSs, Merri and The Arches. The Merri MS is the most accessible of the Otway MPAs, the others can be viewed from land but are best accessed by boat. The rock stacks of the Twelve Apostles are nationally geologically significant. There are significant little penguin *Eudyptula minor* colonies in Twelve Apostles MNP and on the islands that Merri MS surrounds. Shipwrecks lie in the waters of Discovery Bay and Twelve Apostles MNPs.

High resolution bathymetry mapping has increased our understanding of habitats in the MPAs. All, except for The Arches, have intertidal sandy soft sediments and reefs. All the MPAs have subtidal sandy soft sediments and reefs. The reefs are calcarenite except in the nearshore of Discovery Bay which is basalt. The two MNPs, and The Arches MS have extensive, often sand inundated, deep reef and soft sediments.

Neptune's necklace *Hormosira banksii* is the dominant algae on the basalt intertidal reefs in Discovery Bay MNP. On the calcarenite intertidal reefs in Merri MS sea lettuce *Ulva* sp. and turfing red coralline algae *Corallina officinalis* are dominant. In both MPAs bull kelp *Durvillaea potatorum* fringes the intertidal reef. Intertidal reef sessile invertebrates in Discovery Bay MNP include anemones *Aulactinia veratra*, *Actinia tenebrosa* and *Anthothoe albocincta*, barnacles surf *Catomerus polymerus*, honeycomb *Chamaesipho tasmanica* and rosette *Tetraclitella purpurascens,* and mussels little black horse *Limnoperna pulex* and beaked *Austromytilus rostratus*.

The mobile invertebrate fauna on the intertidal reefs of the MPAs is dominated by molluscs. Common in both Discovery Bay MNP and the Merri MS are the false limpets *Siphonaria diemenensis* and true limpets *Cellana tramoserica.* The MNP fauna also includes top shells *Austrocochlea constricta* and *A. odontis*, and *Patelloida latistrigata*, black nerite *Nerita* *atramentosa*, periwinkles *Austrolittorina praetermissa*, *A. unifasciata* and *Bembicium nanum,* and the predatory gastropods *Cominella lineolata*, *Lepsiella reticulata*, and *L. vinosa*. In the Merri MS the warrener *Turbo undulatus*, and cartrut shell *Diacthais orbita* are common. Sea stars, brittle stars, sea urchins, crabs, and polychaetes are also found on the intertidal reefs of the MPAs. The fish have not been extensively described but usually includes the blenny *Parablennius tasmanianus*. Discovery Bay MNP has cling fish *Aspasmogaster tasmaniensis*, and weedfish Johnston's *Heteroclinus johnstoni*, common *Heteroclinus perspicillatus* and crested *Cristiceps australis*.

In Twelve Apostles MNP *Heterozostera spp,* grows on the sandy subtidal sediment. Crustaceans dominate the infauna and the majority of the subtidal sediments in both MNPs are bare of large biota.

Brown algae species dominate the canopy of the shallow subtidal reefs in the MPAs. The crayweed *Phyllospora comosa* is dominant in Merri MS while in The Arches MS the kelp *Ecklonia radiata* is dominant. A mix of both these algae dominate algal communities in Discovery Bay MNP. These brown algae and beds of mixed red, brown or green algae or a combination of algae and sessile invertebrates dominate Twelve Apostles MNP reefs. Both thallose and coralline red algae are common in the MPAs. In Twelve Apostles MNP and The Arches MS red algae grows at all depths and includes *Phacelocarpus peperocarpus*, *Melanthalia obtusata*, *Gelidium asperum*, *Plocamium mertensii* and *Ballia callitricha*. In the Merri MS coralline algae is abundant, as is a relatively diverse community of fleshy red algae understorey. *E. radiata* can extend into moderately deep waters in both Discovery Bay and Twelve Apostles MNPs.

Merri and The Arches MSs have a low diversity of subtidal invertebrates compared to other reefs in the bioregion. Southern rock lobster *Jasus edwardsii* and blacklip abalone *Haliotis rubra* characterize the subtidal reefs of the MPAs. Seastars are also common in the MPAs. In the Twelve Apostles MNP and The Arches MS seastars include *Nepanthia troughtoni* and *Nectria macrobrachia*. The seastars *Plectaster decanus*, *Echinaster arcystatus* are present in the Twelve Apostles MNP and in *Tosia magnifica* is present in The Arches MS. The warrener *Turbo undulatus* is abundant in Merri MS. Sessile invertebrates, particularly sponges, dominate deep reefs in the MNPs and The Arches MS. Discovery Bay MNP deep reefs have abundant compact sponges, ascidians, hydroids, and bryozoans along with gorgonians, soft corals, hard corals, *Tethya* sponges, zooanthids and the sea whip *Primnoella australasiae*. Twelve Apostles MNP has erect sponges, the isidid gorgonian *Pteronisis* spp. and large hydroid fan *Solanderia fusca*. The Arches MS has a very low abundance of sessile invertebrates. Encrusting or low profile sponges and encrusting soft coral *Erythropodium hicksoni* grow on the ledge edges. Other sponges, gorgonian coral *Mopsella* and ascidian *Herdmania momus* are also conspicuous.

Blue-throated wrasse *Notolabrus tetricus* and rosy wrasse *Pseudolabrus psittaculus*, along with sea sweep *Scorpis aequipinnis* and magpie perch *Cheilodactylus nigripes* are abundant on the shallow subtidal reefs in the Otway MPAs. Twelve Apostles MNP and The Arches MS fish community also includes dusky morwongs *Dactylophora nigricans,* barber perch *Caesioperca rasor,* bastard trumpeter *Latridopsis forsteri* and marble fish *Aplodactylus arctidens.* Marble fish *A. arctidens* is also found in Discovery Bay MNP along with zebra fish *Girella zebra*. In Merri and The Arches MSs zebra fish *G. zebra* and scaly fin *Parma victoriae* are part of the fish community. Twelve Apostles MNP also has senator wrasses *Pictilabrus laticlavius,* butterfly perch *Cheilodactylus lepidoptera,* bullseye *Pempheris multiradiata* and blue morwong *Nemadactylus valenciennesi* but leatherjackets are not abundant. Large schools of purple wrasse *Notolabrus fucicola* and juvenile sea sweep *S. aequipinnis* occur on the nearshore reefs in Discovery Bay MNP and blue gropers *Achoerodus* spp. on the deeper reefs. Pot-bellied seahorse *Hippocampus abdominalis* are found on the reefs in Merri MS.

The MPAs and their surrounds provide important feeding and roosting habitat for many threatened shore and sea birds, from five species in The Arches MS to 51 in Merri MS. Some marine species are found at the limit of their distribution range within individual MPAs. While no species are at their distribution limit in The Arches MS, eight species are at their distribution limit in Merri MS. The southern hooded shrimp *Athanopsis australis* is endemic to Discovery Bay MNP*.* The two MNPs have a large amount of open water, which is habitat to conservation listed marine mammals such as southern right whales *Eubalaena australis.* Blue whales *Balaenoptera musculus* are common in Discovery Bay MNP and humpback whales *Megaptera novaeangliae* in Twelve Apostles MNP. The intertidal reef in both MNPs provides haul-out areas for New Zealand *Arctophoca forsteri* and Australian fur seals *Arctocephalus pusillus doriferus*. The southern elephant seal *Mirounga leonina* has been sighted in Discovery Bay MNP. Large whales are not found within the smaller shallower MSs, they still provide important habitat for smaller marine mammals.

Limited ecological knowledge, and as a consequence inadequate management, are seen as a serious threat to the MPAs, as are poaching of abalone or and illegal fishing and invasive marine pests. Invasive marine pests of particular concern include the Japanese kelp *Undaria pinnatifida,* broccoli weed *Codium fragile (subsp fragile),* screw shell *Maoricolpus roseus,* Northern Pacific seastar *Asterias amurensis* and European fanworm *Sabella spallanzanii*. Abalone viral ganglioneuritus has been slowly spreading along the Otway coast killing a large percentage of abalone from Discovery Bay MNP to the tip of Cape Otway. It could have serious long term ecological consequences for subtidal reef communities in the bioregion. Recreational and commercial boats and diving can be a vector for this virus. Commercial vessels also pose a threat due to the risk of oil spills. Seismic testing for oil and gas are also seen as a threat to the MPAs. Increased nutrients and sediments through land use or waste discharge pose a threat to water quality. Litter and marine debris pose a threat to marine biota.

Climate change represents a serious threat to marine ecosystems but the specific ecological consequences are not well understood in temperate marine systems. Increased sea levels, water and air temperature, cloud cover, ultraviolet light exposure and frequency of extreme weather events are predicted. Other changes in the chemical composition, circulation and productivity of the seas are also predicted. These predicted changes have the potential to impact the marine environment, causing loss of habitats, decreased productivity, reproduction and distribution of species. Some species are at the limit of their distributional range in the bioregion and would be particularly vulnerable to climate change. Measures to address or minimize threats form part of the management plans for the MPAs. Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria’s capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria’s Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. Subtidal reef monitoring only occurs in Merri MS, as the reefs in the other MPAs are either too deep or too exposed for this type of monitoring. Statewide projects are currently underway to determine which MPAs are most at risk from introduced species, to document and photograph marine natural values, and to detect poaching.

Since declaration considerable advancement has been made in identifying and understanding the marine natural values of the Otway bioregion. Habitat type and distribution is known for Discovery Bay MNP and Merri MS, and for most of the Twelve Apostles MNP. There is however relatively little information about habitats in The Arches MS. There are still major gaps in our knowledge for the Otway MPAs. Monitoring changes in flora and fauna over time is limited to the shallow subtidal reef in Merri MS, however there has been a single survey of reefs in Twelve Apostles MNP and The Arches MS. There is limited knowledge of the intertidal and subtidal soft sediment and open waters. Whilst general and individual threats to the MPAs have been identified we have limited knowledge of how those threats will affect marine natural values.

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ACRONYMS

AROTS - Australian Rare or Threatened Species
AME - Australian Marine Ecology
C - listed under CAMBA
CAMBA - Chinese Australia Migratory Bird Agreement
CR - Critically Endangered
CSIRO - Commonwealth Scientific and Industrial Research Organisation
DPI - Department of Primary Industries
DSE - Department of Sustainability & Environment
EAC - East Australian Current
ECC – Environment Conservation Council
EN - Endangered
EPBC - *Environment Protection Biodiversity Conservation Act 1999*
FFG - *Flora and Fauna Guarantee Act 1988*
GIS - Geographic Information System
J - listed under JAMBA
JAMBA - Japan Australia Migratory Bird Agreement
IMCRA - Integrated Marine and Coastal Regionalisation of Australia
IRMP - Intertidal Reef Monitoring Program
IUCN - International Union for Conservation of Nature
L - listed under FFG
LCC - Land Conservation Council
LiDAR - Light Detection And Ranging
MAFRI - Marine & Freshwater Research Institute,
MAVRIC - Monitoring and Assessment of Victoria's Rocky Intertidal reefs
MNP - Marine National Park
MNVS - Marine Natural Values Study
MPA - Marine Protected Area
MS - Marine Sanctuary
MV - Museum Victoria
NT - Near Threatened
PE – presumed to be at or near eastern limit in MPA
PIRVic - Primary Industries Research Victoria
PN – presumed to be at or near northern limit in MPA
PW – presumed to be at or near western limit in MPA
PV Parks Victoria
RE – recorded to be at eastern limit in MPA
RPP – Research Partners Panel
RW – recorded to be at western limit in MPA
ROV - remote operated vehicle
SRMP - Subtidal Reef Monitoring Program
VU - Vulnerable
VROTS - Victorian Rare or Threatened Species

1 Introduction

1.1 Victoria's Marine Protected Areas

Victoria's marine environment has been classified into five bioregions (Otway, Central Victoria, Flinders, Twofold Shelf and Victorian Embayments (Figure 1, IMCRA 2006). Within each marine bioregion there is a variety of distinct and unique habitats and biological communities, structured by a combination of physical, chemical and biological processes (Parks Victoria 2003). These bioregions reflect how physical processes in particular have influenced the distribution of ecosystems and biodiversity over scales of 100 – 1000 km (mesoscales). General habitats include intertidal rocky reefs, shallow rocky reefs, deep rocky reefs, pelagic waters, intertidal sandy (beaches) and muddy (mudflats) soft sediments and subtidal sandy and muddy soft sediments. Habitats are also formed by certain types of plant and animal species. Biological habitats include kelp forests on shallow rocky reefs, sponge and coral gardens on deep rocky reefs, seagrass on sandy sediments and rocky reefs, and mangrove and saltmarsh on sheltered intertidal sediments. The flora and fauna is generally quite different between these habitat types. The types of species and their abundances in any particular habitat can vary along more subtle environmental gradients, particularly gradients in wave exposure, depth and light availability (Parks Victoria 2003).

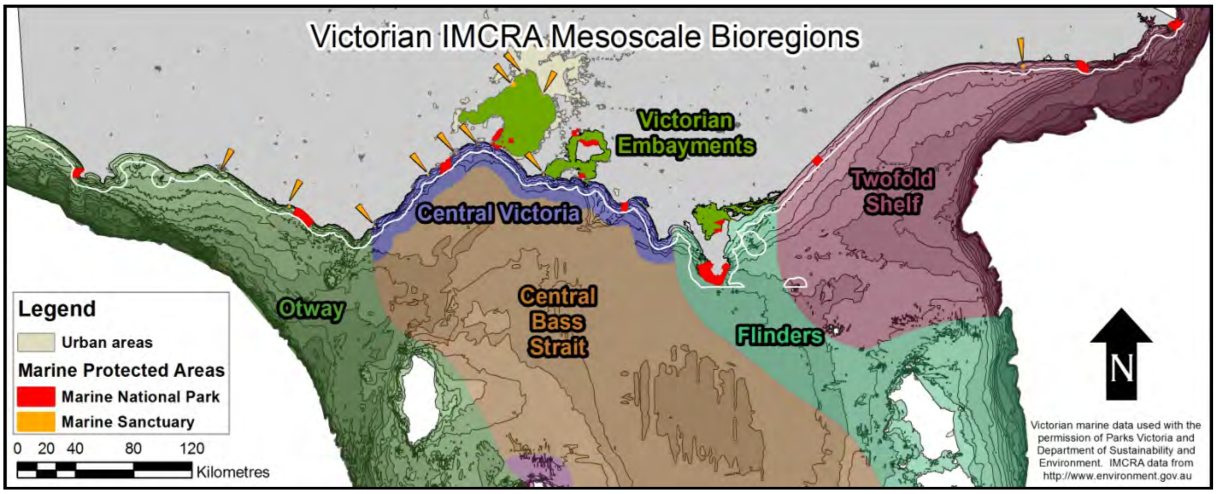


Figure 1. Locations of IMCRA mesoscale (*i.e.* 100-1000km) bioregions (IMCRA 2006 v4)

Victoria's system of Marine National Parks (MNPs) and Marine Sanctuaries (MSs) was established under the *National Parks Act (1975)* and gazetted in November 2002 (Power and Boxshall 2007). It was established to conserve and protect the diversity of Victoria's marine environment, its ecological processes, habitats and associated flora and fauna (Parks Victoria 2003).

Sites for the Marine Protected Areas (MPAs) were chosen to be representative of the diversity of Victoria's marine environment (ECC 2000) and the 24 parks are spread across Victoria's five marine bioregions (Figure 1). More than one park and/or sanctuary was usually selected within each bioregion, to reflect as far as possible the range of habitats and biological communities within each, to incorporate the variability within habitats, and to insure against loss due to unforeseen or future catastrophic events (Parks Victoria 2003). These parks and sanctuaries now protect 5.3 % of Victoria's coastal waters, incorporating important marine habitats and species, significant natural features, cultural heritage and aesthetic values (Parks Victoria 2003). The MPAs are highly protected areas where no fishing, extractive or damaging activities are allowed but to which access is unrestricted. Recreation, tourism, education and research are encouraged and properly managed (Power and Boxshall 2007). Marine Sanctuaries are much smaller than MNPs. MPAs are generally classified Category II (MNP) and III (MS) under the International Union for Conservation of Nature (IUCN) classification (Power and Boxshall 2007); the exceptions are Point Cooke, Ricketts Point and Beware Reef MSs which are all IUCN Category II. There are also Marine Parks, Marine Reserves, and Marine and Coastal Parks which have the primary objective of conservation but allow a larger range of ecologically sustainable uses than MNPs or MSs (Parks Victoria 2003).

1.2 Purpose of Report

Since declaration of Victoria's system of MPAs and release of the first Marine Natural Values Study (MNVS) in September 2003 (Plummer *et al.* 2003) there have been ongoing monitoring and research programs aiming to increase our knowledge about the MPAs. Programs commissioned by Parks Victoria include habitat mapping, intertidal and subtidal reef monitoring, statewide and individual MPA risk assessment as well as various research projects (reports from which are available online at http://www.parkweb.vic.gov.au). These programs have considerably increased our knowledge of the habitats, and flora and fauna of Victoria's 13 MNPs and 11 MSs. The primary aim of this report is to add this new knowledge to the identification and description of the natural values associated with Victoria's MPAs.

Natural values are defined as the parts of the environment valued by people and are considered to be a proxy for biodiversity and natural processes. They are also the basis of Parks Victoria's Adaptive Management Framework (Power and Boxshall 2007). The natural values of Victoria's MPA system incorporate qualities such as distinct physical environments and processes, the diversity and arrangement of marine habitats, ecological communities (including their diversity, richness and important biological processes) as well as species of particular conservation significance (Power and Boxshall 2007).

This report updates the first MNVS (Plummer *et al.* 2003) for the Otway bioregion and is one of a series of four reports covering Victoria's MPAs. It aims to give a comprehensive overview of the important natural values of each MPA that will assist in park management within the region. The report will also provide a resource for education and public recognition of the natural values of the MPAs in the Otway bioregion.

1.3 Structure

This report firstly describes the Otway bioregion and the MPAs within that bioregion. This report then identifies and describes the specific natural values on a park by park basis, including maps of the available spatial data. Research undertaken within each MPA is identified and the findings of that research in relation to the parks' natural values are discussed. The report also discusses the major threats to the natural values as identified by a comprehensive risk assessment conducted by Carey *et al.* (2007a; 2007b). Knowledge gaps for each MPA are identified and highlighted. Marine Parks, Reserves and Marine and Coastal Parksare not specifically addressed in this report.

1.4 Methods

The information within the original MNVS (Plummer *et al.* 2003) was used as a starting point and guide for this report. Bioregional scale physical, habitat and biota assemblage characteristics were derived from mostly pre-declaration sources (*i.e.* LCC 1993; ECC 2000; Ferns and Hough 2000; IMCRA 2006). Technical reports and papers from the Parks Victoria MPA monitoring and research programs and other research conducted since the first natural values report were reviewed and incorporated. The aim was to achieve consistency in the basic level of information presented for each MPA and to highlight knowledge gaps.

This report used existing spatial data in a geographic information system (GIS) format to assist in determining the physical and biological characteristics of natural values for each MPA. The available spatial layers included:

- MNP and MS boundary (for calculating areas of MPAs; Parks Victoria, PV);
- Victorian Coastline at 1:25,000 (for calculating shoreline lengths; Department of Sustainability & Environment, DSE);
- Marine substrata for Victoria's open coast (derived from Landsat imagery and hydro-acoustic mapping, Marine & Freshwater Research Institute, MAFRI and CSIRO);
- Marine substrata for shallow marine habitats (derived from aerial photography and Landsat imagery and video ground truthing; Primary Industries Research Victoria, PIRVic for PV);
- Marine substrata and habitats in Victoria MNPs (from hydro-acoustic mapping, video ground truthing and modelling as part of a joint venture between Parks Victoria and the Coastal CRC; involving the University of Western Australia, Fugro Pty Ltd and Deakin University);
- Bathymetry for Bass Strait (1:250,000) and bays and inlets (1:25,000) (MAFRI database and sourced from Victorian Channel Authority and Australian Hydrographic Office databases);
- Detailed bathymetry for shallow waters from Light Detection And Ranging (LiDAR) (DSE);
- Shoreline coastal type (Oil Spill Response Atlas – MAFRI);
- Vicmap watercourse 1:25000 (used to identify fresh water sources; metadata at http://www.giconnections.vic.gov.au/content/vicgdd/record/ANZVI0803002490.htm);
- Shorebird habitats and roosts (Oil Spill Response Atlas and DSE);
- Victorian Threatened Fauna database point records (DSE);
- Atlas of Victorian Wildlife point records (DSE); and
- Sites of Geological and Geomorphological Sites of Significance (Minerals and Petroleum Victoria).

In addition to these spatial databases, a number of digital datasets provided quantitative and descriptive information about habitats and species in and around the MNPs and MSs. The primary datasets used in this study:

- Subtidal Marine Monitoring Programs (SRMP, Australian Marine Ecology, AME for PV);
- Sea Search Community Based Monitoring Program (PV); and
- Monitoring and Assessment of Victoria's Rocky Reefs (Monitoring and Assessment of Victoria's Rocky Intertidal reefs, MAVRIC, Museum Victoria).

The assessment of marine habitat distribution included new shallow (<10m) and deeper subtidal mapping of bathymetry, substrates and biota as well as previous mapping. Not all MPAs had the same data from monitoring, survey or research so a tiered approach was taken, especially with the substrate and habitat descriptions and maps. All MPAs have broad level (*i.e.* 1:250,000 scale) bathymetry and substrate mapping. All MPAs also have high resolution bathymetric mapping in shallow waters derived from aerial LiDAR surveys. Some MPAs have high resolution hydroacoustic mapping that, with video ground truthing, allows the bathymetry and substrate to be mapped and modelled respectivelyat finer scales. This substrate mapping and modelling can be extended to broad habitat mapping for some MPAs. Descriptions of marine ecological communities were derived from new monitoring and mapping reports as these generally had a greater level of detail and more sites than previous research.

Species of conservation significance, particularly species distribution information, were derived from new research, monitoring and mapping reports. Species from the Atlas of Victorian Wildlife recorded near and within MPAs were included in the lists of species of conservation significance for each MPA. Constraints were made on the database searches to ensure all records were for animals in the marine habitats in or near (*i.e.* within 5 km) individual MPAs. All animals not found below the high water limit were excluded. Records of dead animals were not included in this report.

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next ten years were identified. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). The threats listed in this report are the hazards identified as having an extreme risk. The outputs from the workshops have informed Parks Victoria in their management planning process and prioritisation of research gaps and on ground works.

Data gaps were identified for each MPA as existing information was reviewed.

Results from Parks Victoria monitoring and research programs and other databases were used to produce a non-comprehensive checklist of species known to be part of the intertidal and subtidal reef flora and fauna in MPAs in the Otway bioregion (Appendix 1).

1.5 Otway Bioregion

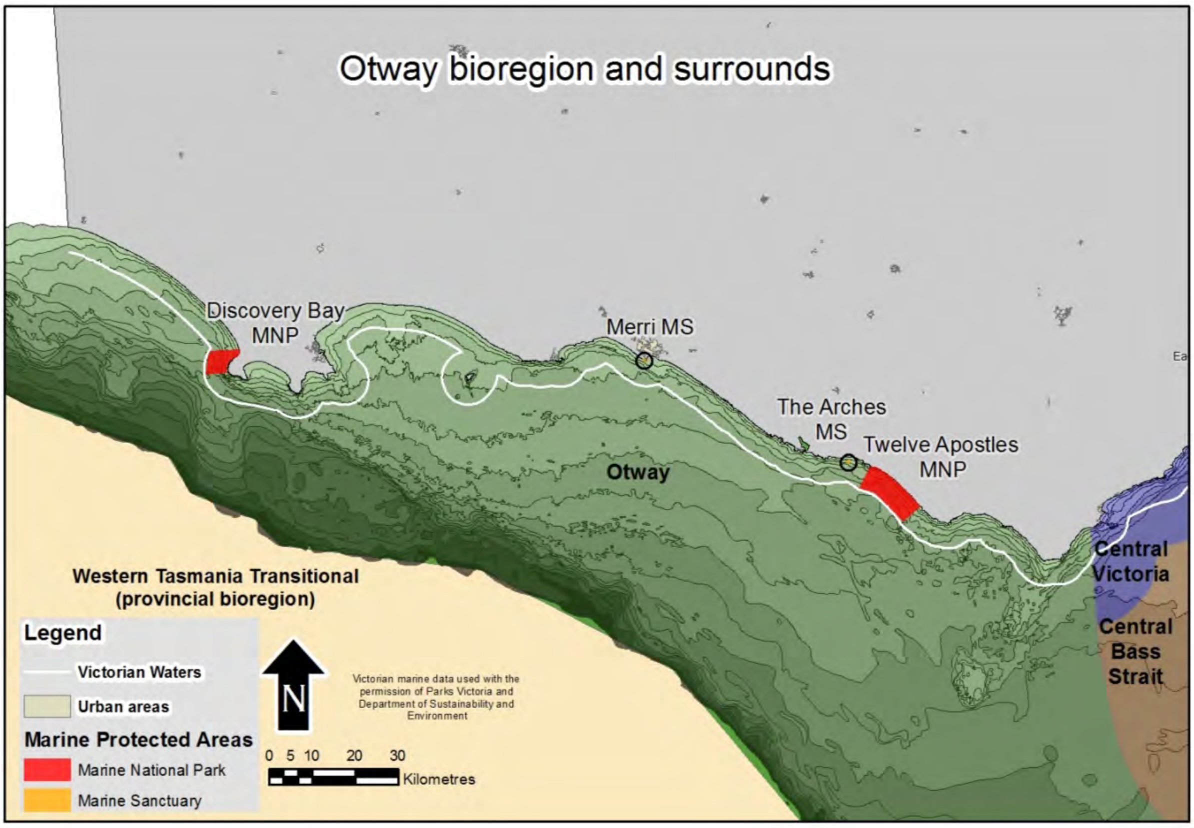


Figure 2. Otway bioregion with IMCRA mesoscale bioregions, Marine National Parks and Marine Sanctuaries.

The Otway Marine Bioregion extends from Cape Jaffa in South Australia to Apollo Bay and to the western Bass Strait islands such as King Island (IMCRA 2006). In Victoria it contains two MNPs, Discovery Bay and Twelve Apostles, and two MSs, Merri and The Arches (Figure 2). It has a cool temperate climate and waters, with localised coastal upwellings along the

Bonney coast to Discovery Bay, Cape Bridgewater and Cape Nelson, which provide nutrient enrichment and increase productivity, making it an important area for seabirds, fur seals and whales. The sea temperature is generally 2 – 3 °C lower than in the other Victorian bioregions (Parks Victoria 2003). The tidal range is microtidal (0.8 to 1.2 m). It is subject to the greatest wave action in Victoria, being nearly continuously subjected to large predominantly south-west swells generated in the Southern Ocean (Parks Victoria 2003). Its high energy coastline has headlands of volcanic outcrops and limestone cliffs and extensive and complex deeper reef systems offshore. The seascapes include submerged volcano cones, drowned river channels, highly eroded underwater steps and reef faces and the islands of Lawrence Rocks and Deen Maar (Lady Julia Percy Island) (Edmunds *et al.* 2010a). Sandy beaches and dunes are common in the western region and cliffed shorelines are common elsewhere (IMCRA 2006). Marine habitats also include rocky rubble, steep drop-offs at the base of cliffs, sandy soft sediments and extensive offshore reefs (Parks Victoria 2003). They include extensive kelp and seaweed beds extending into deep waters, as well as sessile invertebrate (sponge garden) communities on complex inshore reefs and offshore deep reefs. Seagrass beds occur in the lee of reefs (IMCRA 2006). The biota of this region consists predominantly of cosmopolitan, southern temperate and western temperate species that are well adapted to the colder, rough water conditions (Parks Victoria 2003). However the reef habitats and communities are largely unexplored (Edmunds *et al.* 2010a). For many macro-algal communities, this region forms the westward limit of a number of species (IMCRA 2006). Plant species diversity is very high, particularly among the red algae. Fish and plant species-richness are both high compared to other South Australian, Victorian and Tasmanian regions (IMCRA 2006).

1.6 Other Victorian Bioregions

The Central Victorian Bioregion extends from Apollo Bay to Cape Liptrap, it does not include Port Phillip Bay and Western Port, which are included in the Victorian Embayments Bioregion (IMCRA 2006). Within the Central Victoria Bioregion, there are two MNPs, Point Addis and Bunurong, and five MSs, Marengo Reef, Eagle Rock, Point Danger, Barwon Bluff and Mushroom Reef. It has a temperate climate with moist winters and warm summers. The shore is characterised by cliffs with sandy beaches and has the western-most occurrence of granites in its eastern region. Offshore gradients are steep in the east to very steep in the west (IMCRA 2006). It is relatively exposed to swells and weather from the south-west, but less so than the Otway Bioregion (Parks Victoria 2003). Sea surface temperatures are representative of Bass Strait waters and wave energy is moderate (IMCRA 2006). Tides change from twice to four times a day from west to east (IMCRA 2006). The habitats include shallow near-shore reefs and sandy beaches along with large areas of subtidal sandy sediment and patchy, low profile subtidal reef. Reefs can be limestone, basalt, granite or mudstone (Parks Victoria 2003). The limestone reefs are usually offshore from a surf beach and readily erode to provide a complex habitat for a diverse array of macroalgae, sponges, bryozoans, corals and ascidians as well as mobile crevice dwellers (Parks Victoria 2003). The dominant biota of this region consists of a diverse mixture of species from all of the adjacent biogeographical provinces – western, eastern and southern temperate species – in addition to cosmopolitan southern Australian species (Parks Victoria 2003).

The Victorian Embayment bioregion is a discontinuous region that contains the major embayments, inlets and some of the major estuaries along the Victorian coast (Figure 1, IMCRA 2006). Within the bioregion, there are five MNPs, Port Phillip Heads in Port Phillip Bay, Yaringa, French Island, Churchill Island in Western Port, and Corner Inlet. Port Phillip Heads MNP is discontinuous and consists of six sites in the southern region of Port Phillip Bay. Three MSs, Point Cooke, Jawbone and Ricketts Point in Port Phillip Bay, also occur in the bioregion. The climate is moist temperate, with a pronounced west to east variation in catchment run off and seasonality. Variations in salinity and temperature are much higher than on the open coast (Parks Victoria 2003). The embayments have a variety of forms from drowned river valleys to impounded drainage behind dune barrier systems, their maximum depth is generally less than 20 m, but reaches depths of approximately 50 metres in Port Phillip Heads. They have low energy coastlines with large tides, influencing the extensive areas of subtidal and intertidal sediments. Rock outcrops are limited mainly to the margins (IMCRA 2006). Some shallow reef areas are present in Port Phillip and Western Port (Parks Victoria 2003). The biota of the Victorian embayments include a diverse range of biotic assemblages found in estuarine and open coast environments depending on their morphological and hydrological characteristics (Parks Victoria 2003; IMCRA 2006). Port Phillip Bay is a marine embayment fringed by seagrass beds, rocky reefs and sandy beaches. The benthic assemblages in the muddy central region are distinct from those in the sand to the west and east. Western Port Bay and Corner Inlet are large muddy estuaries with extensive mudflats, mangroves, saltmarshes and seagrass beds (IMCRA 2006).

The Flinders Bioregion encompasses Wilsons Promontory and the eastern Bass Strait islands of the Furneaux Group in Tasmania (Figure 1, IMCRA 2006). In Victoria, it contains one MNP, Wilsons Promontory, and no Marine Sanctuaries. It has a cold temperate climate. It has less exposure to swells compared with the other bioregions (Parks Victoria 2003). However, this region is subject to high current flows and high winds, with some influences from local and regional upwellings and current boundaries (*e.g.* East Australian Current, EAC). The winds can create substantial surface waves, affect local currents and cause turbidity (Parks Victoria 2003). Wave exposure is moderate but higher on the western side of Wilsons Promontory than on the eastern side. The tidal range is macrotidal. The coastline is predominantly granite headlands and promontories with long sandy beaches in between. Shores plunge steeply onto a sandy sea floor (IMCRA 2006). The reefs consist of a variety of forms: smooth, featureless reef; deep vertical walls; fissures and pinnacles; boulder fields (with boulders ranging from 1 to 5 m in size) creating extensive overhang and cavern spaces; and rubble beds (0.1 – 1 m cobble and boulders) (Parks Victoria 2003). There are extensive deepwater and shallow sandy beds. The biota is cool temperate with low numbers of warm-temperate species that are commonly found in New South Wales (IMCRA 2006). Although the dominant biota of this region consists of a mixture of species from all of the adjacent biogeographical provinces, the eastern and southern provincial species appear to be more prevalent than the western province species (Parks Victoria 2003).

The Twofold Shelf Bioregion extends east of Wilsons Promontory (including the Kent Group Islands in Tasmania) to Tathra in southern New South Wales (Figure 1, IMCRA 2006). Within Victorian waters there are three MNPs, Ninety Mile Beach, Point Hicks and Cape Howe, and one MS, Beware Reef. Its climate is moist cool temperate. Water temperatures are generally warmer than elsewhere on the Victorian open coast due to the influence of the EAC (Parks Victoria 2003). These waters are also seasonally and periodically influenced by the boundary of the EAC with the more southern subtropical convergence (Harris *et al.* 1987). The continental slope is quite close to the far eastern Victorian shore and cold-water upwellings are frequent (Parks Victoria 2003). These upwellings provide nutrients to inshore ecosystems, contributing to higher productivity. Wave energy is relatively low. The coastline is dominated by dunes and sandy shorelines, with granite outcrops (IMCRA 2006). There are extensive areas of inshore and offshore sandy soft sediments. This region also has occasional strips of low-relief calcarenite reef immediately behind the surf zone (7 – 25 m deep) (Parks Victoria 2003). The continental shelf becomes broader and shallower in the west. Reefs are generally dominated by warm temperate species. The fauna is characterised by distinctive assemblages of reef fish, echinoderms, gastropods and bivalves. Southern NSW species occur in Victorian waters. In particular the large sea urchin *Centrostephanus rodgersii,* which removes macroalgae from shallow reefs creating a coralline algal encrusted habitat, occurs on the reefs in the east (IMCRA 2006).

2 Marine National Parks

2.1 Discovery Bay Marine National Park

Discovery Bay MNP is the one of two Marine National Parks in the Otway bioregion (Figure 2). The Otway Bioregion also contains Twelve Apostles MNP, and Merri and The Arches Marine Sanctuaries. Discovery Bay MNP is on the western side of Cape Duquesne. It is approximately 19 km west of Portland and 380 km west of Melbourne. The MNP covers 2830 hectares adjacent to Cape Bridgewater along the coast from Blacks Beach to Whites Beach and offshore to three nautical miles, the limit of Victorian waters (Figure 4 & Figure 5). Between Whites Beach and Cape Duquesne the park boundary commences 500 m from the coastline. Discovery Bay MNP abuts the Discovery Bay Coastal Park and includes the areas between high and low water mark that were formerly part of the Coastal Park (Parks Victoria 2007a). The main access to the MNP shore is via a short walk from Whites Beach and Blacks Beach (Parks Victoria 2007a). Boat access is from the beach at Bridgewater Bay and Portland Harbour boat ramp (Parks Victoria 2007a). The wrecks of three wooden sailing barques, the *Jane,* the *Ann* and the *Marie,* are thought to be in the vicinity of the MNP (Parks Victoria 2007a).

Aboriginal tradition indicates that the Discovery Bay MNP is part of Gunditjmara *Country* (Parks Victoria 2007a).

Important natural values of Discovery Bay MNP are its basalt and calcarenite intertidal and subtidal rocky reefs, extensive sandy subtidal soft sediment and the biota they support (ECC 2000; Carey *et al.* 2007b; Parks Victoria 2007a). The MNP is part of the largest coastal basalt formation in western Victoria, and among the highest wave energy environments in the State (ECC 2000; Carey *et al.* 2007b). It has rocky habitats of complex forms, including low profile calcarenite-capped basalt platforms, isolated low calcarenite reefs, and heavy sloping basalt walls (ECC 2000; Carey *et al.* 2007b). Its deep (33 - 55 m) calcarenite reefs with thick growths of sessile invertebrates (*e.g.* sponges, ascidians, bryozoans and gorgonians) are an important natural value (ECC 2000; Carey *et al.* 2007b), as are its shallow basaltic reefs covered by large kelps such as *Ecklonia radiata*. Its intertidal and shallow subtidal reefs have a high diversity of invertebrates (ECC 2000; Carey *et al.* 2007b; Parks Victoria 2007a). Its extensive subtidal soft sediments of mainly fine sand, with high (80%) carbonate content, is an important natural value (ECC 2000; Carey *et al.* 2007b). Its open waters support blue whale *Balaenoptera musculus* and white shark *Carcharodon carcharias* (ECC 2000; Carey *et al.* 2007b).

The Bonney Coast, from South Australia to Discovery Bay, is a productive area because of cold water upwellings (Edmunds *et al.* 2010a). These greatly influence primary productivity and maintain commercially important fisheries species such as blacklip abalone *Haliotis rubra* and the southern rock lobster *Jasus edwardsii* (Edmunds *et al.* 2010a). High productivity in the Bonney Coast is also an important feeding ground for seabirds, fur seals and whales (Edmunds *et al.* 2010a).

On the intertidal basalt reefs in the north of the MNP Neptune's necklace *Hormosira banksii* is common, along with sea lettuce *Ulva* sp., globe algae *Colpomenia sinuosa* and encrusting red algae (Plummer *et al.* 2003; Costa *et al.* 2010; O'Hara *et al.* 2010). Sessile invertebrates found on the intertidal rock platforms in the MNP include the anemones *Aulactinia veratra*, *Actinia tenebrosa* and *Anthothoe albocincta*, the surf *Catomerus polymerus*, honeycomb *Chamaesipho tasmanica* and rosette barnacles *Tetraclitella purpurascens,* and the mussels little black horse *Limnoperna pulex* and beaked *Austromytilus rostratus* (Costa *et al.* 2010; O'Hara *et al.* 2010). The purple rock crab *Leptograpsus variegatus* is also found on the intertidal reef of the MNP (Costa *et al.* 2010; O'Hara *et al.* 2010). The invertebrate fauna is dominated by molluscs (Costa *et al.* 2010; O'Hara *et al.* 2010). This includes top shells *Austrocochlea* constricta and *A. odontis*, the false limpet *Siphonaria diemenensis*, true limpets *Cellana tramoserica* and *Patelloida latistrigata*, black nerite *Nerita atramentosa*, periwinkles *Austrolittorina praetermissa*, *A. unifasciata* and *Bembicium nanum,* and the predatory gastropods *Cominella lineolata*, *Lepsiella reticulata*, and *L. vinosa* (Costa *et al.* 2010; O'Hara *et al.* 2010). Intertidal fish include the blenny *Parablennius tasmanianus*, cling fish *Aspasmogaster tasmaniensis*, and weedfish including Johnston's *Heteroclinus johnstoni*, common *Heteroclinus perspicillatus* and crested *Cristiceps australis* (Plummer *et al.* 2003).

Bull kelp *Durvillaea potatorum* grows on the intertidal reef edge (Ball and Blake 2007; Costa *et al.* 2010; O'Hara *et al.* 2010). Mixed brown algae, including kelp *Ecklonia radiata* and crayweed *Phyllospora comosa,* form the canopy algae on the sand free basalt subtidal reefs in the south-east of Discovery Bay MNP (Ierodiaconou *et al.* 2007). Also growing on these reefs are the brown algae *Scytothalia*, *Sargassum* and giant kelp *Macrocystis pyrifera,* and green algae *Caulerpa* (Ball and Blake 2007; Holmes *et al.* 2007a). Sessile invertebrates, predominately compact sponges, become more dominant with depth (Ierodiaconou *et al.* 2007). Mobile invertebrates on these subtidal reefs include seastars, southern rock lobster *J. edwardsii* and blacklip abalone *H. rubra* (Plummer *et al.* 2003). On the deeper sand-inundated reefs in the west of the MNP sessile invertebrates dominate the reef where it is free of sand (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007; Monk *et al.* 2011). This includes abundant ascidians, hydroids, and bryozoans along with gorgonian soft corals, hard corals, *Tethya* sponges, zooanthids and the sea whip *Primnoella australasiae* (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007; Monk *et al.* 2011).

Large schools of purple wrasse *Notolabrus fucicola* and juvenile sea sweep *Scorpis aequipinnis* occur on the nearshore subtidal reefs (Plummer *et al.* 2003; Ball and Blake 2007). Also observed on these reefs are marble fish *Aplodactylus arctidens,* moonlighters *Tilodon sexfasciatus*, magpie perch *Cheilodactylus nigripes*, zebra fish *Girella zebra*, yelloweye mullet *Aldrichetta forsteri* and painted dragonets *Eocallionymus papilio* (Plummer *et al.* 2003). Other fish commonly found on the subtidal reefs of the MNP include the blue-throated wrasse *Notolabrus tetricus* and rosy wrasse *Pseudolabrus psittaculus* (Monk *et al.* 2010). Western blue gropers *Achoerodus gouldii* have been observed in the high profile reef systems in 50 m of water west of Cape Duquesne (Ierodiaconou *et al.* 2007).

Discovery Bay MNP provides important feeding and roosting habitat for fifteen threatened bird species listed under the *Flora and Fauna Guarantee* (*FFG*) *Act* (1998). Two of these are regarded as endangered; the wandering albatross *Diomedea exulans is* listed as endangered at the state level, while the southern giant-petrel *Macronectes giganteus* is endangered at the national level. The MNP protects feeding areas for ten internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). The intertidal reef provides an occasional haul-out area for state vulnerable New Zealand *Arctophoca forsteri* and Australian fur seals *Arctocephalus pusillus doriferus*. It is an important feeding ground for the nationally endangered blue whale *Balaenoptera musculus.* The MNP has one endemic crustacean, the southern hooded shrimp *Athanopsis australis.* Seven species of algae and one invertebrate are known or presumed to be at the limit of their distribution in the MNP.

Serious threats to the MNP include poaching of abalone and the limited ecological knowledge of important habitats, communities and processes. Climate change also poses a serious threat to the integrity of Discovery Bay MNP. Measures to address or minimise these threats form part of the management plan for Discovery Bay MNP (Parks Victoria 2007a). Specific research aims to increase ecological knowledge about the natural values of, and threats to Discovery Bay MNP.

2.1.1 PHYSICAL PARAMETERS & PROCESSES

The Discovery Bay MNP is 2830 hectares in size which makes it the eighth largest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 1, Figure 4). The MNP is predominately > 30 m deep (Figure 4). The MNP is exposed to storms and southwesterly swells of the Southern Ocean, and resulting high deepwater wave energy. The Zeehan Current is influential moving water in a south-easterly direction through the MNP. The warm Leeuwin Current flows east along the southern coast of Australia and may influence water temperature in the MNP particularly during La Niña years (Parks Victoria 2007a). The continental shelf is relatively narrow near the MNP, extending only 50 km offshore. Wind driven coastal circulation across the shelf causes regular upwellings of cool nutrient rich water, particularly during spring and summer, known as the Bonney Upwelling. The upwelling has a major influence on the ecosystem. It stimulates phytoplankton and zooplankton blooms that form the basis of a rich pelagic food chain providing feeding grounds for seabirds, fish, blue whales *Balaenoptera musculus* and Australian fur seals *Arctocephalus pusillus doriferus*. Surface water temperatures are influenced by the cold Bonney Upwelling, with mean surface water temperature varying seasonally between 14 °C and 18 °C. Tidal variation is 0.8 m for spring tides and 0.4 m for neap tides (Plummer *et al.* 2003). Glenelg River discharges approximately 50 km to the west of Discovery Bay MNP and Fawthrop Lagoon discharges 19 km east of the MNP (Table 1). A number of freshwater springs flow from the cliff faces of Cape Bridgewater onto the basalt wavecut platforms within the park boundary (Parks Victoria 2007a).

The coastline in the Discovery Bay MNP consists of cliffed basalt which is capped by dune calcarenite (Bird 1993). The coast exposes a variety of volcanic lava structures such as pahoehoe or ropey lava, and lava blisters (Bird 1993). These have been dissected into cliffs and stone ledges, with blowholes, caves and clefts also present (Bird 1993). Cape Duquesne adjacent to Discovery Bay MNP is listed as state geological significance due to its calcarenite cliffs with caves and blowholes overlying basalt (Figure 6). To the east of the MNP Shelley Beach in Bridgewater Bay is listed as regionally significant due to its modern deposits of shells.

Figure 3. Discovery Bay Marine National Park. Photo by NRE.

Table 1. Physical attributes of the Discovery Bay Marine National Park.

Park Name	Discovery Bay
Conservation status	Marine National Park
Biophysical Region	Otway
Size	2830 ha (ranked 8th of 24)
Length of coastline	~ 2.3 km
Shoreline geology	Basalt and calcarenite limestone
Area with depth:	
Less than 10m	112.5 ha
Comprising: Intertidal (high res)	*(1.5 ha)*
Intertidal-5m (high res)	*(42 ha)*
5 - 10 m (high res)	*(61 ha)*
*0-10m (low res)**	*(8 ha)*
10-20 m	160 ha
20-30 m	363 ha
30-40 m	434 ha
40-50 m	305 ha
50-60m	915 ha
60-70m	465 ha
70-80m	77 ha
Mean tidal variation - spring	0.8 m
Mean tidal variation - neap	0.4 m
Mean water temp - summer	17.0°C
Mean water temp - winter	14.0°C
Adjacent catchment	Coastal Park
Discharges into MNP	None
Nearest major estuary (distance & direction)	Glenelg River 50km to the west Fawthrop Lagoon 19 km to the east

* artefact of combining three different resolutions of bathymetric mapping, coarse mapping could not be separated into smaller depth categories

2.1.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats (Figure 6, Figure 7 & Figure 8) is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to target management activities effectively, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. The main habitats present in Discovery Bay MNP include subtidal reef and soft sediment, and the water column. A relatively small amount of intertidal reef and beaches are also present in the MNP. In 2004 underwater video was used to groundtruth shallow water habitat mapping derived from aerial photos (Ball and Blake 2007). This shallow water mapping was only possible in the north-eastern section of the MNP between Whites and Blacks Beaches in Descartes Bay as the water depth quickly drops off along Cape Duquesne (Figure 4 & Figure 8). In 2005 the deep (>15 m) subtidal substrate and biota was surveyed (Figure 6 & Figure 7) and mapped acoustically (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007). Underwater video transects allowed the substrate and biota to be modelled for the areas not surveyed.

The MNP is shallower along its eastern edge and gets deeper as you move south-west (Holmes *et al.* 2007a). In the south of the MNP the water depth is 30 to 75 m and 14 to 55 m close to shore (Holmes *et al.* 2007a). The nearshore substrate is mixed solid reef and sand to water depths of approximately 35 m; then there is a band of sand from 35 to 55 m, then a complex mosaic of sediment and broken reef out to the MNP boundary (Holmes *et al.* 2007a). Unconsolidated subtidal sediments (Figure 6) form the largest habitat class in the MNP (Ierodiaconou *et al.* 2007). The shallower north eastern area in Descartes Bay is largely composed of fine, well sorted sand flats with some fine rippling (Ball and Blake 2007; Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007). The occurrence of ripples attests to the frequent movement and transport of sediment (Ierodiaconou *et al.* 2007). The nearshore substrate in the north-east is predominantly bare sand (Figure 8) extending offshore from the dunes and sand beach (Ball and Blake 2007). Sessile invertebrates occur in isolated areas within the sand band from 35 to 55 m depth, suggesting that the sediment is a thin veneer over hard substrate (Holmes *et al.* 2007a). In deeper areas to the west of the MNP (Figure 6), sediments tend to be coarser and form into broad (> 40 cm), well defined sand waves (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007).

In the south of Descartes Bay (Figure 6 & Figure 8) a narrow intertidal basalt reef extends offshore from the rocky cliffs of Cape Duquesne into a narrow band of shallow subtidal basalt reef (Ball and Blake 2007; Ierodiaconou *et al.* 2007). This reef is not inundated by sand like other reefs in the MNP (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007). These are very high profile reefs, with vertical walls and cliffs up to 30 m (Ierodiaconou *et al.* 2007). Massive basalt boulder fields occur at the base of these submarine cliffs over a bed of calcarenite reef and coarse sand (Ierodiaconou *et al.* 2007). Areas of mostly bare boulders also occur amongst the reef (Ball and Blake 2007). Lower profile (< 1 m – 5 m), sand inundated calcarenite reef characterize the western half of the MNP in depths ranging from 40 – 70 m (Ierodiaconou *et al.* 2007).

Habitat dominated by mixed brown algae, kelp *Ecklonia radiata* and crayweed *Phyllospora comosa* is confined to shallow (<20 m) high profile basalt peaks (Figure 7) in the south-east of the MNP (Ierodiaconou *et al.* 2007). The habitats are highly dynamic as a result of the wave and storm activity. Kelp beds are often decimated by storm activity (Parks Victoria 2007a). A sparse mixed red algal understorey becomes denser at the deeper margins of these reefs (Ierodiaconou *et al.* 2007). Sessile invertebrates, in the mixed brown algae beds, become more dominant with depth (Ierodiaconou *et al.* 2007). Deeper reefs in the west of the MNP consist of a sponge dominated habitat with other sessile invertebrates (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007; Monk *et al.* 2011). The sessile invertebrates are in highest densities on reef crests, ridges and high profile plateaus where the effects of sand inundation are mitigated by vertical relief (Ierodiaconou *et al.* 2007). Sponges occur at all depths in the MNP (Ierodiaconou *et al.* 2007). Red algae grows in depths up to 60 m and kelp *Ecklonia radiata* in up to 50 m, although both decrease in abundance with depth (Ierodiaconou *et al.* 2007). Bryozoans and gorgonians are found in depths >30 m. Ascidians were only observed in 30-40 m and the sea whip *Primnoella australasiae* is only found in depths >50 m (Ierodiaconou *et al.* 2007).

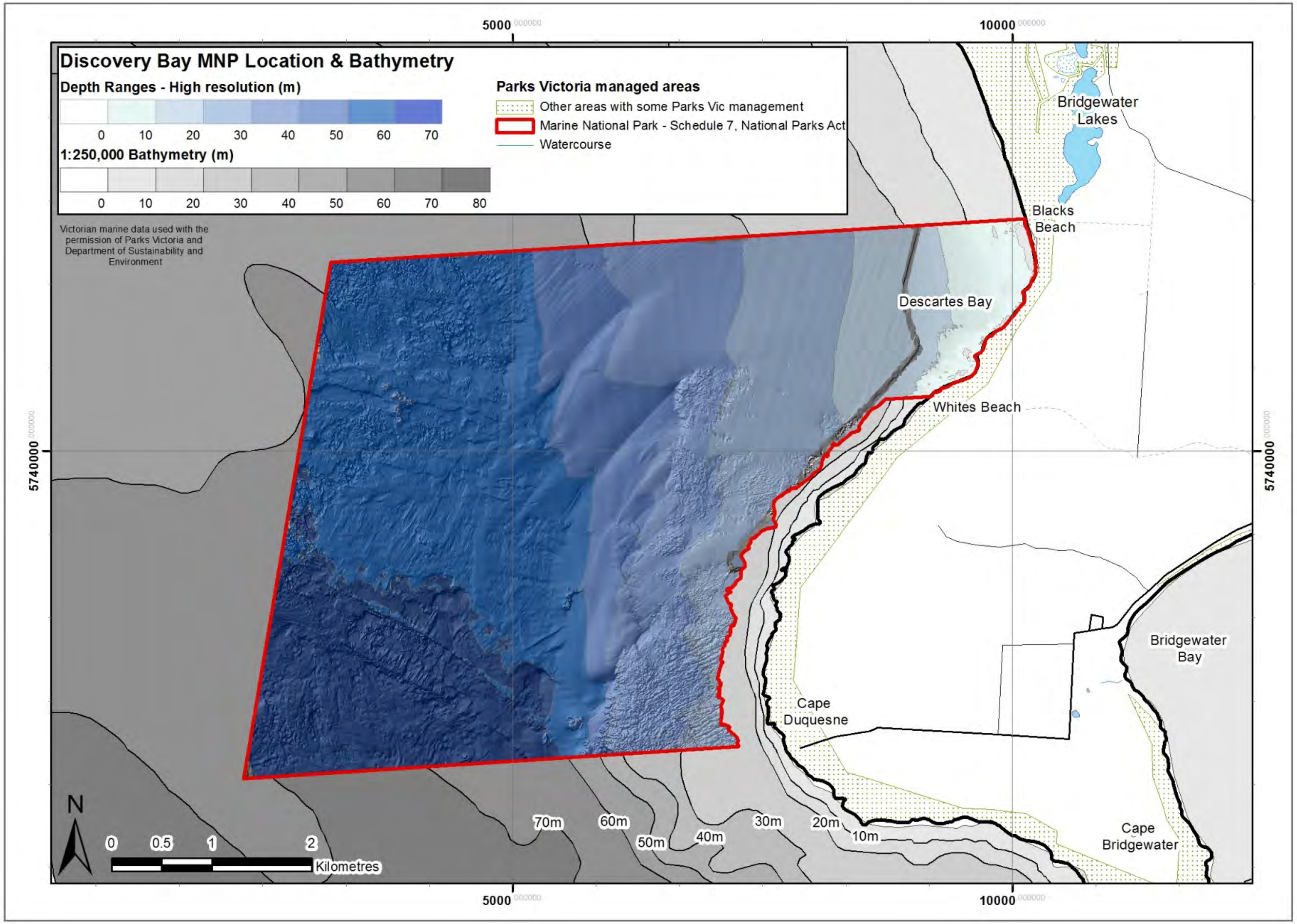


Figure 4. Location map of the Discovery Bay Marine National Park with bathymetry. There are no ongoing monitoring sites in the MNP.

Figure 5. Aerial photograph of the coastline of the Discovery Bay Marine National Park (Skyview Aviation 21/01/06). From Ball and Blake 2007.

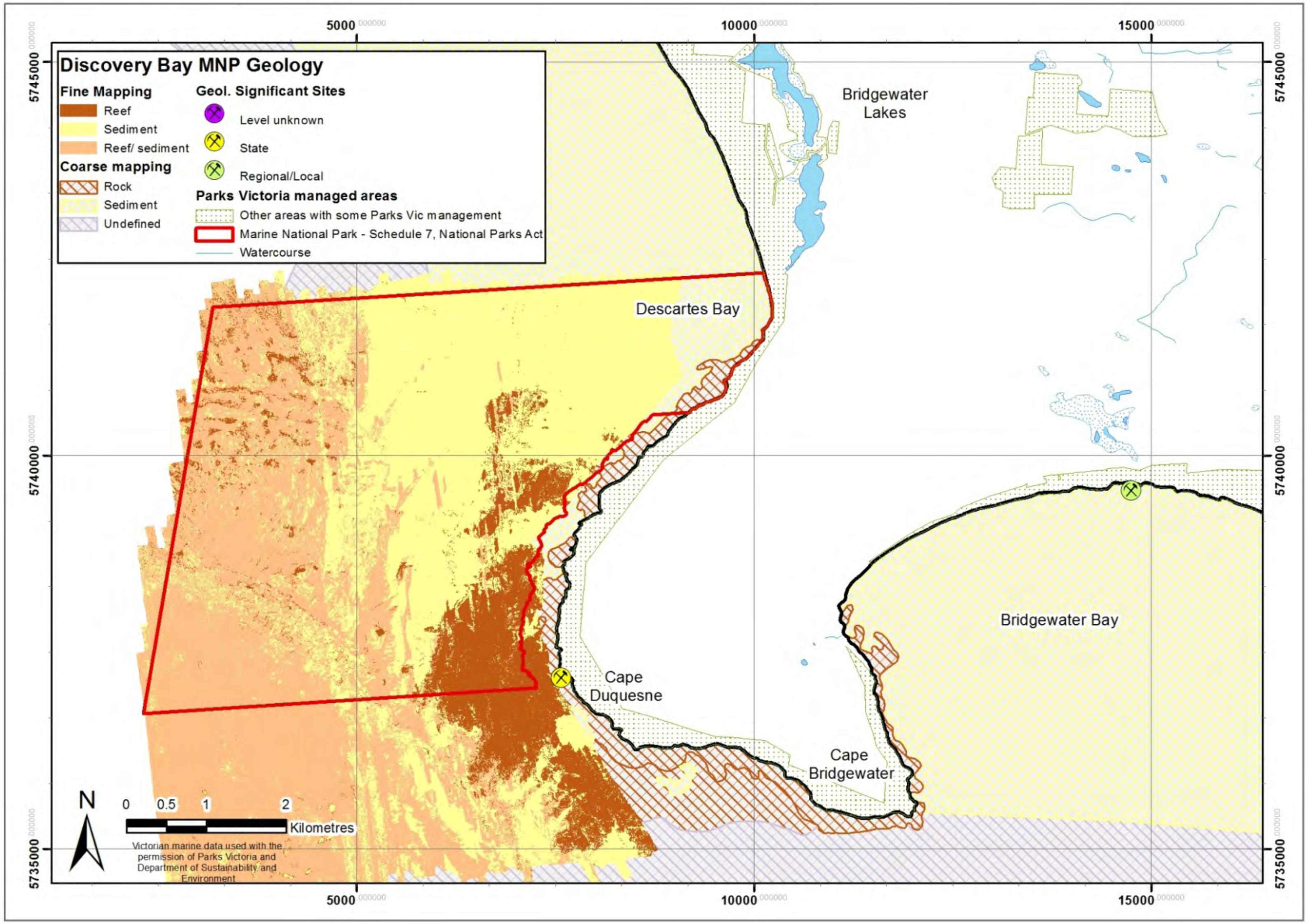


Figure 6. Substrate mapping of Discovery Bay Marine National Park and surrounds, showing sites of geological significance.

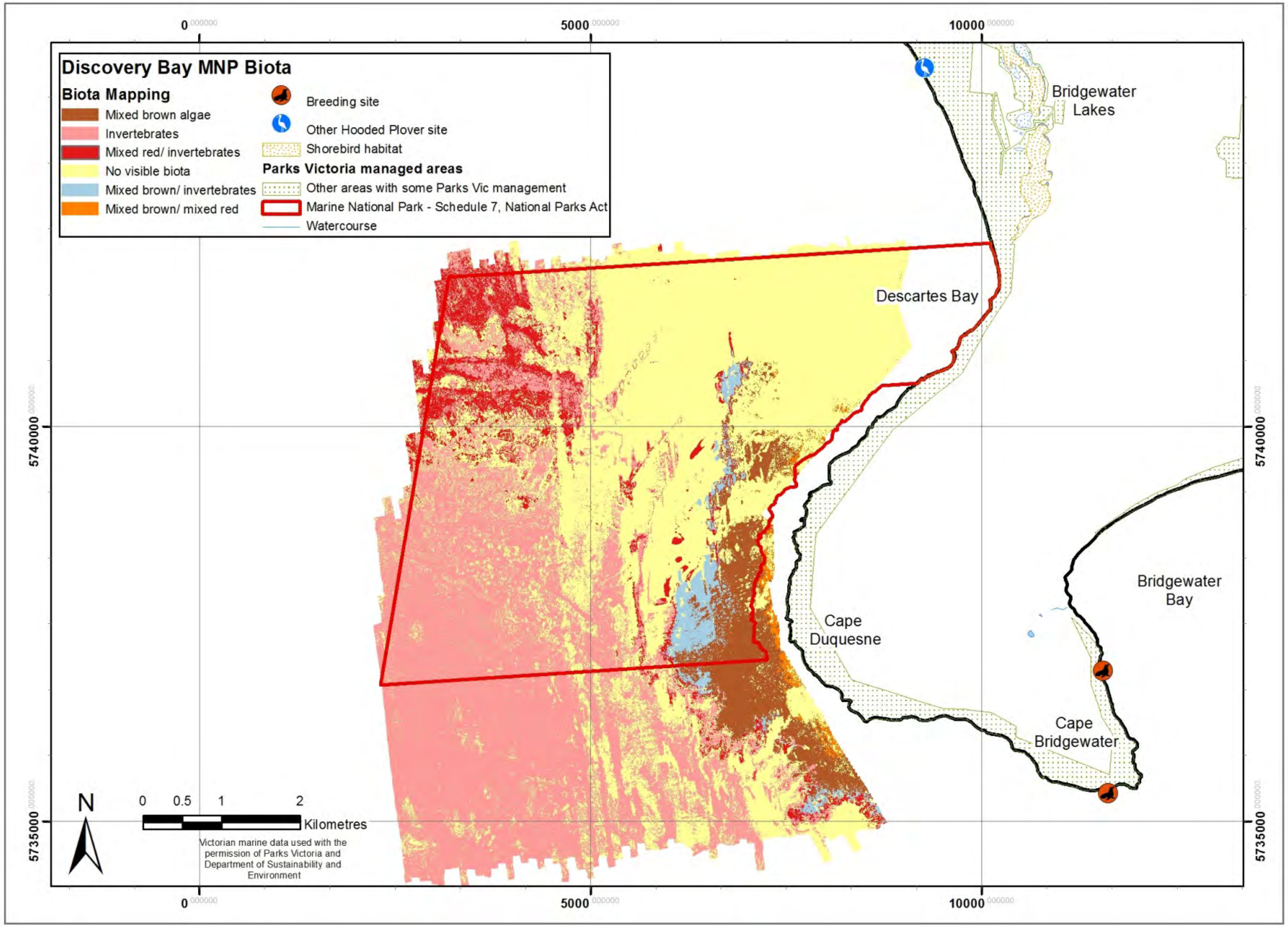


Figure 7. Biota mapping of the Discovery Bay Marine National Park and surrounds showing sites of biological significance.

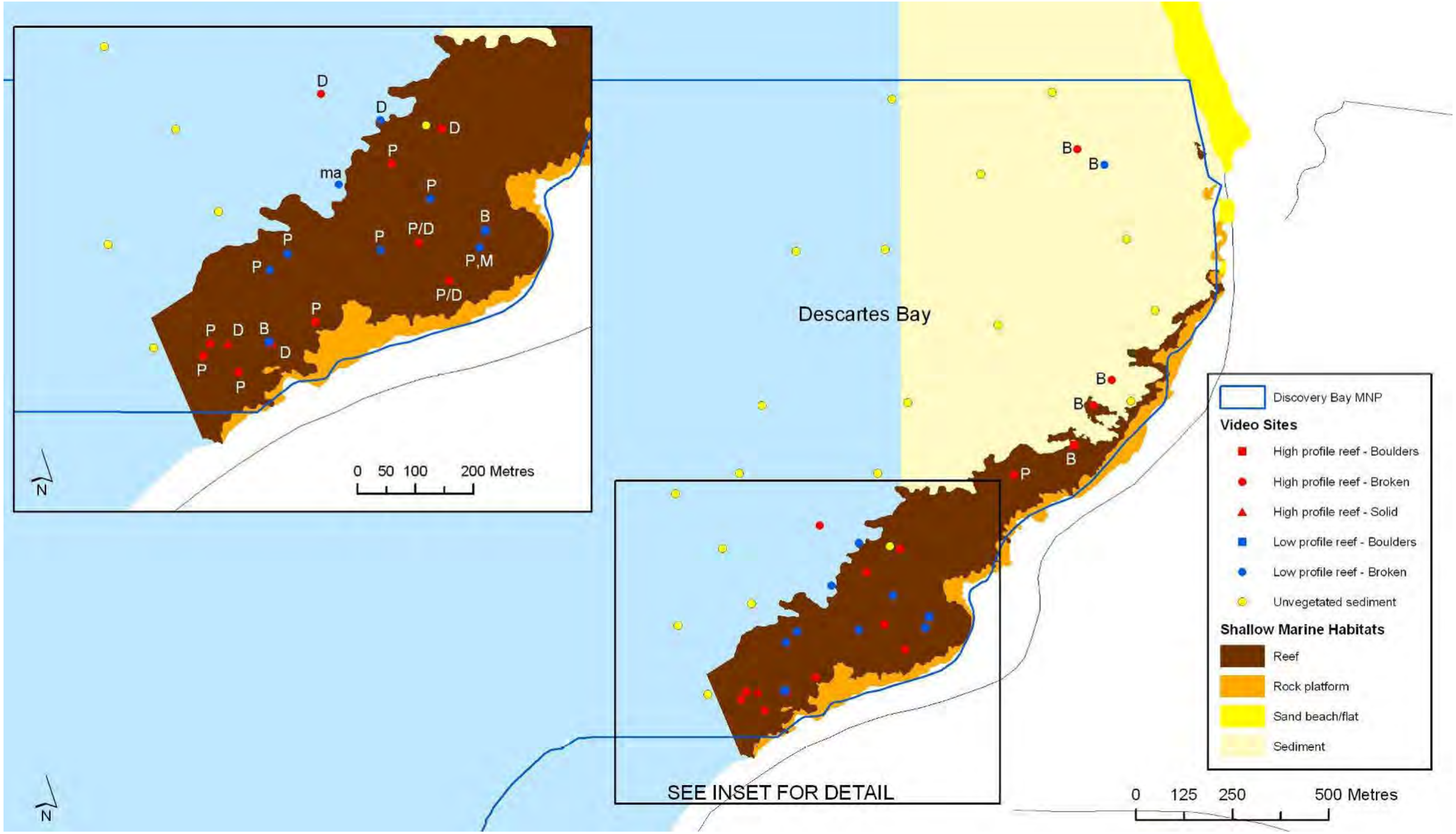


Figure 8. Detailed shallow substrate mapping of Discovery Bay Marine National Park from Ball and Blake 2007. Dominant biota categories on the map B = bare reef or sediment, D = *Durvillaea potatorum,* M = *Macrocystis pyrifera,* P = *Phyllospora comosa* and ma = mixed algae.

2.1.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003), Parks Victoria has invested in detailed habitat mapping of the shallow (Ball and Blake 2007) and deep habitats of the MNP (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). Intertidal biota has been surveyed as part of Museum of Victoria's large intertidal reef research (MAVRIC) study (Costa *et al.* 2010; O'Hara *et al.* 2010). Subtidal soft sediment fauna has been assessed as part of a statewide project (Coleman *et al.* 2007; Heislers and Parry 2007). Surveys in the MNP found that gastropods and birds dominate the number of species in Discovery Bay MNP (Table 2 & Appendix 1). Comprehensive surveys of the subtidal reef biota have not been done. There have been no surveys of the biota of the intertidal soft sediment.

Table 2. Summary of the number of species in major biotic groups from surveys in Discovery Bay Marine National Park.

Biotic Group	Number of Species
Macrophytes	**18**
Green algae	4
Brown algae	5
Red algae	9
Invertebrates	**48**
Cnidaria	5
Polychaetes	1
Barnacles	3
Decapod crustaceans	2
Chitons	4
Gastropods	31
Echinoderms	2
Vertebrates	**40**
Birds	33
Mammals	7

Intertidal

Soft sediment

Within the MNP intertidal soft sediment or beach only occurs in the north-east between Whites and Blacks Beaches (Figure 5, Figure 6 & Figure 8). Flora is restricted to macroalgae drift and macroalgal epiphytes. The invertebrates and fish of the intertidal soft sediment habitat in Discovery Bay MNP have not been surveyed. Beach-washed materials in sandy beach habitats are a significant source of food for scavenging birds, and contribute to the detrital cycle that nourishes many of the invertebrates, such as bivalves, living in the sand. The intertidal soft sediment is an important feeding and roosting habitat for shorebirds. There is no specific data on the biota of the beaches in the Discovery Bay MNP (Plummer *et al.* 2003).

Reef

Rocky intertidal reefs, also called rocky reefs or intertidal platforms, are generally found in Victoria on and near headlands with stretches of sandy beaches either side. Along with beaches, intertidal reefs are one of the most accessible components of the marine environment as they are the interface between the ocean and the land (Power and Boxshall

2007). As such they are valued as important habitats by people and tend to be visited more than other sections of the coast (Carey *et al.* 2007a; Carey *et al.* 2007b). This means they are often subjected to human pressures like harvesting, fossicking and trampling as well as pressures from pollution sources on land and in the sea (Power and Boxshall 2007).

Intertidal reef biota is exposed to large changes in physical conditions such as temperature and desiccation. There is great spatial and temporal variability in the life histories of the organisms and the environmental processes in reef habitats (Underwood and Chapman 2004). The recruitment of new biota onto the reef, largely from plankton, strongly influences the ecological patterns for individual species and assemblages. Interactions between biota on the reef also influence biota distribution. Resources which are often in short supply on intertidal reefs are space on which to live and food (Underwood and Chapman 2004).

Macroalgae and sessile invertebrates

A survey of the intertidal biota of Discovery Bay found eleven species of algae: three green, four brown and four red (Costa *et al.* 2010; O'Hara *et al.* 2010). Neptune's necklace *Hormosira banksii* is common along the intertidal rock platforms, along with sea lettuce *Ulva* sp. and encrusting red algae. Towards the lower intertidal zone, the bull kelp *Durvillaea potatorum* (Figure 9), giant kelp *Macrocystis pyrifera*, and green algae *Codium* sp. and *Caulerpa* sp. are also common (Plummer *et al.* 2003; Ball and Blake 2007). Freshwater springs on the cliff face support communities of green algae (Plummer *et al.* 2003). Sessile invertebrates found on the intertidal rock platforms in the MNP include the anemones *Aulactinia veratra*, *Actinia tenebrosa* and *Anthothoe albocincta*, including the surf *Catomerus polymerus*, honeycomb *Chamaesipho tasmanica* and rosette barnacles *Tetraclitella purpurascens,* and the mussels little black horse *Limnoperna pulex* and beaked *Austromytilus rostratus* (Costa *et al.* 2010; O'Hara *et al.* 2010).

Figure 9. Bull kelp *Durvillaea potatorum* on basalt subtidal reef in Discovery Bay Marine National Park. Photo by NRE.

Mobile invertebrates

A survey of the intertidal biota of Discovery Bay found forty-eight species of invertebrates, dominated by 37 species of molluscs (Costa *et al.* 2010; O'Hara *et al.* 2010). This includes top shells *Austrocochlea* constricta and *A. odontis*, the false limpet *Siphonaria diemenensis*, the true limpets *Cellana tramoserica* and *Patelloida latistrigata*, black nerite *Nerita atramentosa*, periwinkles *Austrolittorina praetermissa*, *A. unifasciata* and *Bembicium nanum,* and the predatory gastropods *Cominella lineolata*, *Lepsiella reticulata*, and *L. vinosa* (Costa *et al.* 2010; O'Hara *et al.* 2010). Also the purple rock crab *Leptograpsus variegatus* is also found on the intertidal reef of the MNP (Costa *et al.* 2010; O'Hara *et al.* 2010). The elephant snail *Scutus antipodes*, cowrie *Cypraea* sp., cone shell *Conus anemone*, urchin *Holopneustes* sp., biscuit star *Tosia australis,* tessellated sea star *Nectria* sp., hairy stone crab *Lomis hirta*, decorator crab *Notomithrax ursus* and cleft fronted shore crab *Paragrapsus quadridentatus* have also been found on the intertidal reefs in the MNP (Plummer *et al.* 2003).

Fish

A variety of fish live in intertidal pools and shallow subtidal gutters in the rock platform (Plummer *et al.* 2003). Common species are Tasmanian blenny *Parablennius tasmanianus*, cling fish *Aspasmogaster tasmaniensis*, juvenile sea carp *Cheilodactylus* sp. and weedfish including Johnston's *Heteroclinus johnstoni*, common *Heteroclinus perspicillatus* and crested *Cristiceps australis* (Plummer *et al.* 2003).

Subtidal

Soft sediment

Sessile invertebrates occur in isolated areas within the sand band from 35 to 55 m depth suggesting that the sediment is a thin veneer over hard substrate (Holmes *et al.* 2007a). Depth and sediment affect the distribution of benthic invertebrates along the Victorian coast. Coleman *et al.* (2007), and Heislers and Parry (2007) found that species richness was greater at 40 m compared to 10 or 20 m depth. Their coastal survey of benthic fauna included the benthos of Discovery Bay MNP. One transect in Discovery Bay MNP was sampled with two 0.1 m^2 grab samples in 10 and 20 m water depth. The sediment sampled was fine sand (Heislers and Parry 2007). The grab samples contained between 120 to 688 individuals and 23 to 35 species (Heislers and Parry 2007). There were more individuals and species in 20 m compared to ten metre grab samples. Crustaceans were the dominant taxa in each depth class, representing more than half (*i.e.* 5 and 8) of the most abundant families. The majority of these were amphipods, while isopods and cumaceans were also common. Polychaetes represented the bulk (*i.e.* 2 - 3) of the remaining families while molluscs were poorly represented. Six families were common in both depth classes, including four amphipod families (Phoxocephalidae, Urohaustoriidae, Bodotriidae, and Lysianassidae) and two polychaete families (Spionidae and Syllidae).

Reef

Subtidal reefs and their assemblages are strongly influenced by the position of the reef, its orientation, slope, depth, exposure and topography (Connell 2007). These physical parameters influence key physical processes such as light, water flow and sedimentation, and biological processes such as foraging and recruitment (Connell 2007). Biotic assemblages of algae and sessile invertebrates can form habitat and food sources for invertebrates and fish. Shallow (< 15 m) subtidal reefs are known for their high biological complexity, species diversity and productivity and in addition they have significant economic value through commercial and recreational fishing (outside of MPAs), diving and other tourism activities (Power and Boxshall 2007). Shallow subtidal reefs are often dominated by canopy forming algae. Deep reefs, where light penetration is limited, are often dominated by large sessile invertebrates such as massive sponges, whip corals, soft corals and colonial ascidians. Biotic assemblages can form habitat and food sources for other invertebrates and fish.

Flora

Seaweeds provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present. Bull kelp *Durvillaea potatorum* grows on the intertidal reef edge (Ball and Blake 2007). Canopy forming algae on the shallow basalt subtidal reefs in Discovery Bay MNP are mixed brown algae, including kelp *Ecklonia radiata* and crayweed *Phyllospora comosa* (Ierodiaconou *et al.* 2007; Figure 10). *Caulerpa*, *Scytothalia*, and *Sargassum* also grow on the subtidal reef as do sparse stands of giant kelp *Macrocystis pyrifera* (Ball and Blake 2007; Holmes *et al.* 2007a). A sparse mixed red algal understorey becomes denser at the deeper margins of these basalt reefs (Ierodiaconou *et al.* 2007). Mixed red algae and mixed green algae often co-occur (Holmes *et al.* 2007a). Sessile invertebrates, in the mixed brown algae beds, become more dominant with depth (Ierodiaconou *et al.* 2007). Red algae grows in depths up to 60 m and kelp *Ecklonia radiata* in up to 50 m, although both decrease in abundance with depth (Ierodiaconou *et al.* 2007).

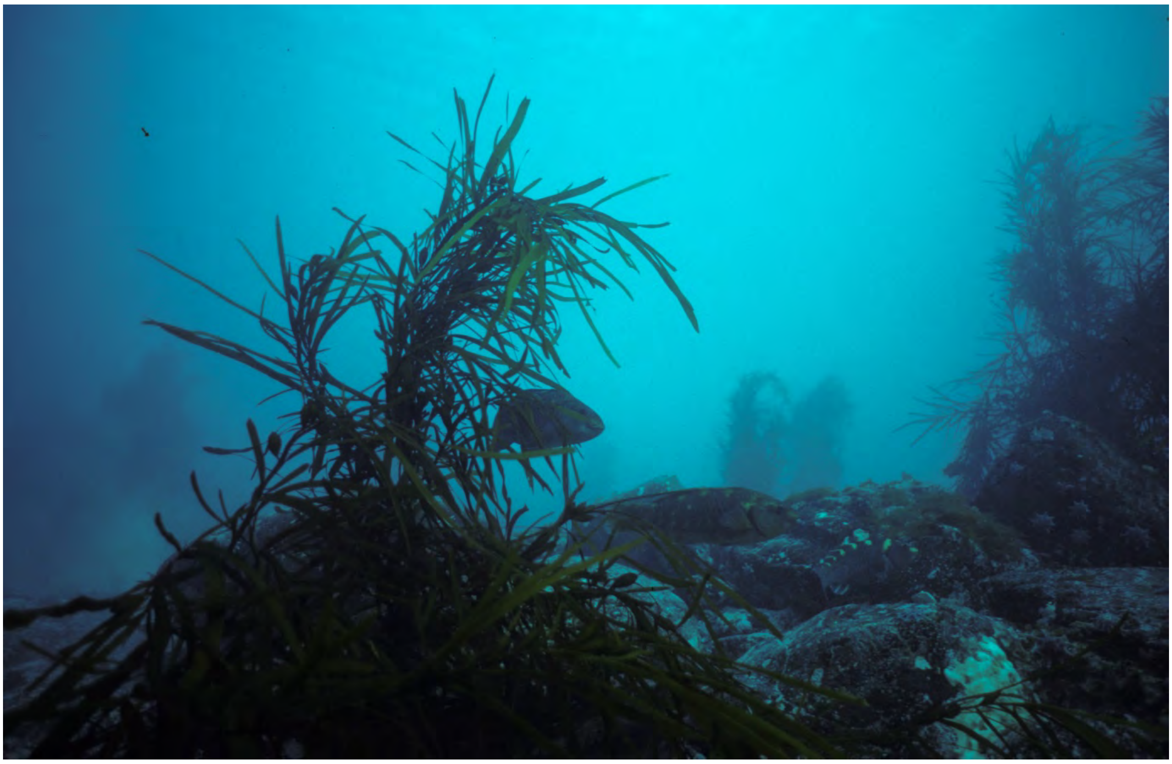


Figure 10. Crayweed *Phyllospora comosa* and wrasse on basalt subtidal reef in Discovery Bay Marine National Park. Photo by NRE.

Invertebrate fauna

A qualitative dive survey of an area of high-profile, high wave-energy basalt reef in 8 m of water in the MNP found small anemones and encrusting sponges under ledges and crevices along with a seastar species, possibly *Patiriella calcar* (Plummer *et al.* 2003). On the shallower basalt subtidal reefs sponges tend to display a more compact morphology than those on the deeper calcarenite reef systems, and are in highest densities in fissures, cracks and on vertical or inverted surfaces (Ierodiaconou *et al.* 2007). Deeper reefs in the west of the MNP consist of a sponge dominated habitat with other sessile invertebrates (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007; Monk *et al.* 2011). This includes abundant ascidians, hydroids, and bryozoans along with gorgonian soft corals, hard corals, *Tethya* sponges, zooanthids and sea whips (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007; Monk *et al.* 2011). The sessile invertebrates are in highest densities on reef crests, ridges and high profile plateaus where the effects of sand inundation are mitigated by vertical relief (Ierodiaconou *et al.* 2007). Sponges occur at all depths in the MNP (Ierodiaconou *et al.* 2007). Bryozoans and gorgonians are found in depths > 30 m. Ascidians are only observed in 30 - 40 m and the sea whip *Primnoella australasiae* is only found in depths > 50 m (Ierodiaconou *et al.* 2007).

Fish

The blue-throated wrasse *Notolabrus tetricus* and rosy wrasse *Pseudolabrus psittaculus* are common on the subtidal reefs (Monk *et al.* 2010). Large schools of purple wrasse *Notolabrus fucicola* have been observed on the shallow nearshore subtidal reefs in approximately 7 to 10 m (Plummer *et al.* 2003; Ball and Blake 2007). Western blue gropers *Achoerodus gouldii* have been observed in the high profile reef systems in 50 m of water west of Cape Duquesne (Ierodiaconou *et al.* 2007). Sea sweep *Scorpis aequipinnis* and marble fish *Aplodactylus arctidens* occur on the reef (Plummer *et al.* 2003). Very high abundances of juvenile sea sweep *S. aequipinnis* congregate in shallow subtidal gutters in the near-shore rock platform during November (Plummer *et al.* 2003). Also observed in shallow waters in the MNP are moonlighters *Tilodon sexfasciatus*, magpie perch *Cheilodactylus nigripes*, zebra fish *Girella zebra*, yelloweye mullet *Aldrichetta forsteri* and painted dragonets *Eocallionymus papilio* (Plummer *et al.* 2003).

Water column

The water column is a large habitat in the MNP. It is important in different ways for many organisms including for transit or as a permanent home for particular stages of their life cycle. Organisms that use the water column environment can be broadly grouped into two categories based on mode of movement: either pelagic (actively swimming) or planktonic (drifting with the current). Larger species are often planktonic during early life stages before becoming pelagic as they grow. Smaller species tend to be planktonic but can influence their movement to some extent by controlling their height in the water column. Organisms that make their permanent home in the water column include sea jellies, salps, many fish, and both phytoplankton and zooplankton. Planktonic organisms play an important role in nutrient cycling, dispersal of species and providing food for larger animals, both within the MNP and more broadly in the marine environment. The water column is also used by fish, invertebrates and algae for transport and food (and other resources like oxygen). Parks Victoria does not currently monitor the water column as a habitat (Power and Boxshall 2007). As described in the following section a wide variety of seabirds and mammals are found in the waters of Discovery Bay MNP.

2.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is likely to protect and enhance threatened species populations (Power and Boxshall 2007). Whole-of-habitat management may also result in the protection of species not yet identified because of their rarity or cryptic nature (Power and Boxshall 2007).

Flora

No conservation listed marine flora has been recorded in Discovery Bay MNP.

Fish

The open waters of Discovery Bay MNP are a probable habitat for the FFG listed threatened migratory southern bluefin tuna *Thunnus maccoyii*. Likewise the open waters could be used by the grey nurse shark *Charcharias taurus* which is listed as threatened in Victoria (*FFG*) and critically endangered nationally (*EPBC*). The great white shark *Carcharodon carcharias* threatened in Victoria (FFG) and vulnerable nationally (EPBC) probably also uses the waters of Discovery Bay MNP.

Birds

Fifteen conservation listed shore or sea birds have been sighted in or in the immediate surrounds of the Discovery Bay MNP (Table 3). Ten are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Two of these are regarded as endangered; the wandering albatross *Diomedea exulans is* listed as endangered at the state level, while the southern giant-petrel *Macronectes giganteus* is endangered at the national level.. Five birds listed as vulnerable at the national level have been recorded in the MNP. Ten migratory birds are recognized internationally under either CAMBA or JAMBA.

There are no registered sites of biotic significance in Discovery Bay MNP. To the north of the MNP hooded plovers *Thinornis rubricollis* have been sighted on the beach (Figure 7).

Table 3. Conservation listed shorebird and seabird records from Discovery Bay Marine National Park and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
wandering albatross	*Diomedea exulans*	L	EN	VU		J
southern giant-petrel	*Macronectes giganteus*	L	VU	EN		
shy albatross	*Thalassarche cauta*	L	VU	VU		J
yellow-nosed albatross	*Thalassarche chlororhynchos*	L	VU	VU		J
black-browed albatross	*Thalassarche melanophris*		VU	VU		J
blue petrel	*Halobaena caerulea*			VU		J
hooded plover	*Thinornis rubricollis*	L	VU			
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
Pacific gull	*Larus pacificus*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
sooty shearwater	*Ardenna grisea*				C	J
short-tailed shearwater	*Ardenna tenuirostris*					J
flesh-footed shearwater	*Ardenna carneipes*					J
Wilson's storm-petrel	*Oceanites oceanicus*					J

L= FFG listed, NT = Near Threatened, VU = Vulnerable, EN = Endangered, C = Listed under the CAMBA treaty, J = Listed under the JAMBA treaty

Marine mammals

Southern right whales *Eubalaena australis*, blue whales *Balaenoptera musculus* and southern elephant seals *Mirounga leonina* have been recorded in or near the Discovery Bay MNP (Table 4). Both the southern right whale *E. australis* and blue whale *B. musculus* are listed as critically endangered in Victorian waters and endangered nationally. The southern elephant seal *Mirounga leonina* is listed as vulnerable and as a migratory species at the national level (Table 4).

The intertidal reefs provide occasional haul-out areas for Australian fur seals *Arctocephalus pusillus doriferus* (Figure 11). To the east of the MNP on Cape Bridgewater there are two haulout colonies Australian fur seals *A. pusillus doriferus* (Kirkwood *et al.* 2003)*.* One haulout has established a small breeding colony and pups between November and December. They are protected species under the *Wildlife Act 1975* and listed under *FFG Act 1988.* New Zealand fur seals *A. forsteri* are also recorded as hauling out at these sites and have established a small breeding colony (Kirkwood *et al.* 2009). A tourism operator offers boat based seal viewing tours of one colony and the other can be viewed from land (Kirkwood *et al.* 2003).

Table 4. Conservation listed marine mammal records from the Discovery Bay Marine National Park and surrounds.

		Victorian listing		National listing
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**
southern right whale	*Eubalaena australis*	L	CE	EN
blue whale	*Balaenoptera musculus*	L	CE	EN
southern elephant seal	*Mirounga leonina*			VU, M
New Zealand fur seal	*Arctophoca forsteri*		VU	L
Australian fur seals	*Arctocephalus pusillus doriferus*			L

L= FFG listed, VU = Vulnerable, EN = Endangered, M = listed Migratory

Figure 11. Australian fur seals *Arctocephalus pusillus doriferus* on an intertidal reef in Discovery Bay Marine National Park. Photo by Marcel Hoog Antink, Parks Victoria.

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that Discovery Bay MNP has one endemic crustacean, the southern hooded shrimp *Athanopsis australis,* which is *FFG* listed in Victoria (O'Hara and Barmby 2000; O'Hara and Poore 2000). Seven algae and one invertebrate (Table 5) are at or presumed to be at their distributional range in the MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). The green algae *Palmoclathrus stipitatus* is at its eastern distributional limit and five red algae are presumed to be at their eastern distributional limit. One brown algae and a seastar are presumed to be at their western distributional limit. The distributional limits of the biota may reflect collection effort in this area rather than actual Victorian distributions. Many areas of the Victorian coast have never been sampled and therefore biota ranges may be much greater than those suggested.

Table 5. Marine species at their distribution limits in Discovery Bay MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Order	Family	Species	Common name	Category
Tetrasporales	Palmellaceae	*Palmoclathrus stipitatus*	green algae	RE
Ectocarpales	Chordariaceae	*Chordaria cladosiphon*	brown algae	PW
Ceramiales	Ceramiaceae	*Ceramium monacanthum*	red algae	PE
Ceramiales	Ceramiaceae	*Ptilocladia vestita*	red algae	PE
Gigartinales	Gigartinaceae	*Gigartina densa*	red algae	PE
Gigartinales	Sarcodiaceae	*Trematocarpus concinnus*	red algae	PE
Nemaliales	Liagoraceae	*Helminthocladia beaugleholei*	red algae	PE
Forcipulatida	Asteriidae	*Smilasterias multipara*	seastar	PW

2.1.5 MAJOR THREATS

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPA's. Through public and agency workshops, the natural values in individual MPA's and the threats that could affect them over the next ten years, were considered and ranked to identify hazards. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Two hazards with the potential to be of extreme risk to the Discovery Bay MNP were identified by Carey *et al.* (2007b). It was generally agreed that because of its exposure and remoteness, the park was subject to fewer threats than many of the other MPAs in Victoria (Carey *et al.* 2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Poaching of abalone near Blacks Beach resulting in decreased abalone populations in the park (intertidal and subtidal reef); and
2. Lack of ecological knowledge affecting park habitats, communities and processes (whole of MNP).

The introduction of marine pests also threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). No introduced species or marine pest has been recorded from the Discovery Bay MNP (Parks Victoria 2007a). An exotic marine pest survey of the Portland harbour to the east of the MNP found a total of nine exotic species: the toxic dinoflagellate *Alexandrium tamarense*; the bottom-dwelling sabellid tube worms *Euchone* sp.1 and *Myxicola infundibulum;* the bottom-dwelling molluscs *Corbula gibba, Musculista senhousia* and *Theora lubrica;* and the bryozoans *Bugula dentata, B. neritina* and *Watersipora subtorquata* (Parry *et al.* 1997). The small (25 mm) sabellid tube worm *Euchone* sp.1 was the only species abundant enough to cause a significant ecological impact in the harbour. *Grateloupia turuturu, Caulerpa racemosa* var. *cylindracea* and *Codium fragile* ssp. *fragile* were also recorded in Portland harbour in 2010 (John Lewis pers. comm.). Japanese kelp *Undaria pinnatifida* has recently been found in Apollo Bay harbour and there are grave concerns about its spread to other MPAs on the west coast. It is thought that the introduced green shore crab *Carcinus maenas* is not found within the MNP as the coast is too rough. To the east in Flinders Bioregion the Northern Pacific seastar *Asterias amurensis* was found in Anderson Inlet and may have been eradicated in a broad-based community effort in 2004–05, led by DSE (Parks Victoria 2006a). *Asterias* was also found at San Remo jetty in late 2011. Further east in the Twofold bioregion the introduced New Zealand screw shell *Maoricolpus roseus* has been recorded in high densities (Holmes *et al.* 2007b). This species is regarded as a serious threat to the high diversity of infauna that is characteristic of much of Bass Strait (Patil *et al.* 2004; Heislers and Parry 2007). Other species of particular concern include the marine fanworm *Sabella spallanzanii* and broccoli weed *Codium fragile (subsp. fragile)* (Parks Victoria 2003).

A virus affecting abalone called abalone viral ganglioneuritus has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area and has been confirmed from Discovery Bay MNP to Cape Otway (DPI 2009). Its long term ecological consequences for rocky reef communities are unknown (DPI 2009).

Climate Change

Climate change represents a serious threat to marine ecosystems (McLeod *et al.* 2009) but specific ecological consequences of accelerating climate change are not well understood in marine systems, particularly in temperate systems. Climate change is predicted to increase water temperature, alter chemical composition (salinity, acidity and carbonate saturation), change circulation and productivity, increase frequencies of extreme weather events and exposure to damaging ultraviolet light (UVB), and increase air temperature, cloud cover and sea levels (conservatively 80 cm by 2100; CSIRO-BoM 2007; Fine and Franklin 2007; VCC 2008; McLeod *et al.* 2009). A combined increase in cloud cover and sea level could result in decreased light availability potentially changing benthic flora. Increased storm surges and ocean current changes also have the potential to change the distribution of fauna and flora and could result in loss of habitats (CSIRO-BoM 2007). Intertidal communities will face increased desiccation, storm wave exposure and habitat shift. Changes in the relationship between climate and annual life-history events may force major change in functional groups and consequent ecosystem function (Fine and Franklin 2007). Climate change is also anticipated to modify species recruitment and habitat connectivity, species interactions and disturbance regimes in the marine environment (CSIRO-BoM 2007; Fine and Franklin 2007).

Measures to address or minimise these threats form part of the management plan for the Discovery Bay MNP (Parks Victoria 2007a). For example research is being conducted into marine pest species, and investigations into water quality issues have also been conducted in relation to park values. Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

2.1.6 CURRENT RESEARCH AND MONITORING

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring

Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. The research relevant to Discovery Bay MNP has been published in Parks Victoria's Technical Series available on Parks Victoria's website (http://www.parkweb.vic.gov.au). As most research in the MNP has been carried out under permits issued by DSE, the permit database was also used to identify relevant projects for this report (see Table 6 and Appendix 2).

The Discovery Bay MNP does not have an ongoing intertidal or subtidal reef monitoring program. A review of monitoring needs in relation to conservation outcomes for the park will be done by 2013. The major directions for monitoring include implementing an expanded and improved monitoring program following a review of the major findings taking into account knowledge generated since park declaration (Power and Boxshall 2007; Keough and Carnell 2009).

Table 6. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Discovery Bay Marine National Park.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimizing the allocation of resources for defending Marine Protected Areas against invasive species.
Multiple Research Partners: Marine Monitoring and Marine Natural Values ***Deakin University:*** Jan Barton, Adam Pope, Gerry Quinn Marine Natural Values Reports for the Marine National Parks and Sanctuaries – Version 2. ***University of Melbourne:*** Jan Carey Developing Report Cards for the Marine National Parks.
Museum Victoria: Mark Norman, Julian Finn. ***Parks Victoria:*** Roger Fenwick Under the Lens - Natural History of Victoria's Marine National Park System.
University of Melbourne: Tarek Murshed, Jan Carey, Jacqui Pocklington Conceptual model development for marine habitats.
Ongoing Habitat Mapping Projects
DSE / DPI / Worley Parsons/ Deakin University LiDAR Mapping Project. Mapping of bathymetry and marine habitats along the Victorian coast

Statewide, the Museum of Victoria is collecting additional data on the marine natural values of Victoria's MPAs. They are gathering information about natural history through video and photos, and using semi-quantitative methods to determine spatial and temporal changes across the system in response to threats, including marine pests and climate change. Jan Carey (University of Melbourne) is conducting research focussing on marine pest species which may impact on park values, and the MPAs which are most at risk of invasion. This will help prioritise Parks Victoria surveillance monitoring efforts to MPAs where there is greatest potential for successful management.

2.1.7 KNOWLEDGE GAPS

Some quantitative information has been collected on the intertidal reef biota. Knowledge of the subtidal reef ecological communities is based on qualitative video sampling in which the dominate habitat forming biota have been identified. Smaller or more cryptic biota is not well sampled by this method. There is no quantitative data on fish abundances, distributions or interactions in the subtidal reef (Figure 12) or water column habitats. Some information exists for subtidal soft sediment. Limited information has been collected on the soft sediment. Major threats have been identified for the Discovery Bay MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.

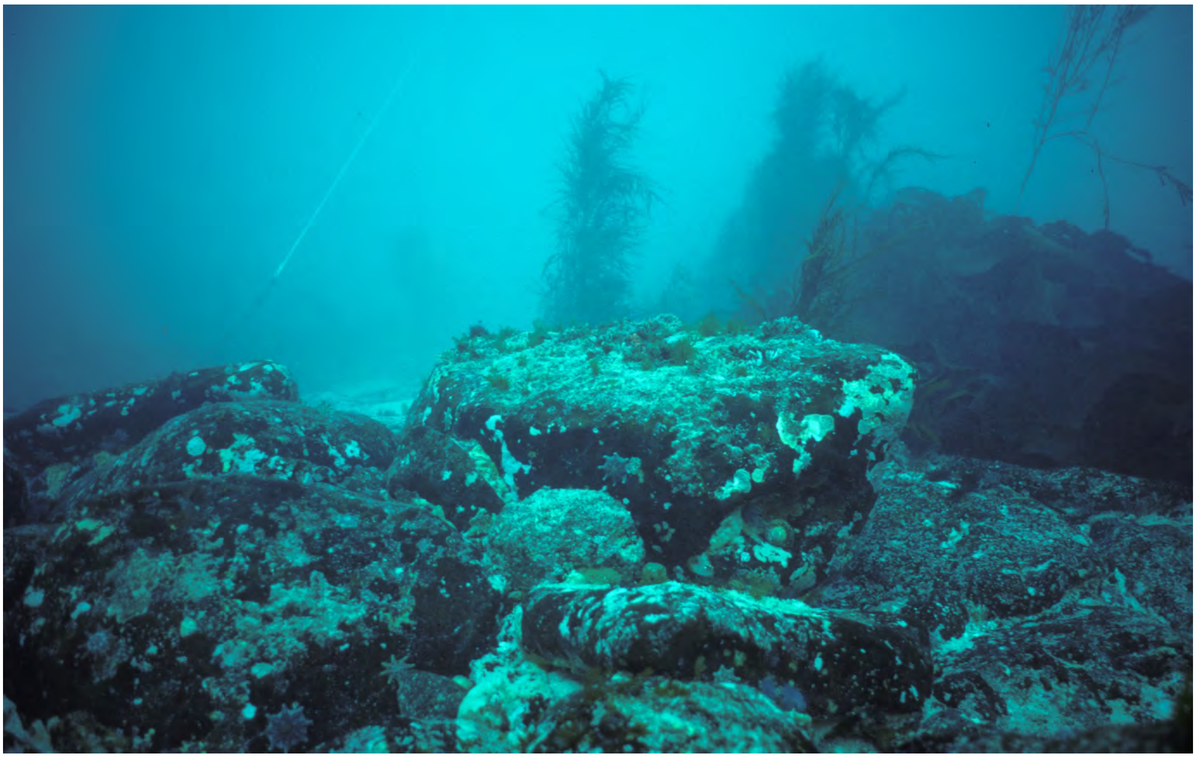


Figure 12. Subtidal basalt reef in Discovery Bay Marine National Park. Photo by NRE.

2.2 Twelve Apostles Marine National Park

The Twelve Apostles Marine National Park (Figures 13 and 23) is the one of two MNPs in the Otway bioregion, . The Otway bioregion also contains Discovery Bay MNP, and the Merri and The Arches Marine Sanctuaries. It adjoins the Port Campbell and the Great Otway National Parks. The Twelve Apostles MNP is approximately 280 km west of Melbourne, 8 kilometres south-east of Port Campbell and one kilometre south of Princetown. The MNP covers 7510 hectares along the coast from Broken Head to Pebble Point and out to the state nautical limit (Table 7 & Figure 16). The MNP includes some land above the high water mark, including Mutton Bird Island and a series of offshore rock stacks that includes the Twelve Apostles. Excluded from the MNP are beaches, from the high water mark extending 100 m out to sea, west of Gibson Steps to Clifton Beach and east of Point Ronald to Rivernook. The main access points to the MNP are at Loch Ard Gorge, Gibson Steps, Clifton Beach, Princetown and Rivernook and by boat from Port Campbell (Parks Victoria 2006b). The wreck of the *Loch Ard* (Figure 14) lies within Twelve Apostles MNP near Mutton Bird Island and is listed on the Register of the National Estate (Parks Victoria 2006b), as are the intertidal areas and rock stacks within the MNP (Parks Victoria 2006b). There are many geologically significant sites within and near the MNP. These include the high limestone stacks that make up the Twelve Apostles formation which are recognised nationally, Loch Ard Gorge which is of state significance (Figure 18), and the geological formation at Pebble Point which is recognised regionally.

Figure 13. Twelve Apostles Marine National Park. Photo by NRE.

Aboriginal tradition indicates that the Twelve Apostles MNP is situated within two language group areas (Parks Victoria 2006b). To the west of the Gellibrand River is Kirrae Whurrong *Country*; to the east of the Gellibrand is Gadubanud *Country*.

Important natural values of Twelve Apostles MNP are its intertidal and subtidal limestone reef, intertidal and subtidal soft sediment, and open water that provide habitat for a diversity of marine flora and fauna species, including sessile invertebrates, algae, fish and transient whales (ECC 2000; Parks Victoria 2006b; Carey *et al.* 2007b). Its intertidal shoreline has a mixture of rocky reef, cliffs and some small sandy beaches. Its shoreline, rockstacks and islands provide habitat for breeding seabirds (Parks Victoria 2006b; Carey *et al.* 2007b). The MNP is regarded as having the highest diversity of intertidal and shallow subtidal invertebrates on limestone reef in Victoria (ECC 2000; Carey *et al.* 2007b).

Subtidal reefs occur on the western and eastern areas of the MNP, and the centre of the MNP is a gently sloping sandy basin (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). Sparse beds of seagrass *Heterozostera* spp grow in 10 - 30m water depth on the shallow subtidal sandy sediment (Ierodiaconou *et al.* 2007). Elsewhere, the subtidal sediment is usually devoid of visible biota except in deeper areas where it is a thin veneer of sand covering reef allowing sessile invertebrates to grow (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007).

The varied form and depths of the subtidal reefs in the Twelve Apostles MNP provide habitat for a diverse range of algae and sessile invertebrates (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007; Edmunds *et al.* 2010b). Beds of either mixed red, brown or green algae or a combination of algal types and sessile invertebrates grow on the high profile reefs (Ierodiaconou *et al.* 2007). In the MNP red algae grows at all depths, on shallow reefs its species are typical of that found on other Victorian reefs and includes: *Phacelocarpus peperocarpus*, *Melanthalia obtusata*, *Gelidium asperum*, *Plocamium mertensii*, *Callophyllus rangiferina*, *Ballia callitricha*, *Sonderopelta coriacea* and *Haliptilon roseum* (Edmunds *et al.* 2010b). The kelp *Ecklonia radiata* and the green algae *Caulerpa* spp grow in depths less than 40m and their abundance decreases with depth (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007; Edmunds *et al.* 2010b). Smaller brown algae including *Carpomitra costatum* and *Homoeostrichus* sp., grow in more sandy areas (Edmunds *et al.* 2010b).

Mobile invertebrates on the subtidal reef in the Twelve Apostles MNP include the southern rock lobster *Jasus edwardsii,* and the seastars *Nepanthia troughtoni, Plectaster decanus*, *Echinaster arcystatus*, *Nectria macrobrachia* and other *Nectria* species (Edmunds *et al.* 2010b). Sponges are particularly diverse in the MNP (Edmunds *et al.* 2010b). In depths greater than 40 m sessile invertebrates dominate. Their abundance on the reef tops increases with depth, particularly the isidid gorgonian *Pteronisis* spp., erect sponges, and the large hydroid fan *Solanderia fusca* (Edmunds *et al.* 2010b).

Subtidal reef fish in the Twelve Apostles MNP are typical of the Otway Bioregion, including: the blue-throated *Notolabrus tetricus*, rosy *Pseudolabrus psittaculus* and senator wrasses *Pictilabrus laticlavius*; the magpie perch *Cheilodactylus nigripes* and dusky morwongs *Dactylophora nigricans*; sea sweep *Scorpis aequipinnis*; barber *Caesioperca rasor* and butterfly perches *C. lepidoptera*; marble fish *Aplodactylus arctidens*; and bullseye *Pempheris multiradiata* (Edmunds *et al.* 2010b). Leatherjackets are not abundant (Edmunds *et al.* 2010b). Larger fish include the bastard trumpeter *Latridopsis forsteri*, and blue morwong *Nemadactylus valenciennesi* (Edmunds *et al.* 2010b).

The Twelve Apostles MNP provides important feeding and roosting habitat for eleven threatened bird species which are listed under the *Flora and Fauna Guarantee* (*FFG*) *Act* (1998) and regarded as endangered in Victoria. These include the wandering albatross *Diomedea exulans*, little egret *Egretta garzetta*, and Australasian bittern *Botaurus poiciloptilus*. The MNP protects feeding areas for four internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Between the Twelve Apostles and London Bridge is a major breeding colony of little penguins *Eudyptula minor* which is of state biotic significance. The intertidal reef provides an occasional haul-out area for state vulnerable New Zealand *Arctophoca* *forsteri* and Australian fur seals *Arctocephalus pusillus doriferus*. A brittle star *Ophiacantha heterotyla* is presumed to be at its western limit of its distribution in the MNP.

Serious threats to the Twelve Apostles MNP include limited ecological knowledge of important processes, and the complexity and cost of management. Possible oil spills, increased nutrients from the land, invasive marine pests, resource exploration and extraction, land and marine derived litter, and climate change all pose serious threats to the integrity of the MNP. Measures to address or minimise these threats form part of the management plan for the Twelve Apostles MNP (Parks Victoria 2006b). Specific research aims to increase ecological knowledge about the natural values of, and threats to the Twelve Apostles MNP.

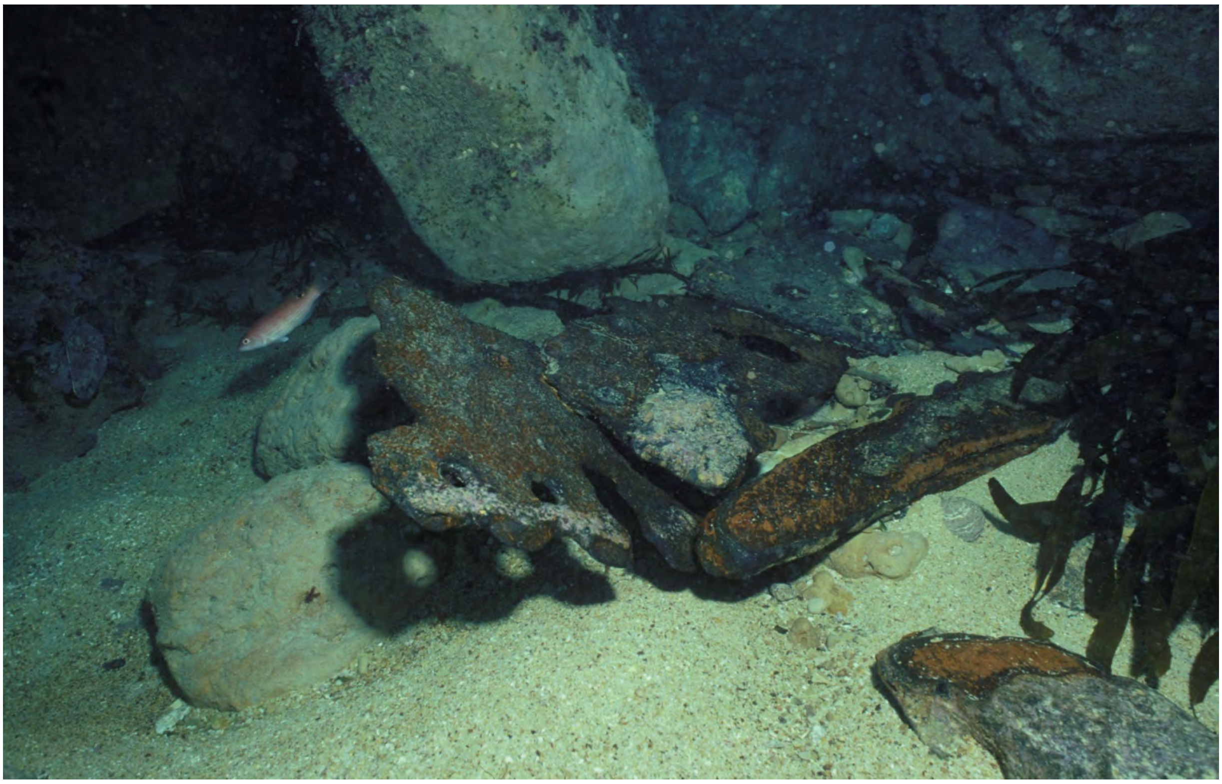


Figure 14. Wreck of the Loch Ard in Twelve Apostles Marine National Park. Photo by NRE.

2.2.1 PHYSICAL PARAMETERS & PROCESSES

The Twelve Apostles MNP is 7510 hectares in size which makes it the second largest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 7, Figure 16 and 17). The MNP is predominately > 20 m deep (Table 7). It is open to the prevailing south-west winds and swells of the Southern Ocean in winter and in spring/summer south-east winds and swells of Bass Strait (Parks Victoria 2006b; Edmunds *et al.* 2010b). The West Wind Drift causes an easterly current through the MNP (Parks Victoria 2006b). Local complex hydrodynamics around the MNPs islands and stacks are poorly understood and may change seasonally or after rock falls (Parks Victoria 2006b). High tides, storms and large swells can also alter the movement of sand (Parks Victoria 2006b). Tidal variation is 0.9 metres for spring tides and 0.3 metres for neap tides (Plummer *et al.* 2003). Surface water temperatures average 17.5 °C in the summer and 13.5 °C in the winter. Gellibrand River discharges into the centre of the Twelve Apostles MNP and Sherbrooke River discharges 600m west of the MNP (Table 7).

The Twelve Apostles MNP spans two distinctive geological regions: the Port Campbell Coast and the Otways Coast, with the change in geology occurring around Point Ronald (Bird 1993). Underwater, the Twelve Apostles MNP is a mixture of sandy sediment and limestone rocky reef with platforms, fissures, gutters, small rounded boulders and steeply sloping ridges rising from a gently sloping sandy sea floor (ECC 2000). The tall limestone cliffs of the Port Campbell Coast are exposed to the high energy coast and over time have progressively eroded, creating rock stacks, numerous caves, arches, tunnels and blowholes (Bird 1993). The collapse of caves and tunnels has resulted in the development of coves and gorges such as Loch Ard Gorge and elongated promontories such as Broken Head. The erosion of the promontories forms archways which when they collapse create islands and rock stacks (Bird 1993). There are relatively few beaches along the Port Campbell coast because of the lack of sand in the eroding cliffs (Bird 1993). Within the MNP beaches or intertidal soft sediment are generally small isolated pockets at the base of cliffs. To the east of Point Ronald the Otways Coast limestone cliffs are replaced by dune-backed sandy beaches and bays between small promontories (Bird 1993).

Table 7. Physical attributes of the Twelve Apostles Marine National Park.

Park Name	**Twelve Apostles**
Conservation status	Marine National Park
Biophysical Region	Otway
Size	7510 ha (ranked 2nd of 24 MPAs)
Length of coastline	~ 16.5 km
Shoreline geology	limestone
Area with depth:	
Less than 10m	628 ha
Comprising: Intertidal (high res)	*(14 ha)*
Intertidal-5m (high res)	*(266 ha)*
5 - 10 m (high res)	*(309 ha)*
*0-10m (low res)**	*(39 ha)*
10-20 m	889 ha
20-30 m	1218 ha
30-40 m	1459 ha
40-50 m	1749 ha
50-60m	1400 ha
60-70m	169 ha
Mean tidal variation - spring	0.9 m
Mean tidal variation - neap	0.3 m
Mean water temp - summer	17.0°C
Mean water temp - winter	13.5°C
Adjacent catchment	Conservation and agricultural
Discharges into MNP	Gellibrand River
Nearest major estuary (distance & direction)	Gellibrand River discharges into the MNP Sherbrooke River is 600 m north of the western boundary

* artefact of combining three different resolutions of bathymetric mapping, coarse mapping could not be separated into smaller depth categories

Within the Twelve Apostles MNP the high limestone stacks that make up the Twelve Apostles (Figure 22) formation are recognised nationally as geologically significant and the Loch Ard gorge area of state significance (Figure 18). The geological formation at Pebble Point is recognised regionally as geologically significant. So are the formations at Gibsons Steps, Clifton Beach, and from Pt Ronald to Pt Margaret outside the MNP. The coast from Cape Otway to Peterbourgh, including Port Campbell and Great Otway National Parks, is recognised nationally as geologically significant. To the east of the MNP in the Gellibrand valley there are three regionally significant geological sites including old river spurs, tekites and in the Princetown Quarry an Eocene Dilwyn formation (Figure 18). On the coast Bell Point is regionally geologically significant. To the west of the MNP regionally significant geological sites are recognised at Rutledge Creek, Goudies lookout, Sentinel Rock, Beacon Steps, Port Campbell and Two Mile Bay (Figure 18).

There is one site of biotic significance in the MNP between the Twelve Apostles and London Bridge which is a major breeding colony of little penguins *Eudyptula minor* (Figure 19). Just outside the park boundaries there are two significant hooded plover *Thinornis rubricollis* nesting sites on Clifton and Rivernook Beaches. *T rubricollis* has also been sighted west of the MNP at Shelley Beach and the mouth of the Sherbrook River.

2.2.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. The main habitats present in Twelve Apostles MNP include intertidal and subtidal reef and soft sediment, and the water column. In 2005 the deep (> 15 m) subtidal substrate and biota was surveyed (Figure 18 & Figure 19) and mapped acoustically (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). Underwater video transects allowed the substrate and biota to be modelled across the park. The biota was also surveyed in 2006 using underwater video transects (Edmunds *et al.* 2010b).

There are some intertidal reefs in the Twelve Apostles MNP (Parks Victoria 2006b). Small limestone intertidal reefs have formed where rock stacks have been eroded away (Bird 1993). They have also formed as narrow ledges on cliffs at the mid-tide level due to erosion, or by hardening due to precipitation of carbonates from sea water (Bird 1993). The vertical faces of the cliffs themselves provide intertidal habitat.

Unconsolidated subtidal sediment (Figure 18) covers 47 % (47.67 km^2) of the MNP, the majority in a gently sloping (< 2°) central sandy plain (Ierodiaconou *et al.* 2007). In shallower depths the sediment is characteristically fine rippled sand (< 5 cm) and deeper depths course rippled (> 20 cm) gravel and cobble substrate (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). Solid subtidal reef and high profile broken limestone subtidal reef systems (Figure 18) dominate the far western end of the MNP and an extensive region in the east (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). This substrate covers 32 % (33.11 km^2) of the MNP (Ierodiaconou *et al.* 2007). Mixed subtidal reef/unconsolidated sediment (Figure 18) consisting of low relief (< 1m) reef partially inundated by sand is the remaining substrate in the MNP (Ierodiaconou *et al.* 2007). It is found along the deep margins of the high profile reefs and where sand has inundated cracks and fissures within the reef (Ierodiaconou *et al.* 2007). A distinct large deep ancient subtidal rocky platform (~ 400 m in diameter) occurs in the MNP and may have been of importance to the local indigenous people as a potential harvesting resource (Ierodiaconou *et al.* 2007).

Areas of unconsolidated sediment are usually devoid of visible biota (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). The exception is in the deeper regions where a thin veneer of sand covers the underlying reef (Figure 19) allowing sessile invertebrates to grow (Ierodiaconou *et al.* 2007). Sparse seagrass *Heterozostera* spp (Figure 19) grows in 10 – 30 m on the shallow sandy plain and covers 3 % of the MNP (Ierodiaconou *et al.* 2007). On the reefs dense macroalgal beds grow on the north-west reef and become mixed with sessile invertebrates in the south-west and south-east (Holmes *et al.* 2007c). The habitat class of mixed red algae/invertebrates covers 32 % (32.70 km^2) of the MNP and dominates in areas where reef is inundated with sediment (Ierodiaconou *et al.* 2007). Mixed red algae habitat covers 8 % (8.24 km^2) of the MNP on mainly high profile reef (Ierodiaconou *et al.* 2007). High profile reefs also support a number of other biotic habitat classes including mixed brown/invertebrates (5 %) and mixed brown /mixed red /invertebrates (3 %) (Ierodiaconou *et al.* 2007). Less than 1 % of high profile reef is dominated by either mixed brown/ mixed red algae, mixed green algae or mixed brown algae (Ierodiaconou *et al.* 2007).

Some biotic groups contribute to the dominant biotic habitats at all depth strata while others are restricted in their distribution (Ierodiaconou *et al.* 2007). The kelp *Ecklonia radiata* and the green algae *Caulerpa* spp grow in depths less than 40 m and their abundance decreases with depth (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007; Edmunds *et al.* 2010b). *Caulerpa* spp is more dominant in 10 – 20 m (Ierodiaconou *et al.* 2007). *E. radiata* dominates the middle of the western reef (Holmes *et al.* 2007c). Red algae and sponges occur at all depths although their abundance varies (Ierodiaconou *et al.* 2007; Figure 15). Sponges are more dominant at depths > 40 m while red algae is dominant at all depths <50m depth (Ierodiaconou *et al.* 2007). Ascidians are found between 30 – 60 m with the highest abundance in 40 – 50 m (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). Bryozoans are found between 40 – 60 m and sea whips *Primnoella australasiae* are restricted to between 40 – 50 m. Gorgonians are restricted to the deepest depths at 60 – 70 m (Ierodiaconou *et al.* 2007). Sessile invertebrates are denser on the eastern reef (Holmes *et al.* 2007c).

Figure 15. Sessile invertebrates and algae on subtidal reef in Twelve Apostles Marine National Park. Photo by NRE.

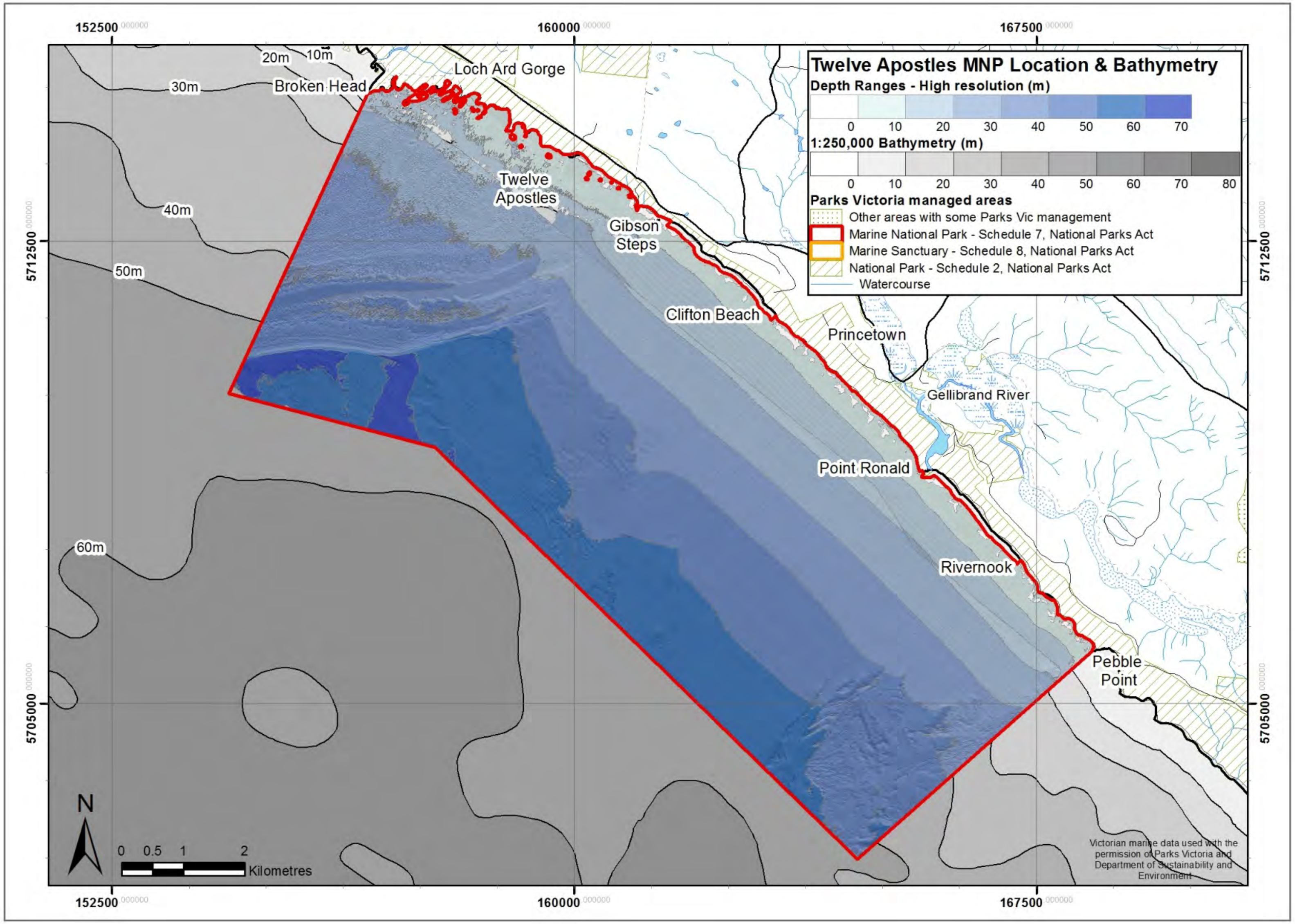


Figure 16. Location map of the Twelve Apostles Marine National Park with bathymetry. There are no ongoing monitoring sites in the MNP.

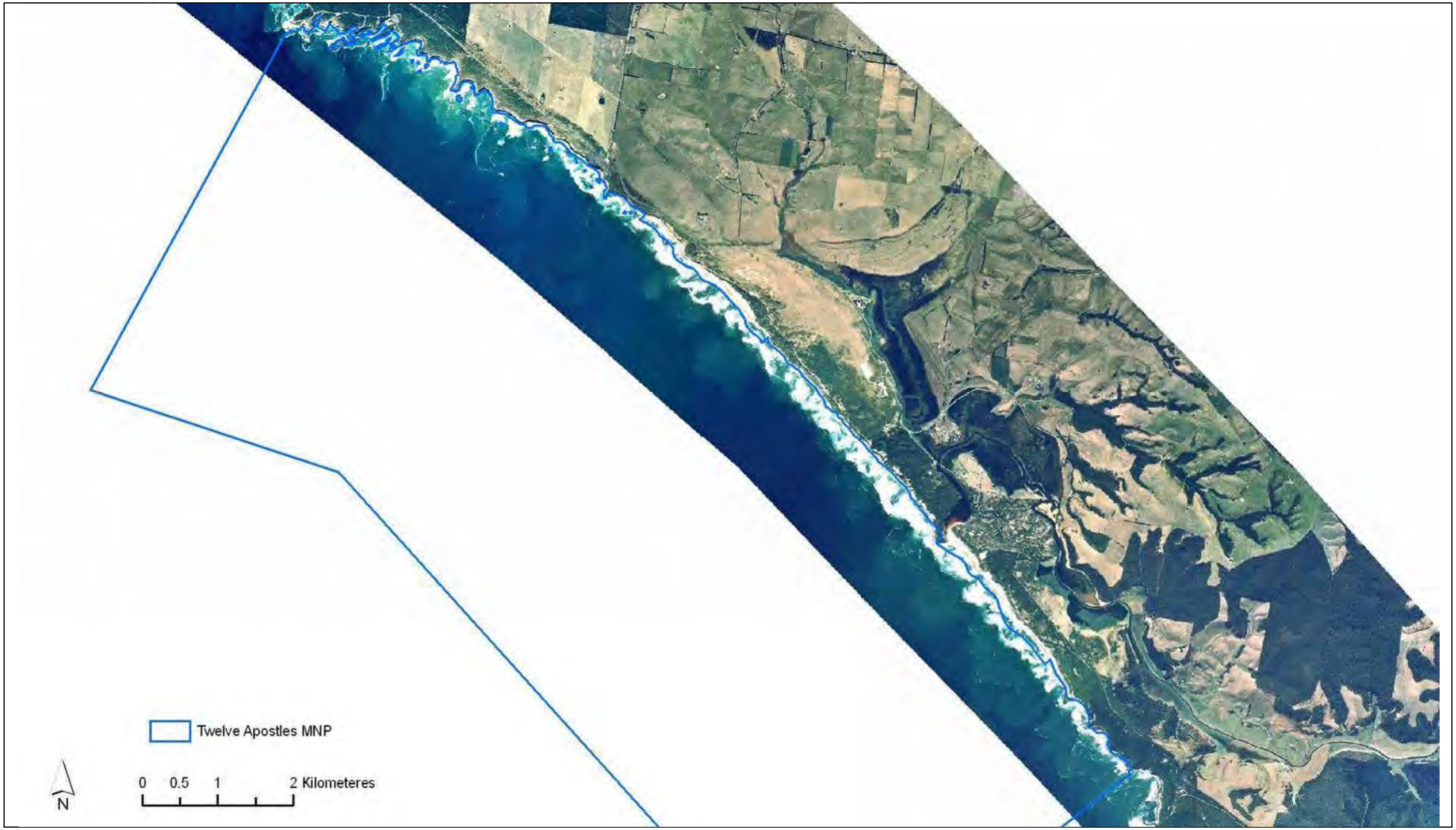


Figure 17. Aerial photograph of the coastline of the Twelve Apostles Marine National Park (QASCO 2003). From Ball and Blake 2007.

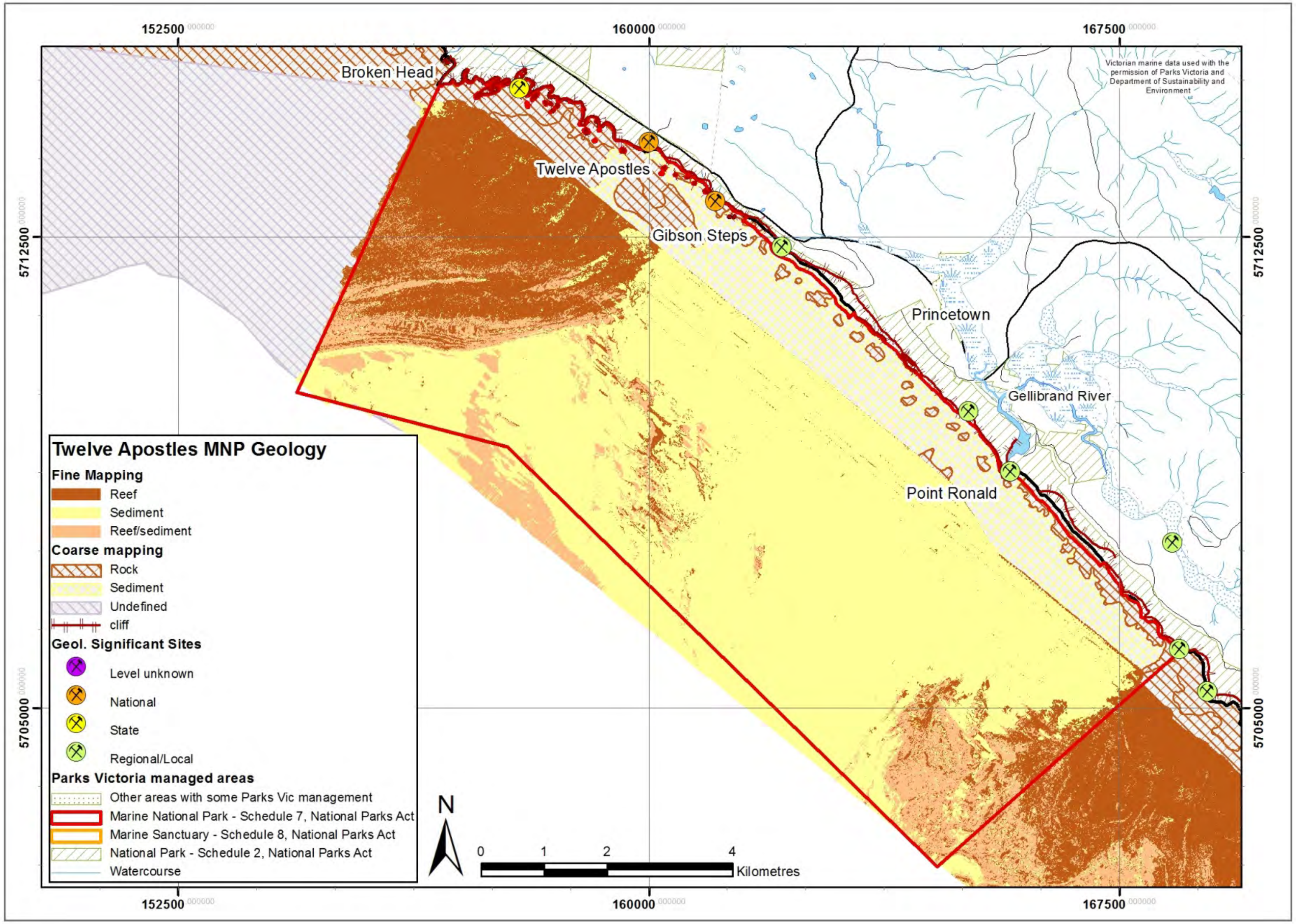


Figure 18. Substrate mapping of Twelve Apostles Marine National Park and surrounds, showing sites of geological significance.

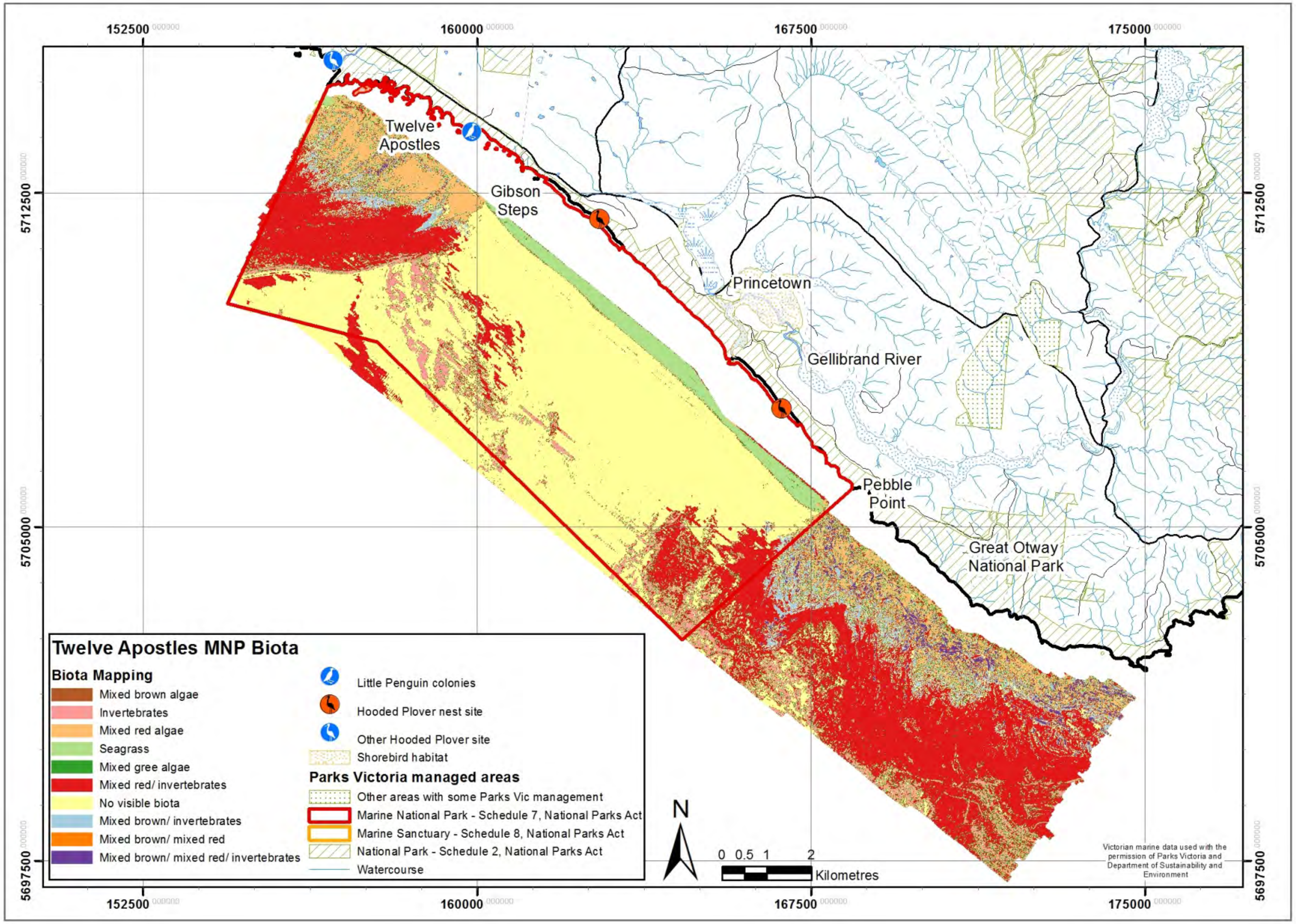


Figure 19. Biota mapping of the Twelve Apostles Marine National Park and surrounds showing sites of biological significance.

2.2.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in descriptive surveys in the Twelve Apostles MNP (Edmunds *et al.* 2010b) and detailed biotic mapping (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). Twenty-seven birds and seven marine mammals have been recorded in or near the MNP (Appendix 1). There is one site of biotic significance in the MNP, between the Twelve Apostles and London Bridge with a large breeding colony of little penguins *Eudyptula minor* (Figure 19). Comprehensive surveys of the subtidal reef biota have not been done. There have been no surveys of the biota of the intertidal soft sediment or pelagic habitats.

Intertidal

Soft sediment

Within the MNP intertidal soft sediment or beaches are generally small isolated pockets at the base of cliffs. The large beaches at Gibson Steps and the mouth of the Gellibrand River are not within the MNP. Flora is restricted to macroalgae drift and macroalgal epiphytes. The invertebrates and fish of the intertidal soft sediment habitat in Twelve Apostles MNP have not been surveyed. Beach-washed materials in sandy beach habitats are a significant source of food for scavenging birds, and contribute to the detrital cycle that nourishes many of the invertebrates, such as bivalves, living in the sand. The intertidal soft sediment is an important feeding and roosting habitat for shorebirds. There is no specific data on the biota of the beaches in the Twelve Apostles MNP (Plummer *et al.* 2003).

Reef

Rocky intertidal reefs, also called rocky reefs or intertidal platforms, are generally found in Victoria on and near headlands with stretches of sandy beaches either side. Along with beaches, intertidal reefs are one of the most accessible components of the marine environment as they are the interface between the ocean and the land (Power and Boxshall 2007). As such they are valued as important habitats by people and tend to be visited more than other sections of the coast (Carey *et al.* 2007a; Carey *et al.* 2007b). This means they are often subjected to human pressures like harvesting, fossicking and trampling as well as pressures from pollution sources on land and in the sea (Power and Boxshall 2007).

Intertidal reef biota is exposed to large changes in physical conditions such as temperature and desiccation. There is great spatial and temporal variability in the life histories of the organisms and the environmental processes in reef habitats (Underwood and Chapman 2004). The recruitment of new biota onto the reef, largely from plankton, strongly influences the ecological patterns for individual species and assemblages. Interactions between biota on the reef also influence biota distribution. Resources which are often in short supply on intertidal reefs are space on which to live and food (Underwood and Chapman 2004).

The invertebrate fauna of some of the intertidal reefs in the Twelve Apostles (Figure 20) have been surveyed (Plummer *et al.* 2003). The fauna was similar to that elsewhere on the Otways coast with over 63 species of invertebrates recorded in the MNP and Gibson Steps area (Plummer *et al.* 2003). These range from echinoderms such as sea stars, brittle stars and sea urchins, barnacles, crabs, sea anemones, polychaetes, and molluscs which are numerous (Plummer *et al.* 2003). No data are available on intertidal macrophytes or fish in the MNP. The MNP is regarded as having one of the highest diversity of intertidal invertebrates on limestone in Victoria (ECC 2000; Carey *et al.* 2007b).

Figure 20. Intertidal reef with bull kelp *Durvillaea potatorum* at the base of the calcarenite rock stacks in Twelve Apostles Marine National Park. Photo by AME.

Subtidal

Soft sediment

Areas of subtidal soft sediment in the MNP are usually devoid of visible biota (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). The exception is in the deeper regions where a thin veneer of sand covers the underlying reef allowing sessile invertebrates to grow (Ierodiaconou *et al.* 2007). Also, sparse seagrass *Heterozostera* spp grows in 10-30m on the shallow sandy plain (Ierodiaconou *et al.* 2007).

Depth and sediment affect the distribution of benthic invertebrates along the Victorian coast (Coleman *et al.* 2007; Heislers and Parry 2007). A coastal survey of benthic fauna included the benthos of the Twelve Apostles MNP (Coleman *et al.* 2007; Heislers and Parry 2007). One transect in the MNP was sampled with two 0.1 m^2 grab samples in 10, 20 and 40 m water depth. The sediment was fine sand that became coarser with depth (Heislers and Parry 2007). The grab samples contained between 93 to 403 individuals and 19 to 27 species (Heislers and Parry 2007). Crustaceans were the dominant taxa in each depth class, representing more than half (*i.e.* 4 - 9) of the most abundant families. The majority of these were amphipods, while isopods and cumaceans were also common. Polychaetes represented the bulk (*i.e.* 2 - 3) of the remaining families while molluscs were poorly represented. Four families were common in all depth classes, including two amphipod families (Phoxocephalidae and Urohaustoriidae) and two polychaete families (Spionidae and Syllidae).

Reef

Subtidal reefs and their assemblages are strongly influenced by the position of the reef, its orientation, slope, depth, exposure and topography (Connell 2007). These physical parameters influence key physical processes such as light, water flow and sedimentation, and biological processes such as foraging and recruitment (Connell 2007). Biotic assemblages of algae and sessile invertebrates can form habitat and food sources for invertebrates and fish. Shallow (< 15 m) subtidal reefs are known for their high biological complexity, species diversity and productivity and in addition they have significant economic value through commercial and recreational fishing (outside of MPAs), diving and other tourism activities (Power and Boxshall 2007). Shallow subtidal reefs are often dominated by canopy forming algae. Deep reefs, where light penetration is limited, are often dominated by large sessile invertebrates such as massive sponges, whip corals, soft corals and colonial ascidians. Biotic assemblages can form habitat and food sources for invertebrates and fish.

Flora

Seaweeds provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present. For example, canopy forming algae on subtidal reefs in Twelve Apostles MNP varies with depth, sand coverage and microhabitat such as reef tops (horizontal surfaces), ledge edges, vertical walls and caverns under ledges (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007; Edmunds *et al.* 2010b). High profile reefs are variable in their dominant canopy type and can support beds of either mixed red, brown or green algae or a combination of algal types and sessile invertebrates (Ierodiaconou *et al.* 2007). Dense mixed macroalgae beds dominate the shallow reef in the north-west of the MNP (Holmes *et al.* 2007c). The kelp *Ecklonia radiata* and the green algae *Caulerpa* spp grow in depths less than 40 m and their abundance decreases with depth (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007; Edmunds *et al.* 2010b). *E. radiata* dominates the middle of the western reef (Holmes *et al.* 2007c). Smaller brown algae including *Carpomitra costatum* and *Homoeostrichus* sp. are present in sandier areas. *Caulerpa* spp is abundant in 10 – 20 m (Ierodiaconou *et al.* 2007). Green alga in the MNP is predominantly *Caulerpa flexilis*, but *C. cactoides/annulata* and *Codium* sp. are also present. Red algae occurs in all depths although their abundance varies and is greater in depths < 50 m (Ierodiaconou *et al.* 2007). The thallose red algal species in the MNP are similar to those found on shallow subtidal reefs elsewhere in Victoria, including: *Phacelocarpus peperocarpus*, *Melanthalia obtusata*, *Gelidium asperum*, *Plocamium mertensii*, *Callophyllus rangiferina*, *Ballia callitricha*, *Sonderopelta coriacea* and *Haliptilon roseum* (Edmunds *et al.* 2010b). In deeper reefs sessile invertebrates grow in amongst the macroalgae (Holmes *et al.* 2007c; Edmunds *et al.* 2010b). Mixed red algae and sessile invertebrates dominate in areas where reef is inundated with sediment (Ierodiaconou *et al.* 2007).

Invertebrate fauna

Mobile invertebrates on the subtidal reef in the Twelve Apostles MNP include the southern rock lobster *Jasus edwardsii,* and the seastars *Nepanthia troughtoni, Plectaster decanus*, *Echinaster arcystatus*, *Nectria macrobrachia* and other *Nectria* species (Edmunds *et al.* 2010b). The Twelve Apostles MNP is regarded as having the highest diversity of shallow subtidal invertebrates on limestone reef in Victoria (ECC 2000; Carey *et al.* 2007b). The abundance of sessile invertebrates on the reef tops increases with depth, particularly the isidid gorgonian *Pteronisis* spp., erect sponges, and the large hydroid fan *Solanderia fusca* (Edmunds *et al.* 2010b). Sessile invertebrates are denser on the eastern reef (Holmes *et al.* 2007c).

Sponges are diverse in the MNP and can occur at all depths but are more dominant at depths >40m (Ierodiaconou *et al.* 2007). Over 30 distinguishable types of sponges, based on morphology and texture, have been observed in the MNP (Edmunds *et al.* 2010b). The most common types are encrusting ruffled, massive ruffled, massive reticulated and arborescent ruffled sponges (Edmunds *et al.* 2010b). A distinctive sponge found in the MNP is the 'taco' sponge (resembling a stalked Mexican taco), which is also known to occur at Point Addis, but not on deep reefs further to the east (Edmunds *et al.* 2010b). *Holopsamma laminaefavosa* is a distinctive sponge of the Port Phillip Heads region but was in very low abundance at the Twelve Apostles MNP (Edmunds *et al.* 2010b).

Common hydroids are the distinct red *Halopteris glutinosa*, the feathery brown *Gymnangium superbum,* and the large fan-like *Solandaria fusca* (Edmunds *et al.* 2010b). The yellow soft coral *Parazoanthus* sp. is generally found under ledges and in caves (Edmunds *et al.* 2010b). The soft coral *Erythropodium hicksoni* is common and can form large sheets over the substratum (Edmunds *et al.* 2010b). A species of stony coral *Plesiastrea versipora* not often observed on cool temperate deep reefs has been observed in the MNP (Edmunds *et al.* 2010b). Common erect corals include the gorgonians *Mopsella* spp., *Acabaria* sp. and *Pteronisis* spp (Edmunds *et al.* 2010b). Gorgonians are restricted to the deepest depths at 60 – 70 m (Ierodiaconou *et al.* 2007). Sea whips *Primnoella australasiae* are restricted to between 40 – 50 m.

Bryozoans, particularly bushy and erect plate forms, can be found at most depths but are most abundant in 40 – 60 m depth (Ierodiaconou *et al.* 2007; Edmunds *et al.* 2010b). Ascidians are found between 30 – 60 m with the highest abundance in 40 – 50 m (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007). The solitary ascidian *Herdmania momus* is common in the MNP (Edmunds *et al.* 2010b).

Figure 21. Sea sweep *Scorpis aequipinnis* off a sessile invertebrate dominated subtidal reef in Twelve Apostles Marine National Park. Photo by NRE.

Fish

Commonly observed subtidal reef fish in the Twelve Apostles MNP are typical of the Otway Bioregion, including: the blue-throated *Notolabrus tetricus*, rosy *Pseudolabrus psittaculus* and senator wrasses *Pictilabrus laticlavius*; the magpie perch *Cheilodactylus nigripes* and dusky morwongs *Dactylophora nigricans*; sea sweep *Scorpis aequipinnis* (Figure 21); barber *Caesioperca rasor* and butterfly perches *C. lepidoptera*; marble fish *Aplodactylus arctidens*;

and bullseye *Pempheris multiradiata* (Edmunds *et al.* 2010b). Leatherjackets, Monacanthidae, are generally not as abundant as on other shallow reefs in Victoria (Edmunds *et al.* 2010b). Larger fish include bastard trumpeter *Latridopsis forsteri*, and blue morwong *Nemadactylus valenciennesi* (Edmunds *et al.* 2010b).

Water column

The water column is a large habitat in the MNP. It is important in different ways for many organisms including for transit or as a permanent home for particular stages of their life cycle. Organisms that use the water column environment can be broadly grouped into two categories based on mode of movement: either pelagic (actively swimming) or planktonic (drifting with the current). Larger species are often planktonic during early life stages before becoming pelagic as they grow. Smaller species tend to be planktonic but can influence their movement to some extent by controlling their height in the water column. Organisms that make their permanent home in the water column include sea jellies, salps, many fish, and both phytoplankton and zooplankton. Planktonic organisms play an important role in nutrient cycling, dispersal of species and providing food for larger animals, both within the MNP and more broadly in the marine environment. The water column is also used by fish, invertebrates and algae for transport and food (and other resources like oxygen). Parks Victoria does not currently monitor the water column as a habitat (Power and Boxshall 2007). As described in the following section a wide variety of shorebirds, seabirds and mammals of conservation significance are found in the waters of the Twelve Apostles MNP.

2.2.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is likely to protect and enhance threatened species populations (Power and Boxshall 2007). Whole-of-habitat management may also result in the protection of species not yet identified because of their rarity or cryptic nature (Power and Boxshall 2007).

Flora

No threatened marine flora has been recorded in Twelve Apostles MNP.

Fish

The open waters of Twelve Apostles MNP are a probable habitat for the FFG listed threatened migratory southern bluefin tuna *Thunnus maccoyii*. Likewise the open waters could be used by the grey nurse shark *Charcharias taurus* which is listed as threatened in Victoria (*FFG*) and critically endangered nationally (*EPBC*). The great white shark *Carcharodon carcharias* threatened in Victoria (FFG) and vulnerable nationally (EPBC) probably also uses the waters of Twelve Apostles MNP.

Birds

Eleven conservation listed shore or sea birds have been sighted in or in the immediate surrounds of the Twelve Apostles MNP (Table 8). Nine are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Three are regarded as endangered, the wandering albatross *Diomedea exulans*, little egret *Egretta garzetta*, and Australasian bittern *Botaurus poiciloptilus*. Four birds are listed as vulnerable at the national level. Six migratory birds are recognized internationally under either CAMBA or JAMBA.

The Twelve Apostles beach between the Twelve Apostles and London Bridge has one of Victoria's largest breeding colonies of little penguins *Eudyptula minor* (Parks Victoria 2006b). Over 1,000 *E. minor* breed at the beach and are protected under the *Wildlife Act 1975*. Eggs are laid between August to October. Adults may travel large distances from their colonies to feed but typically remain within 20 km of the colony while feeding chicks. The colony is recognized as a site of state biotic significance (Figure 19).

Offshore, Mutton Bird Island supports a breeding colony of short-tailed shearwaters *Puffinus tenuirostris* (Parks Victoria 2006b).

Just outside the park boundaries there are two significant hooded plover *Thinornis rubricollis* nesting sites on Clifton and Rivernook Beaches. *T. rubricollis* has also been sighted west of the MNP at Shelley Beach and the mouth of the Sherbrook River (Table 8 & Figure 19).

Table 8. Conservation listed shorebird and seabird records from Twelve Apostles Marine National Park and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
wandering albatross	*Diomedea exulans*	L	EN	VU		J
shy albatross	*Thalassarche cauta*	L	VU	VU		J
black-browed albatross	*Thalassarche melanophris*		VU	VU		J
blue petrel	*Halobaena caerulea*			VU		J
eastern great egret	*Ardea modesta*	L	VU		C	J
little egret	*Egretta garzetta*	L	EN			
Australasian bittern	*Botaurus poiciloptilus*	L	EN			
hooded plover	*Thinornis rubricollis*	L	VU			
glossy ibis	*Plegadis falcinellus*		NT		C	
short-tailed shearwater	*Ardenna tenuirostris*					J
black-faced cormorant	*Phalacrocorax fuscescens*		NT			

L= FFG listed, NT = Near Threatened, VU = Vulnerable, EN = Endangered, C = Listed under the CAMBA treaty, J = Listed under the JAMBA treaty

Marine mammals

Southern right whales *Eubalaena australis*, humpback whales *Megaptera novaeangliae*, and New Zealand fur seals *Arctophoca forsteri* have been recorded in or near the Twelve Apostles MNP (Table 9). The southern right whale *E. australis* is listed as critically endangered in Victorian waters and endangered nationally. The humpback whale *M. novaeangliae* is listed as vulnerable at the state and national level. The New Zealand fur seal *A. forsteri* is listed as vulnerable at the state level (Table 9). The intertidal reefs at the base of the rock outcrops provide occasional haul-out areas for Australian fur seals *Arctocephalus pusillus doriferus*.

Table 9. Conservation listed marine mammal records from the Twelve Apostles Marine National Park and surrounds.

		Victorian listing		National listing
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**
southern right whale	*Eubalaena australis*	L	CE	EN
humpback whale	*Megaptera novaeangliae*	L	VU	VU, M
New Zealand fur seal	*Arctophoca forsteri*		VU	
Australian fur seals	*Arctocephalus pusillus doriferus*			L

L= FFG listed, VU = Vulnerable, EN = Endangered, CE = Critically Endangered, M = listed Migratory

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that no endemic or rare fauna or flora have been recorded in Twelve Apostles MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). One brittle star *Ophiacantha heterotyla* is presumed to be at its western distributional limit in the MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). The distributional limits of the biota may reflect collection effort in this area rather than actual Victorian distributions. Many areas of the Victorian coast have never been sampled and therefore biota ranges may be much greater than those suggested.

2.2.5 MAJOR THREATS

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPA's. Through public and agency workshops, the natural values in individual MPA's and the threats that could affect them over the next ten years, were considered and ranked to identify hazards. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Thirteen hazards with the potential to be of extreme risk to the Twelve Apostles MNP were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Oil spills from offshore platforms or shipping affecting seabirds and intertidal habitats and communities (water column);
2. Terrestrial events/activities such as floods, fires, droughts, nutrients, (water) extractions, affecting water quality (subtidal reef and water column);
3. Pest plants and animals from recreational boating, ballast water discharge, agriculture, shipping and industry, displacing local species (subtidal reef and soft sediment);
4. "Island-based" management focus affecting marine habitats and communities (all of MNP);
5. Funding for management affecting marine communities and habitats (all of MNP);
6. Lack of knowledge affecting marine habitats and communities (all of MNP);
7. Seismic testing affecting larger (marine) vertebrates (water column);
8. Land-based litter affecting the marine environment (all of MNP);
9. Marine debris from elsewhere (*i.e.* beyond parks) resulting in smothering of, entanglement with, or ingestion by marine organisms (all of MNP);
10. Technology creep (*i.e.* better oil/gas extraction/exploration methods, exploitation of new resources, new ways of accessing resources via bioprospecting, aquaculture etc.) affecting marine communities and habitats (all of MNP);
11. Artificial opening of river mouths producing silt plumes resulting in fish kills and sedimentation (subtidal reef and soft sediment);
12. Government influence on management affecting marine communities and habitats (all of MNP); and
13. External management complexity (*e.g.* common boundary of Twelve Apostles MNP with Federal MPA) affecting marine communities and habitats (all of MNP).

Most intertidal areas in the park are not accessible and are well protected from most visitor impacts, but they are susceptible to pollution and would be extremely difficult to clean up should an incident occur (Parks Victoria 2006b).

The introduction of marine pests threatens the integrity of marine biodiversity and may also reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). No introduced species or marine pest has been recorded from the Twelve Apostles MNP (Parks Victoria 2006b). It is thought that the introduced green shore crab *Carcinus maenas* is not found within the MNP as the coast is too rough. Japanese kelp *Undaria pinnatifida* has been recently found in Apollo Bay and there are grave concerns about its spread. To the east in Flinders Bioregion the Northern Pacific seastar *Asterias amurensis* was found in Anderson Inlet and may have been eradicated in a broad-based community effort in 2004 – 05, led by DSE (Parks Victoria 2006a). Asterais was also found at San Remo jetty in late 2011. Further east in the Twofold bioregion the introduced screw shell *Maoricolpus roseus* has been recorded in high densities (Holmes *et al.* 2007b). This species is regarded as a serious threat to the high diversity of infauna that is characteristic of much of Bass Strait (Heislers and Parry 2007). *Grateloupia turuturu, Caulerpa racemosa* var. *cylindracea* and *Codium fragile* subspecies *fragile* were also recorded in Portland harbour in 2010 (John Lewis pers. comm.). Another species of particular concern is the marine fanworm *Sabella spallanzanii*(Parks Victoria 2003).

A virus affecting abalone called abalone viral ganglioneuritus has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area and has been confirmed from Discovery Bay MNP to Cape Otway (DPI 2009). It has been confirmed from the Twelve Apostles MNP, however long term ecological consequences for rocky reef communities are unknown (DPI 2009).

Figure 22. Twelve Apostles Marine National Park. Photo by AME.

Climate Change

Climate change represents a serious threat to marine ecosystems (McLeod *et al.* 2009) but specific ecological consequences of accelerating climate change are not well understood in marine systems, particularly in temperate systems. Climate change is predicted to increase water temperature, alter chemical composition (salinity, acidity and carbonate saturation), change circulation and productivity, increase frequencies of extreme weather events and exposure to damaging ultraviolet light (UVB), and increase air temperature, cloud cover and sea levels (conservatively 80cm by 2100, CSIRO-BoM 2007; Fine and Franklin 2007; VCC 2008; McLeod *et al.* 2009). A combined increase in cloud cover and sea level could result in decreased light availability potentially changing benthic flora. Increased storm surges and ocean current changes also have the potential to change the distribution of fauna and flora and could result in loss of habitats (CSIRO-BoM 2007). Intertidal communities will face increased desiccation, storm wave exposure and habitat shift. Changes in the relationship between climate and annual life-history events may force major change in functional groups and consequent ecosystem function (Fine and Franklin 2007). Climate change is also anticipated to modify species recruitment and habitat connectivity, species interactions and disturbance regimes in the marine environment (CSIRO-BoM 2007; Fine and Franklin 2007).

Measures to address or minimise these threats form part of the management plan for the Twelve Apostles MNP (Parks Victoria 2006b). For example research is being conducted into marine pest species that may impact on park values, which includes identifying the MPAs which are most at risk of invasion. and trialling options for improving management of illegal activities in the MPAs. Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

Figure 23. Coastline of Twelve Apostles Marine National Park. Photo by NRE.

2.2.6 CURRENT RESEARCH AND MONITORING

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. The research relevant to Twelve Apostles MNP has been published in Parks Victoria's Technical Series available on Parks Victoria's website (http://www.parkweb.vic.gov.au). As most research in the MNP has been carried out under permits issued by DSE, the permit database was also used to identify relevant projects for this report (see Table 10 and Appendix 2).

The Twelve Apostles MNP does not have an ongoing intertidal or shallow subtidal reef monitoring program because these habitats are either too exposed or too deep in the MPA. A review of monitoring needs in relation to conservation outcomes for the parks will be done by 2013. The major directions for monitoring include implementing an expanded and improved monitoring program following a review of the major findings taking into account knowledge generated since park declaration (Power and Boxshall 2007; Keough and Carnell 2009).

Statewide, the Museum of Victoria is collecting additional data on the marine natural values of Victoria's MPAs. They are gathering information about natural history through video and photos, and using semi-quantitative methods to determine spatial and temporal changes across the system in response to threats, including marine pests and climate change. Jan Carey (University of Melbourne) is conducting research focussing on marine pest species which may impact on park values, and the MPAs which are most at risk of invasion. This will help prioritise Parks Victoria surveillance monitoring efforts to MPAs where there is greatest potential for successful management.

Table 10. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Twelve Apostles Marine National Park.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimizing the allocation of resources for defending Marine Protected Areas against invasive species.
Multiple Research Partners: Marine Monitoring and Marine Natural Values ***Deakin University:*** Jan Barton, Adam Pope and Gerry Quinn Marine Natural Values Reports for the Marine National Parks and Sanctuaries – Version 2. ***University of Melbourne:*** Jan Carey Developing Report Cards for the Marine National Parks.
Museum Victoria: Mark Norman, Julian Finn. ***Parks Victoria:*** Roger Fenwick Under the Lens - Natural History of Victoria's Marine National Park System.
University of Melbourne: Tarek Murshed, Jan Carey, Jacqui Pocklington Conceptual model development for marine habitats.
Ongoing Habitat Mapping Projects
DSE / DPI / Worley Parsons/ Deakin University* LiDAR Mapping Project. Mapping of bathymetry and marine habitats along the Victorian coast

*led by DSE and includes sections of the Marine National Parks and Sanctuaries.

2.2.7 KNOWLEDGE GAPS

Knowledge of subtidal reef ecological communities comes from qualitative video sampling in which the dominant habitat forming biota has been identified (*e.g.* Figure 24). Smaller or more cryptic biota are not well sampled by this method. There is no quantitative data on fish abundances, distributions or interactions in the subtidal reef or water column habitats. Some information exists for subtidal soft sediment. Limited information has been collected on the intertidal reef or soft sediment. Major threats have been identified for the Twelve Apostles MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.

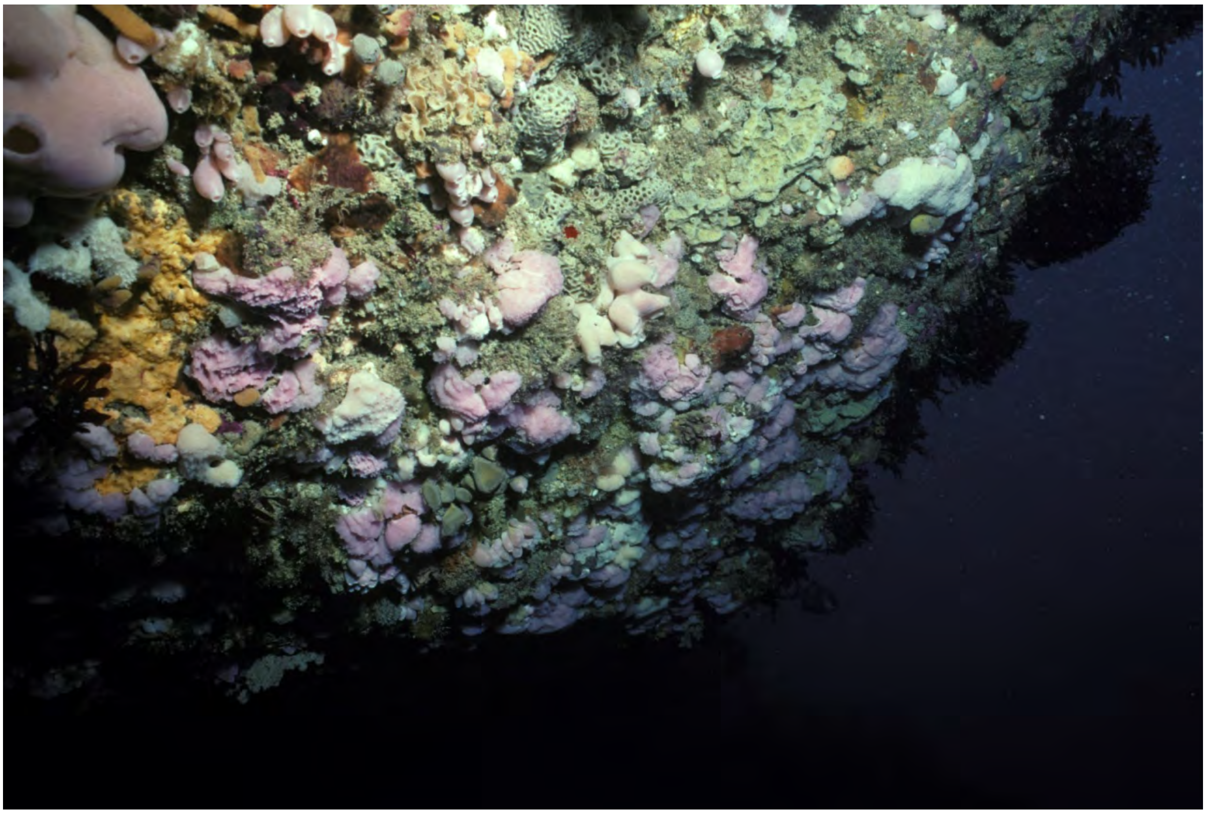


Figure 24. Sessile invertebrate dominated subtidal reef in Twelve Apostles Marine National Park. Photo by NRE.

3 Marine Sanctuaries

3.1 Merri Marine Sanctuary

The Merri Marine Sanctuary (Figure 25) includes an area below the mean high water mark between Thunder Point (Figure 27) in the west and Breakwater Rock in the east (Parks Victoria 2007b). It extends from the footbridge on the Merri River to the south-west for approximately 200 metres (Figure 28). The sanctuary surrounds Middle and Merri Islands (Figure 26), and Pickering Point is a prominent headland. Thunder Point, Stingray Bay and the Breakwater are major access points.

Aboriginal tradition indicates that the Merri MS is part of the sea *Country* of the Gunditjmara and Kirrae Whurrong Aboriginal people (Parks Victoria 2007b). The flora and fauna traditionally accessed by local Aboriginal groups is an important natural value of the Merri MS (Carey *et al.* 2007b).

Important natural values of the Merri MS are the seabed at the river mouth which provides a range of habitats and diverse marine life. This includes the subtidal rocky overhangs and canyons that support a variety of fish (Carey *et al.* 2007b). The intertidal area at Pickering Point is particularly diverse and colourful. It is is accessible during low tides and has important educational value (Parks Victoria 2007b). It has been designated a Special Protection Area (Parks Victoria 2007b). The little penguin *Eudyptula minor* with breeding colonies on Merri and Middle Islands, are protected under the *Wildlife Act (*1975). The islands are also breeding sites for little pied cormorants *Microcarbo melanoleucos* and short-tailed shearwaters *Puffinus tenuirostris*, and roosting areas for transient seabirds such as the Pacific gull *Larus pacificus* (Parks Victoria 2007b). The large diversity of threatened sea and shorebirds recorded in the MS is an important natural value (Carey *et al.* 2007b). The frequent visitation by marine mammals to the MS is also important (Carey *et al.* 2007b).

The intertidal soft sediment is an important feeding and roosting habitat for shorebirds. Algal and invertebrate community diversity is low in the MS, with relatively few molluscs or barnacles but more anemones and seastars (Evans 2007; O'Hara *et al.* 2010). Macroalgal cover on the intertidal calcarenite reefs is sea lettuce *Ulva* sp., turfing red coralline algae *Corallina officinalis,* and the green algae *Caulerpa brownii,* Neptune's necklace *Hormosira banksii* is less common (Williams 2004; Evans 2007). The bull kelp *Durvillaea potatorum* is present on the fringe of the intertidal reef (Monk *et al.* 2008). Common macroinvertebrates are the warrener *Turbo undulatus*, limpets *Siphonaria diemenensis, Cellana tramoserica* and cartrut shell *Diacthais orbita* (Cohen 2000; Williams 2004; Evans 2007).

The subtidal reef is dominated by the brown algae *Phyllospora comosa* with a coralline algae understorey (Monk *et al.* 2008). Other algal habitats in the MS are formed by mixed red and brown algae, *Caulerpa* spp., encrusting and branching coralline algae, foliose red algal mix and *Ecklonia radiata* (Monk *et al.* 2008). The understorey has a relatively diverse community of fleshy red algae (Monk 2006; Crozier *et al.* 2007; Monk *et al.* 2008). The diversity of subtidal invertebrates on the reef near the MS is low compared to other Victorian west coast

Figure 25. Merri Marine Sanctuary. Photo by Jan Barton, Deakin University.

reefs (Crozier *et al.* 2007). Within the Merri MS the herbivorous molluscs the black lip abalone *Haliotis rubra* and the warrener *Turbo undulatus* are the most abundant invertebrates (Monk 2006). Blue-throated wrasse *Notolabrus tetricus* is the most abundant fish on the subtidal reefs in the Merri MS (Monk 2006). Herring cale *Odax cyanomelas,* magpie perch *Cheilodactylus nigripes*, Victorian scalyfin *Parma victoriae,* zebrafish *Girella zebra,* sea sweep *Scorpis aequipinnis* and senator wrasse *Pictilabrus laticlavius* are common but nowhere near as abundant as blue-throated wrasse (Williams 2004; Monk 2006; Crozier *et al.* 2007). The pot-bellied seahorse *Hippocampus abdominalis* is frequently seen on subtidal reefs in the sanctuary (Parks Victoria 2007b).

Merri MS provides important feeding and roosting habitat for fifty-one threatened bird species such as the fairy tern *Sternula nereis*, which is listed under the *Flora and Fauna Guarantee* (*FFG*) Act (1998) and regarded as endangered in Victoria. The MS protects feeding areas for 14 internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Breeding colonies of the little penguin *Eudyptula minor* are sited on Middle Island and in very small numbers on Merri island. Eight species of marine flora are believed to be at their distributional limits within the MS.

Serious threats to the Merri MS include inadequate management and limited ecological knowledge of important processes. Oil spills, degraded water quality from the catchment, artificial estuary opening, invasive marine pests, seismic testing, land and marine debris and climate change all pose serious threats to the integrity of the MS (Carey *et al.* 2007b). Measures to address or minimise these threats form part of the management plan for Merri MS (Parks Victoria 2007b). Ongoing subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Merri MS.

Figure 26. Merri Marine Sanctuary with Merri and Middle Islands in the background. Photo by Jan Barton, Deakin University.

3.1.1 PHYSICAL PARAMETERS & PROCESSES

Merri Marine Sanctuary is one of four MPA's in the Otway Bioregion, the others being Discovery Bay and Twelve Apostles MNP's and The Arches MS. The Bioregion also contains Discovery Bay and Bay of Islands Coastal Parks. Merri MS is 29 hectares in size which makes it the fifth smallest of the 24 MPA's in Victoria (Table 11). It abuts Coastal Reserve with 2.7 km of the coastline, but does not include Merri and Middle Islands (Figure 28). Its shoreline geology is calcarenite backed by coastal dunes (Bird 1993; Parks Victoria 2007b). The Merri MS has a maximum depth of 17 m (Monk *et al.* 2008).

With no major land masses between the Southern Ocean and Australia's southern coast, the Sanctuary is exposed to frequent large swells. Strong south-west winds are also common during the winter months (Monk *et al.* 2008). Currents predominantly carry water from the west and south towards the sanctuary during this time (Parks Victoria 2007b). The Bonney Upwelling in Spring and Summer brings cold water and nutrients to the coastline, with its predominant south-east wind and current flow (IMCRA 2006). The Merri River estuary flows directly into the middle of the MS at Stingray Bay (Figure 28) and is regarded as being in poor ecological condition (GHCMA 2008). The Warrnambool Sewage Treatment Plant (STP) discharges 500 m to the west and the Hopkins River estuary to the east of the MS. Freshwater inflow from the Merri River influences the local hydrodynamics of the MS and the mouth of the Merri River is often closed (Parks Victoria 2007b). High tides, storms, large swells and freshwater inflow cause significant sand movement. Modifications in and near the sanctuary, including the construction of the breakwater, have resulted in a significant accumulation of sand adjacent to the sanctuary (Parks Victoria 2007b). Over 30 % of the Merri River's catchment is urban with the majority of the population adjacent to the estuary (Barton *et al.* 2008).

Table 11. Physical attributes of the Merri Marine Sanctuary.

Park Name	**Merri**
Conservation status	Marine Sanctuary
Biophysical Region	Otway
Size	29 ha (ranked 20th of 24)
Length of coastline	~2.7 km
Shoreline geology	Calcarenite
Area with depth:	
Intertidal	7.1 ha
Intertidal-2m	8 ha
2-4m	6.2 ha
4-6m	4.9 ha
6-8m	2.1 ha
8-10m	0.7 ha
10-12m	0.1 ha
Mean tidal variation - spring	0.8 m
Mean tidal variation - neap	0.0 m
Mean water temp - summer	17.0°C
Mean water temp - winter	13.5°C
Adjacent catchment	Urban, Agricultural
Discharges into MNP	Merri River Warrnambool STP 500m west
Nearest major estuary (distance & direction)	Merri River directly into MS Hopkins River 3 km East

3.1.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. Since Plummer *et al.* (2003) two major habitat mapping surveys have been undertaken for the marine sanctuary (Ball and Blake 2007; Monk *et al.* 2008). Aerial photography from 2004 was used to map the intertidal and shallow subtidal habitats of Merri MS (Ball and Blake 2007; Figure 29). Subtidal habitat data collected by community-based divers (Sea Search, Koss *et al.* 2005a; Koss *et al.* 2005b) over three years (2002-2005) was used in conjunction with remotely sensed data to map in detail the subtidal habitats (Monk *et al.* 2008). This is a more detailed subtidal mapping than that carried out by Ball and Blake (2007) and forms the basis of the following description. Intertidal reef (8.7 ha) is found along the coastline and around the islands. Intertidal sand (2.7 ha) is found mostly in the east of Merri Island at the mouth of the Merri River. Together those two habitats cover 11.4 ha of the sanctuary (Figure 31). Subtidal reefs at Merri are either patchy and interspersed with areas of sand, or more consolidated hard reef cut by deeper depressions and large crevices (Crozier *et al.* 2007). Subtidal habitats cover the majority (17.5 ha) of the MS. High (> 1 m) relief calcarenite reef dominates, making up 47 % (8.7 ha) of the subtidal area and is found adjacent to intertidal reefs. Fine sand covers 28 % (5.2 ha) of the subtidal area and is found adjacent to the intertidal sand and between the islands. Low (< 1 m) relief calcarenite reef covers 25 % (4.6 ha) of the subtidal area and is found seaward of the high relief reefs (Monk *et al.* 2008). Cobble covers just 0.3 % (0.05 ha) of the total subtidal area.

Figure 27. Thunder Point Merri Marine Sanctuary. Photo by Jan Barton, Deakin University.

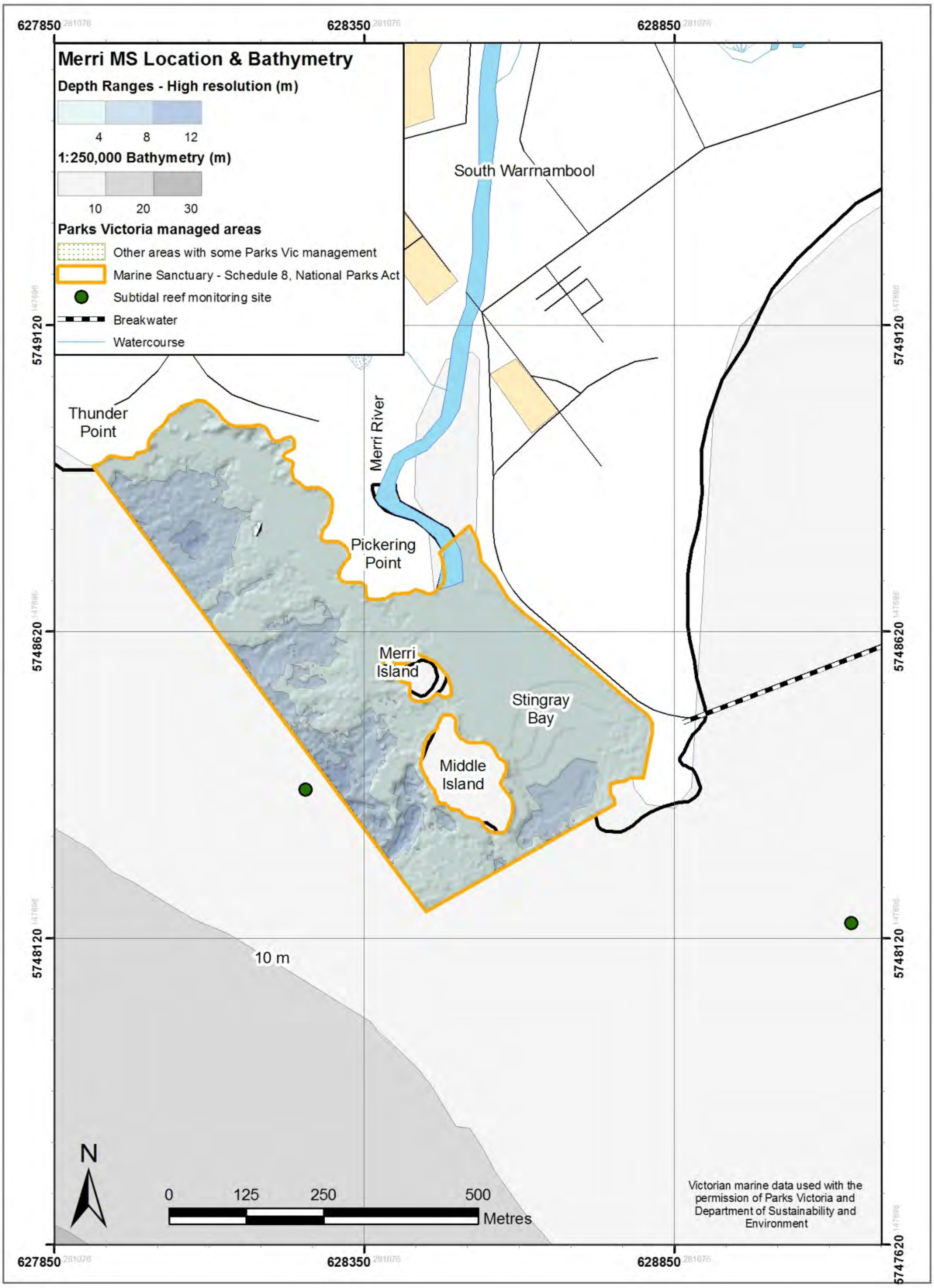


Figure 28. Location map of Merri Marine Sanctuary with 1:250,000 bathymetry. Intertidal regions from Monk *et al.* (2008). For historical reasons the SRMP site for the sanctuary is just outside the boundary. A reference site is located off Breakwater Rock. There are no intertidal reef monitoring sites.

Figure 29. Aerial view of Merri Marine Sanctuary (The State of Victoria through the Department of Sustainability and Environment, 1/12/04). From Ball and Blake 2007.


Figure 30. Intertidal reef in Merri Marine Sanctuary. Photo by Jan Barton, Deakin University

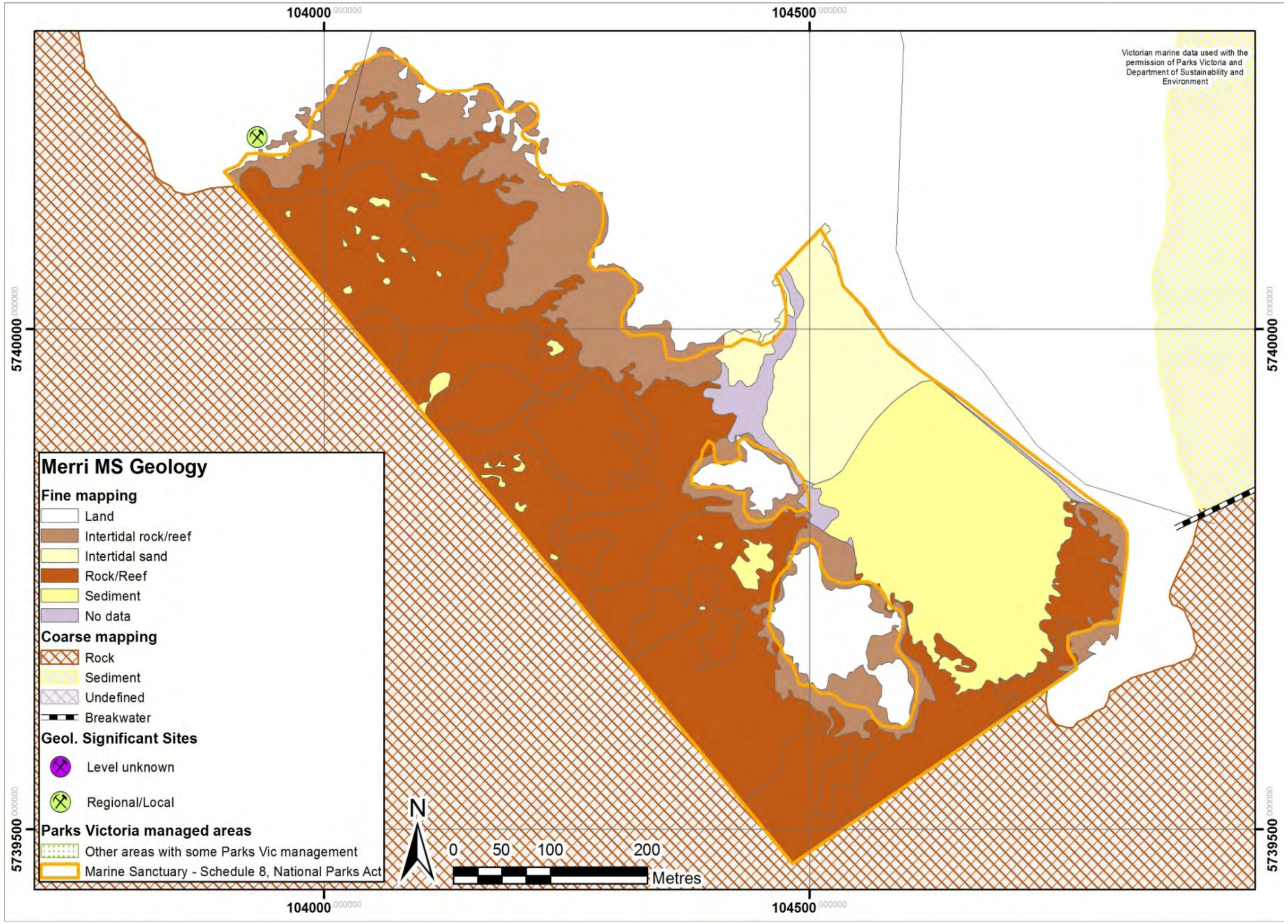


Figure 31. Substrate mapping of the Merri Marine Sanctuary and surrounds, showing nearby sites of geological significance. Fine substrate mapping by Monk *et al.* (2008).

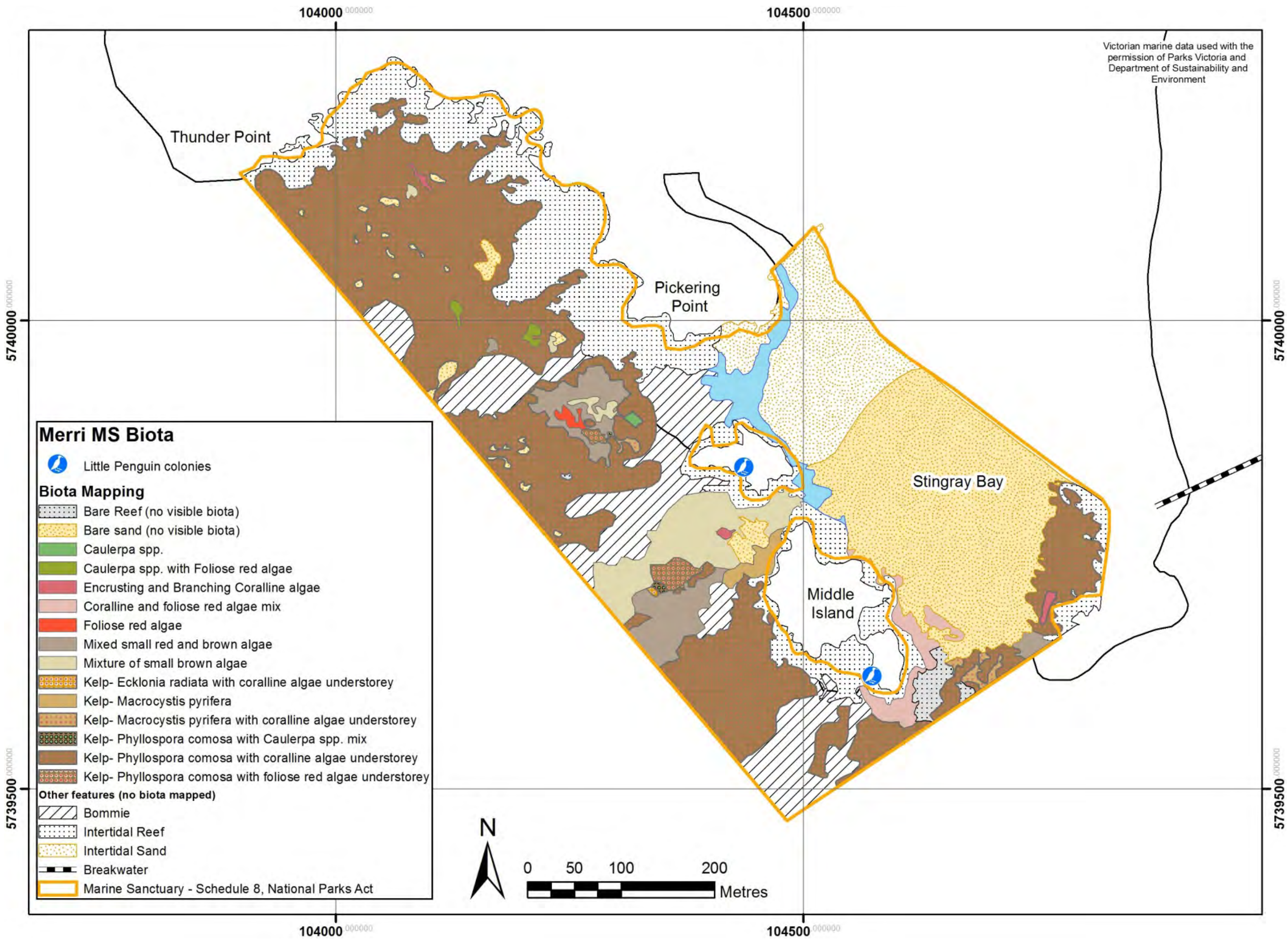


Figure 32. Biota mapped in Merri Marine Sanctuary with sites of biotic significance. Biota mapped by Monk *et al.* (2008).

Approximately 75 % (13.1 ha) of the subtidal zone within the MS has algal habitats, while the remaining is fine sand (5.2 ha) and reef (0.2 ha) (Figure 32). Twenty-one different algal habitat types were identified in the sanctuary (Monk *et al.* 2008). The brown algae *Phyllospora comosa*, was the most abundant habitat-forming alga, occupying 9.9 ha of the subtidal zone (Monk *et al.* 2008). The remaining abundant algal types were small mixed brown algae (1.3 ha), mixed red and brown algae (1.2 ha), *Caulerpa* spp. assemblages (0.7 ha), *Macrocystis pyrifera* dominated assemblages (0.2 ha), encrusting and branching coralline algae dominated assemblages (0.08 ha), foliose red algal mix (0.04 ha) and *Ecklonia radiata* dominated algal assemblages (0.01 ha) (Monk *et al.* 2008).

3.1.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer et al (2003) there have been several subtidal reef monitoring and habitat mapping surveys conducted in the park (Ball and Blake 2007; Crozier *et al.* 2007; Monk *et al.* 2008). A preliminary survey of the intertidal habitat has been conducted but there is no ongoing monitoring (Williams 2004). Two studies assessing the impact of human access (trampling and collection, Cohen 2000; Evans 2007) and one on the impact of the Warrnambool STP (Greenshields 1998) have sampled within the Merri MS. The intertidal reef flora and fauna was quantitatively surveyed at three sites within and two sites outside the Merri MS four times over the summer of 2003/2004 (Williams 2004). The intertidal flora and fauna at Pickering Point has also been sampled for at least two studies (Cohen 2000; Evans 2007). Greenshields (1998) focused on the fauna living in mussel beds and turfing coralline algae. Quantitative surveys have also been conducted by the Museum of Victoria (Costa *et al.* 2010; O'Hara *et al.* 2010). Data on fish abundances, distributions and interactions are confined to shallow (< 10m) subtidal reef habitats. Fish and large invertebrates within the MS have been surveyed twice in the summer of 2003/2004 (Williams 2004) and over three years as part of a community monitoring program (Monk 2006; Monk *et al.* 2008). Relatively few macrophytes and invertebrates are listed as occurring in the Merri MS and the diversity is dominated by birds (Table 12, Appendix 1). This does not necessarily reflect the diversity of the MS rather the lack of major survey and monitoring. There are no significant biotic sites in the MS but two little penguin colonies *Eudyptula minor* are located on the islands that the MS surrounds, Merri and Middle Island (Figure 28).

Table 12. Summary of the number of species in major biotic groups found in Merri Marine Sanctuary.

Biotic group	Number of species
Macroalgae	**82**
green algae	8
brown algae	19
red algae	55
Invertebrates	**14**
cnidarians	2
gastropods	11
echinoderms	1
Vertebrates	**113**
fish	14
birds	89
mammals	10

Intertidal

Soft sediment

Flora is restricted to macroalgae drift and macroalgal epiphytes (Figure 33). Two surveys of the soft sediment communities conducted inside the Merri estuary found low diversity of benthic macroinvertebrates (Kenny 1998; Sherwood *et al.* 2008). Beach-washed materials in sandy beach habitats are a significant source of food for scavenging birds, and contribute to the detrital cycle that nourishes many of the invertebrates, such as bivalves, living in the sand. The intertidal soft sediment is an important feeding and roosting habitat for shorebirds.

Figure 33. Intertidal soft sediment at the mouth of the Merri River in Merri Marine Sanctuary. Photo by Jan Barton, Deakin University.

Reef

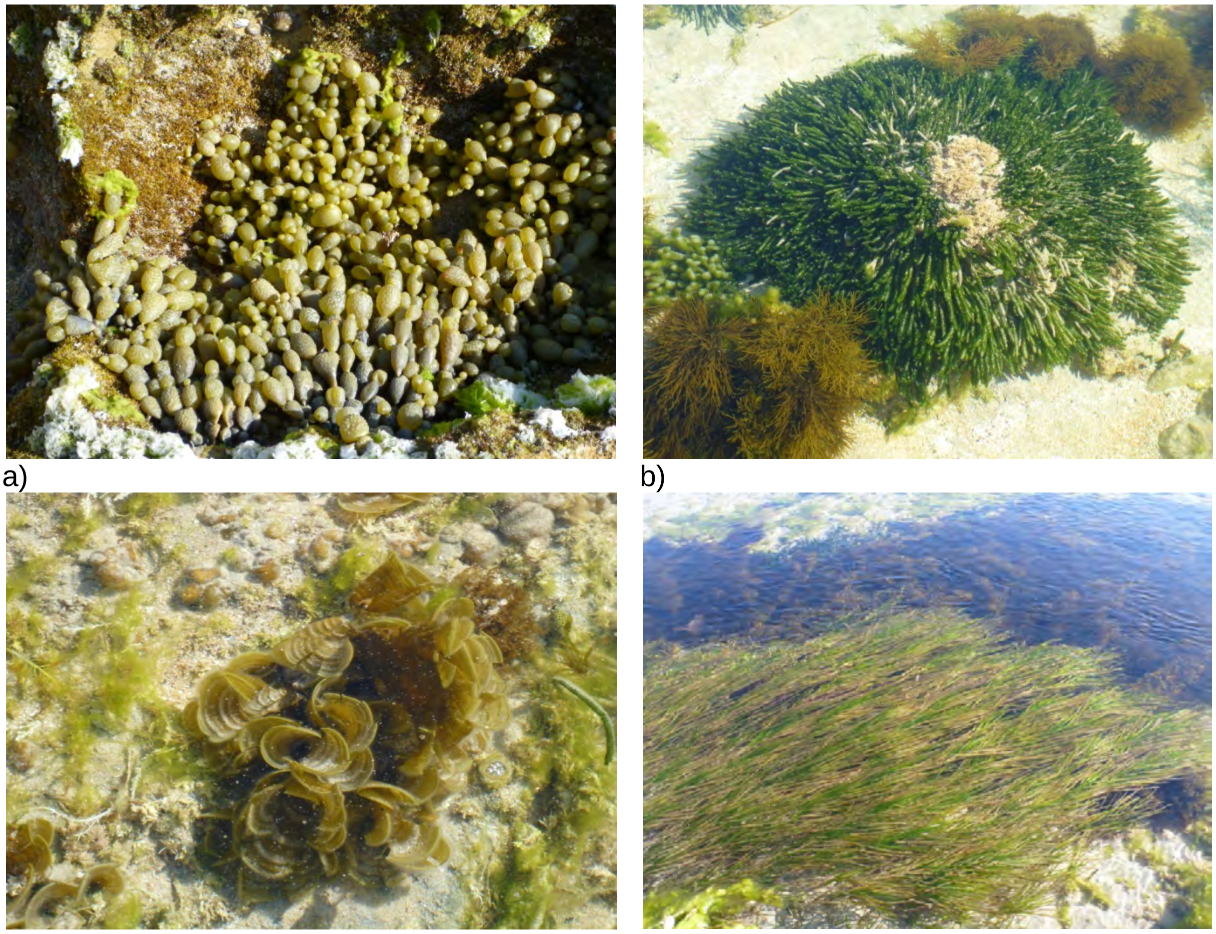
Rocky intertidal reefs (Figures 30 and 39), also called rocky reefs or intertidal platforms, are generally found in Victoria on and near headlands with stretches of sandy beaches either side. Along with beaches, intertidal reefs are one of the most accessible components of the marine environment as they are the interface between the ocean and the land (Power and Boxshall 2007). As such they are valued as important habitats by people and tend to be visited more than other sections of the coast (Carey *et al.* 2007a; Carey *et al.* 2007b). This means they are often subjected to human pressures like harvesting, fossicking and trampling as well as pressures from pollution sources on land and in the sea (Power and Boxshall 2007).

Intertidal reef biota is exposed to large changes in physical conditions such as temperature and desiccation. There is great spatial and temporal variability in the life histories of the organisms and the environmental processes in reef habitats (Underwood and Chapman 2004). The recruitment of new biota onto the reef, from the plankton, strongly influences the ecological patterns for individual species and assemblages. Interactions between biota on the reef also influence biota distribution. Resources which are often in short supply on intertidal reefs are space on which to live and food (Underwood and Chapman 2004). The western portion of Pickering Point intertidal reef is considered particularly diverse (Plummer *et al.* 2003; Parks Victoria 2007b).

Macroalgae and Aggregating Sessile Invertebrates

The intertidal flora and fauna of Merri MS is low, with twelve species of algae and twenty-five species of invertebrates (Williams 2004; O'Hara *et al.* 2010; Figure 34). Common intertidal macrophytes include sea lettuce *Ulva* sp., turfing red coralline algae *Corallina officinalis,* and the green algae *Caulerpa brownii* (Williams 2004; Evans 2007). The brown algae Neptune's necklace *Hormosira banksii* is less common (Williams 2004). The seagrass *Amphibolis antarctica* and *Zostera/Heterozostera* sp. is sometimes present in rockpools (Plummer *et al.* 2003). The bull kelp *Durvillaea potatorum* is present on the fringe of the intertidal reef (Monk *et al.* 2008).

Turfing coralline algae height and coverage were found to have been significantly reduced at the high access Pickering Point compared to other intertidal reefs with lower human access in a study before declaration of the Marine National Parks (Cohen 2000). Algal and invertebrate community diversity is less at Pickering Point compared to low access intertidal reefs outside the Merri MS, with relatively few molluscs or barnacles but more anemones and seastars (Evans 2007; O'Hara *et al.* 2010). Physical damage by trampling is thought to cause these differences (Cohen 2000; Evans 2007). The poor water quality of the Merri River and the close proximity (500 m) to Warrnambool sewage outfall could also influence the intertidal community (O'Hara *et al.* 2010).



a) b) c) d)

Figure 34. Algae on the intertidal reef of Merri Marine Sanctuary a) Neptune's necklace *Hormosira banksii* b) Brown's caulerpa *Caulerpa brownii* and *Cystophora* spp.c) mermaids fan *Padina fraseri* and d) seagrass *Heterozostera* sp. Photos by Jan Barton, Deakin University.

Mobile Invertebrates

Gastropod snails are the most common invertebrates and comprise over half of the species found in the area (Plummer *et al.* 2003; Figure 35). Common macroinvertebrates are the warrener *Turbo undulatus*, limpets *Siphonaria diemenensis, Cellana tramoserica* and cartrut shell *Diacthais orbita* (Cohen 2000; Williams 2004; Evans 2007). Crabs *Cyclograpsus granulosus*, *Paragrapsus quadridentatus*, seastars *Patiriella calcar*, *Coscinasterias muricata*, *Allostichaster polyplax* and anemones *Actinia tenebrosa* are also common (Plummer *et al.* 2003). Also present are the periwinkles *Littorina unifasciata*, *Bembicium nanum,* top shells *Austrocochlea constricta* and *A. odontis,* limpet *Patelloida alticostata,* sea hare *Aplysia* sp., brittle stars *Ophionereis* sp., chitons, terebellid polychaetes and mussel *Brachidontes rostratus* (Cohen 2000; Plummer *et al.* 2003; Williams 2004). Fauna within the coralline algae turf at Pickering Point is dominated by polychaetes and amphipods (Greenshields 1998).

Fish

Fish including sea sweep *Scorpis aequipinnis*, Tasmanian blenny *Parablennius tasmanianus* and wrasse are sometimes found in the larger rockpools (Plummer *et al.* 2003).

a) b) c) d)

Figure 35. Intertidal reef mobile invertebrates in Merri Marine Sanctuary a) warrener *Turbo undulatus*, b) variegated limpet *Cellana tramoserica* c) lined cominella *Cominella lineolata* on coralline aglae and d) red waratah *Actinia tenebrosa*. Photos by Jan Barton, Deakin University.

Subtidal

Soft sediment

No quantitative data are available on subtidal soft sediment communities in the Merri MS (Plummer *et al.* 2003). Common fish include sea mullet *Mugil cephalus*, and salmon *Arripis trutta* near the Merri River mouth and cat shark *Parascyllium* sp., and draughtboard shark *Cephaloscyllium laticeps* (Plummer *et al.* 2003). The southern eagle ray *Myliobatis australis* is also commonly seen in the MS (Parks Victoria 2007b).

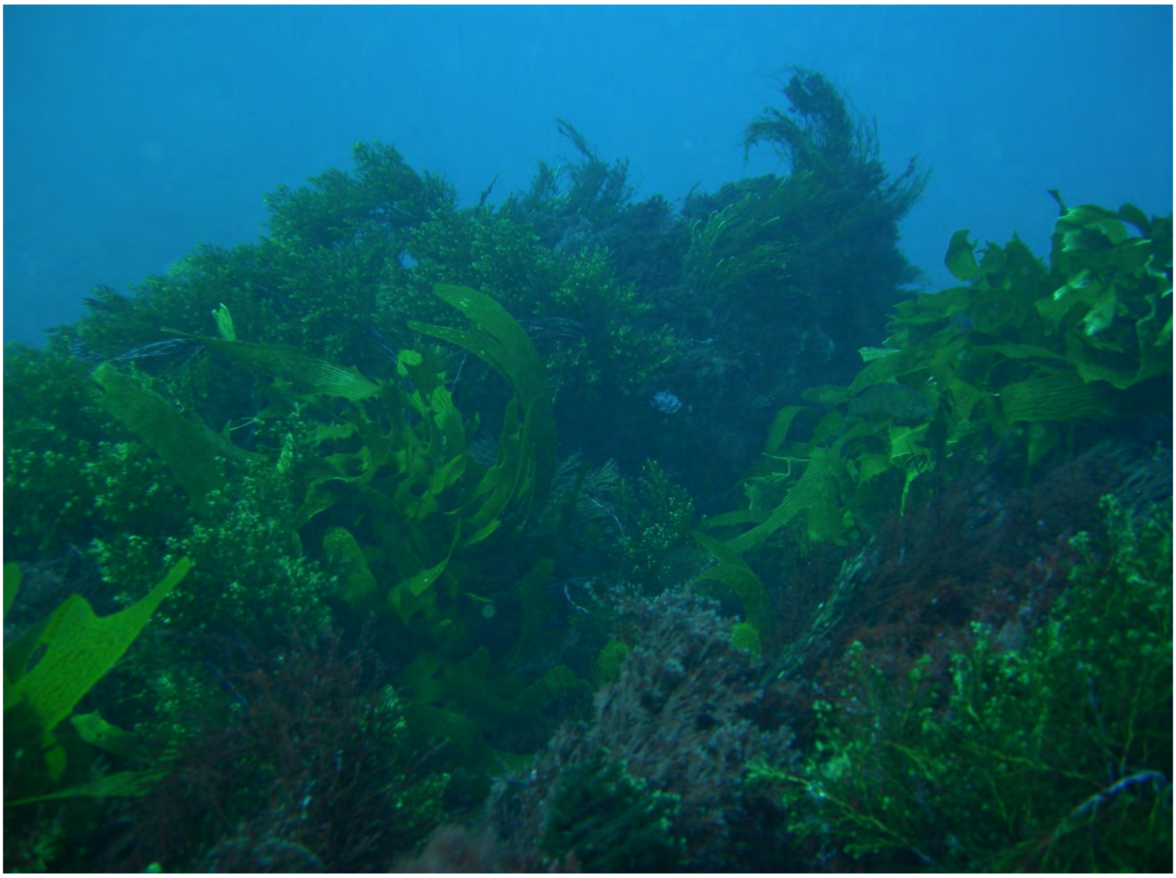


Figure 36. Subtidal reef near Merri Marine Sanctuary. Photo by AME.

Subtidal reef

Subtidal reefs (Figure 36) and the assemblages associated with them are strongly influenced by the position of the reef, its orientation, slope, depth, exposure and topography (Connell 2007). These physical parameters influence key physical processes such as light, water flow and sedimentation, and biological processes such as foraging and recruitment (Connell 2007). Biotic assemblages of algae and sessile invertebrates can form habitat and food sources for invertebrates and fish. Shallow subtidal reefs are known for their high biological complexity, species diversity and productivity and in addition they have significant economic value through commercial and recreational fishing (outside of MPAs), diving and other tourism activities (Power and Boxshall 2007). Shallow subtidal reefs are often dominated by canopy forming algae.

Flora

Seaweeds provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present. The subtidal reef is dominated by the brown algae *Phyllospora comosa* (Figure 37) with a coralline algae understorey (Monk *et al.* 2008). Other canopy forming algae are kelp *Macrocystis pyrifera* and mixed brown algae (Monk 2006; Crozier *et al.* 2007; Monk *et al.* 2008). Other algal habitats in the MS are formed by mixed red and brown algae, *Caulerpa* spp., encrusting and branching coralline algae, foliose red algal mix and *Ecklonia radiata* (Monk *et al.* 2008). There is a relatively low cover of smaller browns, except for *Perithalia caudate* (Crozier *et al.* 2007). Other algae found in the MS are *Cystophora* spp. *Halopteris* spp. and *Plocamium* spp. (Koss *et al.* 2005b). The understorey has a relatively diverse assemblage of fleshy red algae (Monk 2006; Crozier *et al.* 2007; Monk *et al.* 2008). Common species include *Gelidium asperum*, *Pterocladia lucida*, *Areschougia congesta*, *Phacelocarpus peperocarpus* and *Ballia callitricha* (Crozier *et al.* 2007).

Invertebrate fauna

The diversity of subtidal invertebrates on the reef near the MS is low compared to other Victorian west coast reefs (Crozier *et al.* 2007). Within the Merri MS the herbivorous molluscs the black lip abalone *Haliotis rubra* and the warrener *Turbo undulatus* are the most abundant invertebrates (Monk 2006). There are many sponges, gastropods and crabs, as well as occasional sightings of the southern rock lobster *Jasus edwardsii* (Monk 2006).

Fish

Blue-throated wrasse *Notolabrus tetricus* is the most abundant fish in the Merri MS (Monk 2006). Herring cale *Odax cyanomelas,* magpie perch *Cheilodactylus nigripes*, Victorian scalyfin *Parma victoriae,* zebrafish *Girella zebra,* sea sweep *Scorpis aequipinnis* (Figure 38) and senator wrasse *Pictilabrus laticlavius* are common but nowhere near as abundant as blue-throated wrasse *N. tetricus* (Williams 2004; Monk 2006; Crozier *et al.* 2007). Reefs near the Merri MS have a low abundance of fish compared to other reefs along the west coast of Victoria (Crozier *et al.* 2007). The horseshoe leatherjacket *Meuschenia hippocrepis* is recorded at most reefs along the western coast of Victoria however this species is absent on reefs near the Merri MS (Crozier *et al.* 2007). The pot-bellied seahorse *Hippocampus abdominalis* is frequently seen on subtidal reefs in the sanctuary (Parks Victoria 2007b).

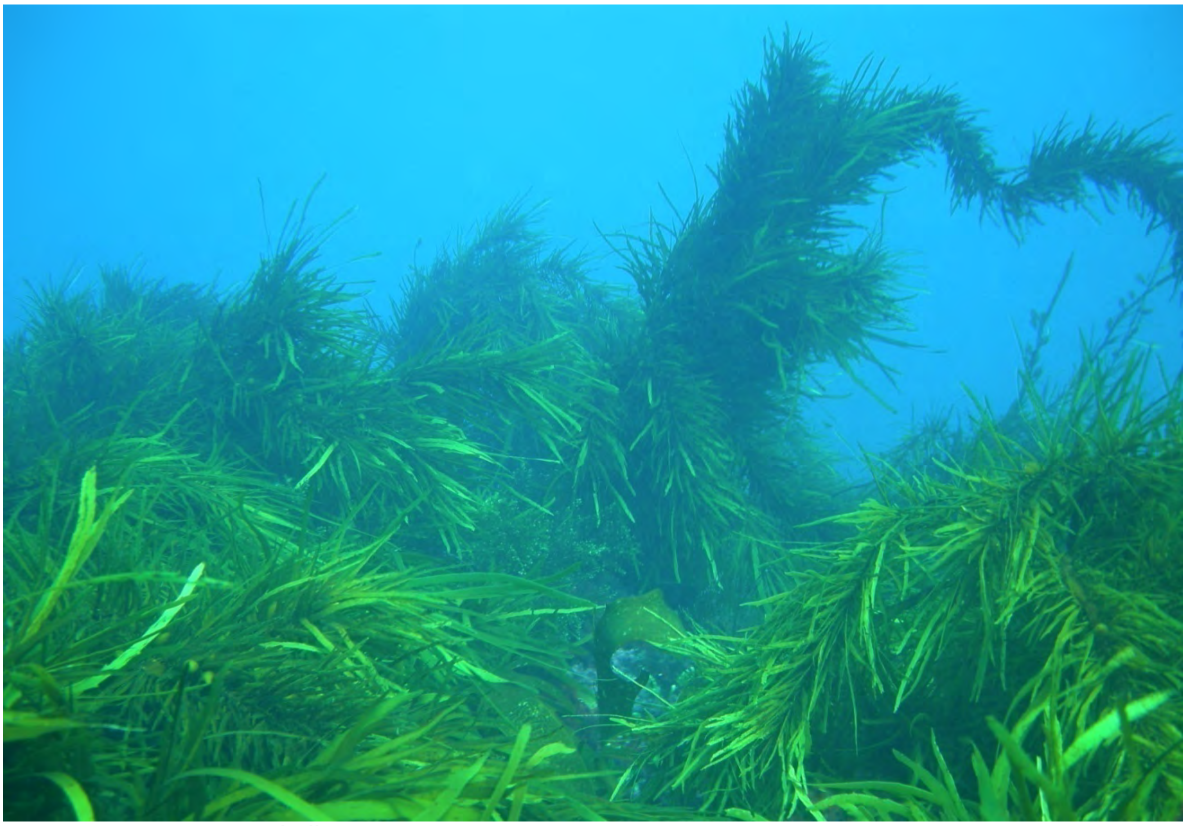


Figure 37. Crayweed *Phyllospora comosa* the most abundant canopy forming alga in the Merri Marine Sanctuary. Photo by AME.

Water column

The water column is a large habitat in the MS. It is important in different ways for many organisms including for transit or as a permanent home for particular stages of their life cycle. Organisms that use the water column environment can be broadly grouped into two categories based on mode of movement: either pelagic (actively swimming) or planktonic (drifting with the current). Larger species are often planktonic during early life stages before becoming pelagic as they grow. Smaller species tend to be planktonic but can influence their movement to some extent by controlling their height in the water column. Organisms that make their permanent home in the water column include sea jellies, salps, many fish, and both phytoplankton and zooplankton. Planktonic organisms play an important role in nutrient cycling, dispersal of species and providing food for larger animals, both within the MS and more broadly in the marine environment. The water column is also used by fish, invertebrates and algae for transport and food (and other resources like oxygen). Parks Victoria does not currently monitor the water column as a habitat (Power and Boxshall 2007). As described in the following section a variety of shore and seabirds of conservation significance are found in the waters of Merri MS.

3.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is likely to protect and enhance threatened species populations (Power and Boxshall 2007). Whole-of-habitat management may also result in the protection of species not yet identified because of their rarity or cryptic nature (Power and Boxshall 2007).

Flora

No threatened marine flora has been recorded in Merri MS (Parks Victoria 2007b).

Fish

Under the Victorian *Fisheries Act* 1995 all syngnathid species are listed as Protected Aquatic Biota. Nationally they are listed as threatened under the *EPBC Act 1999*. The pot-bellied seahorse *Hippocampus abdominalis* is frequently seen on subtidal reefs in the sanctuary (Parks Victoria 2007b).

Birds

Fifty-one conservation listed shore or sea birds have been sighted in or in the immediate surrounds of the Merri MS (Table 13). Seventeen birds are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Four of these birds, Australasian bittern *Botaurus poiciloptilus*, fairy tern *Sternula nereis,* gull-billed tern *Gelochelidon nilotica* and the little egret *Egretta garzetta,* are recognized as being endangered. Eight are recognized as near threatened and five as vulnerable at the state level (Table 13). Eight birds are recognized as threatened under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* or the Australian Rare or Threatened Species (AROTS) (Table 13). Fourteen birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Two large seabirds are regarded as endangered, the wandering albatross *Diomedea exulans* at the state level (also recognized under JAMBA), and the southern giant petrel *Macronectes giganteus* at the national level. Both birds are more commonly offshore of the sanctuary.

Breeding colonies of the little penguin *Eudyptula minor* are sited on Middle and in very small numbers on Merri islands. These birds are present all year round with nesting occurring from May to January, peak laying from August to October and moulting from February to March. The little penguin *E. minor* colony in particular is vulnerable to fox and dog predation and the population declined from over 600 birds to less than ten birds over the period of 2000 to

2005. Since 2006, trained Maremma Guardian Dogs have been guarding Middle Island and the little penguin *E. minor* colony has steadily increased. Middle Island also has colonies of short-tailed shearwater *Puffinus tenuirostris* and little black cormorant *Phalacrocorax sulcirostris*.

Table 13. Conservation listed shorebird and seabird records from Merri Marine Sanctuary and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
grey-tailed tattler	*Heteroscelus brevipes*	L	CR		C	J
great knot	*Calidris tenuirostris*	L	EN		C	J
wandering albatross	*Diomedea exulans*	L	EN	VU		J
Australasian bittern	*Botaurus poiciloptilus*		EN			
fairy tern	*Sternula nereis*		EN			
gull-billed tern	*Gelochelidon nilotica*		EN			
little egret	*Egretta garzetta*		EN			
southern giant-petrel	*Macronectes giganteus*	L	VU	EN		
grey-headed albatross	*Thalassarche chrysostoma*	L	VU	VU		
shy albatross	*Thalassarche cauta*	L	VU	VU		
yellow-nosed albatross	*Thalassarche chlororhynchos*	L	VU	VU		
black-browed albatross	*Thalassarche melanophris*		VU	VU		
fairy prion	*Pachyptila turtur*		VU	VU		
Baillon's crake	*Porzana pusilla*	L	VU			
hooded plover	*Thinornis rubricollis*	L	VU			
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
hardhead	*Aythya australis*		VU			
royal spoonbill	*Platalea regia*		VU			
white-faced storm-petrel	*Pelagodroma marina*		VU			
black-tailed godwit	*Limosa limosa*		VU		C	J
common sandpiper	*Actitis hypoleucos*		VU		C	J
lesser sand plover	Charadrius mongolus		VU		C	J
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
common diving-petrel	*Pelecanoides urinatrix*		NT			
Nankeen night heron	*Nycticorax caledonicus*		NT			
pacific gull	*Larus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
whiskered tern	*Chlidonias hybridus*		NT			
white-fronted tern	*Sterna striata*		NT			
grey plover	*Pluvialis squatarola*		NT		C	J
Latham's snipe	*Gallinago hardwickii*		NT		C	J
long-toed stint	*Calidris subminuta*		NT		C	J
pacific golden plover	*Pluvialis fulva*		NT		C	J
red knot	*Calidris canutus*		NT		C	J
sanderling	*Calidris alba*		NT		C	J

Common name	Scientific name	Victorian listing FFG	VROTS	National listing EPBC	International treaty CAMBA	JAMBA
white-winged black tern	*Chlidonias leucopterus*		NT		C	J
bar-tailed godwit	*Limosa lapponica*				C	J
common greenshank	*Tringa nebularia*				C	J
curlew sandpiper	*Calidris ferruginea*				C	J
marsh sandpiper	*Tringa stagnatilis*				C	J
red-necked stint	*Calidris ruficollis*				C	J
ruddy turnstone	*Arenaria interpres*				C	J
sharp-tailed sandpiper	*Calidris acuminata*				C	J
sooty shearwater	*Ardenna grisea*				C	J
arctic jaeger	*Stercorarius parasiticus*					J

L= listed, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = critically endangered, C = listed under the CAMBA treaty, J = listed under the JAMBA treaty

Figure 38. Sea sweep *Scorpis aequipinnis* is an common species in the Merri Marine Sanctuary. Photo by AME.

Marine mammals and reptiles

Merri MS is shallow and dominated by intertidal and subtidal reefs. It does not provide habitat for large marine mammals. Southern elephant seals *Mirounga leonina* have been recorded from the shore and waters of the Merri MS. They are listed under the *FFG Act 1988* and recognized as vulnerable under the Victorian Rare or Threatened Species (VROTS) list (Table 14). Approximately three kilometres east of the MS is Logan's Beach Whale Marine Sanctuary, an important calving site from May to October for the southern right whale *Eubalaena australis*. They are regularly sighted each year travelling along the coast close inshore. Blue whales, *Balaenoptera musculus* are regularly observed further offshore from November to May each year. Both are listed as critically endangered in Victorian waters and endangered nationally. The humpback whale, *Megaptera novaeangliae*, which is regarded as vulnerable at both the state and national level has also been recorded offshore from the MS.

The Australian fur seal *Arctocephalus pusillus doriferus*, Australian sea lion *Neophoca cinerea* and the leopard seal *Hydrurga leptonyx* have been observed in the waters in and around the MS. The listed leatherback turtle *Dermochelys coriacea* occur as vagrants along the Victorian coast and is probably found near Merri MS.

Table 14. Conservation listed marine mammal records from Merri Marine Sanctuary and surrounds.

		Victorian listing		National listing	International convention
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**Bonn**
southern right whale	*Eubalaena australis*	L	CR	EN	L
southern elephant seal	*Mirounga leonina*	L	VU		
Australian fur seals	*Arctocephalus pusillus doriferus*			L	
Australian sea lion	*Neophoca cinerea*			L	
leopard seal	*Hydrurga leptonyx*			L	

L = FFG listed, VU = vulnerable, EN = endangered, CR = critically endangered

Species at distributional limit

Assessment of distribution, endemism and rarity of biota across the state by O'Hara (2002) found that Merri MS had eight algal species presumed to be at their distributional limit. Seven red algal species were presumed to be at their eastern distributional limit and one brown algae was presumed to be at its western distributional limit (Table 15). The distributional limits of the biota listed in Table 15 may reflect collection effort in this area rather than actual Victorian distributions. Many areas of the Victorian coast have never been sampled and therefore biota ranges may be much greater than those suggested.

Table 15. Biota with distributional limits known to be located at or near the Merri Marine Sanctuary.

Phylum	Family	Species	Common name	Category
Phaeophyta	Dictyotaceae	*Padina fraseri*	brown algae	PW
Rhodophyta	Ceramiaceae	*Antithamnion verticale*	red algae	PE
Rhodophyta	Ceramiaceae	*Pterothamnion squarrulosum*	red algae	PE
Rhodophyta	Ceramiaceae	*Ptilotia hannafordi*	red algae	PE
Rhodophyta	Corallinaceae	*Lithophyllum johansenii*	red algae	PE
Rhodophyta	Erythrotrichiaceae	*Erythrotrichia ligulata*	red algae	PE
Rhodophyta	Halymeniaceae	*Grateloupia ovata*	red algae	PE
Rhodophyta	Kallymeniaceae	*Callophyllis cervicornis*	red algae	PE

PE = presumed eastern limit, PW = presumed western limit.

Figure 39. Intertidal reef and rock pool in Merri Marine Sanctuary. Photo by Jan Barton, Deakin University.

3.1.5 MAJOR THREATS

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPA's. Through public and agency workshops, the natural values in individual MPA's and the threats that could affect them over the next ten years, were considered and ranked to identify hazards. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Threats to the Merri MS were considered in conjunction with those for the Twelve Apostles MNP and the Arches MS. Sixteen hazards with the potential to be of extreme risk were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Oil spills from offshore platforms or shipping affecting seabirds and intertidal habitats and communities (seabirds, intertidal habitats and communities);
2. Terrestrial events/activities such as floods, fires, droughts, nutrients, (water) extractions, affecting water quality (water quality);
3. Pest plants and animals from recreational boating, ballast water discharge, agriculture, shipping and industry, displacing local species (biodiversity);
4. Urban and catchment runoff and outfall discharges direct into Merri MS, impacting on its general ecology (potentially all park);
5. "Island-based" management focus affecting marine habitats and communities (potentially all park);
6. Funding for management affecting marine communities and habitats (potentially all park);
7. Lack of knowledge affecting marine habitats and communities (potentially all park);
8. Edge effects around parks, leading to impacts on marine communities and habitats (potentially all park);
9. Seismic testing affecting larger (marine) vertebrates (marine mammals);
10. Land-based litter affecting the marine environment (marine mammals, sea and shorebirds, fish);
11. Marine debris from elsewhere (*i.e.* beyond parks) resulting in smothering of, entanglement with, or ingestion by marine organisms (marine mammals, sea and shorebirds, fish);
12. Developments around Merri MS affecting marine communities and habitats (potentially all park);
13. Technology creep (*i.e.* better oil/gas extraction/exploration methods, exploitation of new resources, new ways of accessing resources via bioprospecting, aquaculture etc.) affecting marine communities and habitats (potentially all park);
14. Artificial opening of river mouths producing silt plumes resulting in fish kills and sedimentation (fish, intertidal and subtidal habitats);
15. Government influence on management affecting marine communities and habitats (potentially all park); and
16. External management complexity (*e.g.* common boundary of Twelve Apostles MNP with Federal MPA) affecting marine communities and habitats (potentially all park).

The Merri MS intertidal reef is subject to a large amount of human access, with school groups regularly using it for marine education (Cohen 2000; Williams 2004; Evans 2007; Parks Victoria 2007b). Physical damage by trampling is thought to reduce the algal and invertebrate community diversity near access point such as Pickering Point (Cohen 2000; Evans 2007).

The Merri and Hopkins Rivers are highly urbanised (Barton *et al.* 2008) and could be potential pollution sources for the MS as could the nearby Warrnambool wastewater outfall (secondary treatment) and offshore marine waters (Parks Victoria 2007b; O'Hara *et al.* 2010).

The introduction of marine pests threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). At present there have been no recordings of marine pests in the park (Plummer *et al.* 2003; Koss *et al.* 2005b; Crozier *et al.* 2007; Parks Victoria 2007b; Monk *et al.* 2008). Japanese kelp *Undaria pinnatifida* has been recently found in Apollo Bay and there are grave concerns about its spread. Species of particular concern include the marine fanworm *Sabella spallanzanii*, and broccoli weed *Codium fragile (subsp. fragile)* (Parks Victoria 2003).

A virus affecting abalone, called abalone viral ganglioneuritus, has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area and has been confirmed from Discovery Bay MNP to near Cape Otway (DPI 2009). It could have serious long term ecological consequences for rocky reef communities (DPI 2009).

Climate change represents a serious threat to marine ecosystems (McLeod *et al.* 2009) but specific ecological consequences of accelerating climate change are not well understood in marine systems, particularly in temperate systems. Climate change is predicted to increase water temperature, alter chemical composition (salinity, acidity and carbonate saturation), change circulation and productivity (El Niño), increase frequencies of extreme weather events and exposure to damaging ultraviolet light (UVB), and increase air temperature, cloud cover and sea levels (conservatively 80 cm by 2100; CSIRO-BoM 2007; Fine and Franklin 2007; VCC 2008; McLeod *et al.* 2009). A combined increase in cloud cover and sea level could result in decreased light availability potentially changing benthic flora. Increased storm surges and ocean current changes also have the potential to change the distribution of fauna and flora and could result in loss of habitats (CSIRO-BoM 2007). Intertidal communities will face increased desiccation, storm wave exposure and habitat shift. Changes in the relationship between climate and annual life-history events may force major change in functional groups and consequent ecosystem function (Fine and Franklin 2007). Climate change is also anticipated to modify species recruitment and habitat connectivity, species interactions and disturbance regimes in the marine environment (CSIRO-BoM 2007; Fine and Franklin 2007). A number of algal species are at the eastern or western limit of their distributional range at Merri MS and such species would be particularly vulnerable to climate change.

Measures to address or minimise these threats form part of the management plan for Merri MS (Parks Victoria 2007b). For example research is being conducted into marine pest species, and investigations into water quality issues have also been conducted in relation to park values. Management actions have been implemented to minimise these threats (Parks Victoria 2007b). Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

3.1.6 CURRENT RESEARCH AND MONITORING

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. The research relevant to Merri MS has been published in Parks Victoria's Technical Series available on Parks Victoria's website (http://www.parkweb.vic.gov.au). As most research in the MS has been carried out under permits issued by DSE, the permit database was also used to identify relevant projects for this report (see Table 16 and Appendix 2).

Table 16. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Merri Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimizing the allocation of resources for defending Marine Protected Areas against invasive species.
Multiple Research Partners: Marine Monitoring and Marine Natural Values ***University of Melbourne:*** Mick Keough, Paul Carnell Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling data. ***Deakin University:*** Jan Barton, Adam Pope, Gerry Quinn Marine Natural Values Reports for the Marine National Parks and Sanctuaries – Version 2.
Museum Victoria: Mark Norman, Julian Finn. ***Parks Victoria:*** Roger Fenwick Under the Lens - Natural History of Victoria's Marine National Park System.
University of Melbourne: Prue Addison, Jan Carey New statistical methods for the analysis of marine monitoring data.
University of Melbourne: Tarek Murshed, Jan Carey, Jacqui Pocklington Conceptual model development for marine habitats.
Ongoing Habitat Mapping Projects
DSE / DPI / Worley Parsons/ Deakin University LiDAR Mapping Project. Mapping of bathymetry and marine habitats along the Victorian coast
Active Monitoring Programs
Contracted Monitoring Subtidal Reef Monitoring Program

The Merri MS has an ongoing subtidal reef monitoring program. The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003) around Merri MS began in 2004 and there have been five surveys (Hart *et al.* 2004; Hart *et al.* 2005; Crozier *et al.* 2007). The SRMP involves standardised underwater diver-mediated visual survey methods (Edmunds and Hart 2003). The SRMP surveys a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish. The long-term subtidal monitoring program monitors a site on the edge of the Merri MS due to an initial error in park boundary coordinates. A site close to Middle Island (Figure 28) and a reference site southeast of the sanctuary near Breakwater Rock (Crozier *et al.* 2007). The Middle Island site near the MS is in eight metres water depth and covers areas of patchy reef and sand, as well as more continuous reef with deep sections (Crozier *et al.* 2007; Figure 40).

The site further away is southeast of the sanctuary near Breakwater Rock in five metres. The reef at this site is continuous and slightly undulating (Crozier *et al.* 2007).

A clear MPA effect is unlikely to be detected until sometime after declaration. Nationally and internationally it has taken well over a decade since declaration to detect changes in fauna size classes and abundance in MPAs (Edgar *et al.* 2009; Edgar and Stuart-Smith 2009). A major benefit of declaration is to ensure protection of the MS area against future threats to biodiversity and natural processes.

A review of Parks Victoria's monitoring program in relation to conservation outcomes for Merri MS will be done by 2013. The major direction includes implementing an expanded and improved monitoring program taking into account knowledge generated since park declaration (Power and Boxshall 2007; Keough and Carnell 2009). Other groups that have a close association with the sanctuary include the Friends of Merri Marine Sanctuary, Sea Search, Reef Watch MAD (making a difference) for the Merri and Warrnambool Coastcare Landcare Group.

3.1.7 KNOWLEDGE GAPS

Knowledge gaps exist for the intertidal and subtidal soft sediment habitats. There is currently no monitoring of the intertidal habitats within the MS, with the consequence that there is no quantitative measure of change in the Merri MS communities associated with these habitats. There is also a limited understanding of the importance of the Merri MS to the conservation of threatened or distribution limited species. Knowledge gaps exist in our understanding of the specific consequences from major threats to the Merri MS.

Figure 40. Macroalgae dominated subtidal reef in Merri Marine Sanctuary. Photo by AME.

3.2 The Arches Marine Sanctuary

The Arches MS is the one of two Marine Sanctuaries in the Otway bioregion, which also contains Merri MS, and Discovery Bay and Twelve Apostles Marine National Parks. The Arches MS is approximately 200 km west of Melbourne. The MS is a 48 hectares square, 600m offshore from Port Campbell on the Great Ocean Road (Figure 41 & Figure 42). Access to The Arches Marine Sanctuary is by boat only.

Aboriginal tradition indicates that the The Arches MS is part of the *Country* of the Kirrae Whurrong and Gadubanud peoples (Parks Victoria 2006b).

Important natural values of The Arches MS are its subtidal limestone reef and open water that provide habitat for a diversity of marine flora and fauna species (ECC 2000; Parks Victoria 2006b; Carey *et al.* 2007b). The reef consists of spectacular limestone formations such as canyons, tunnels, arches, caverns, ledges and vertical sink holes in 19 to 25 m of water (ECC 2000; Parks Victoria 2006b; Carey *et al.* 2007b). The reefs support a diverse range of algae, sponges, bryozoans, hydroids, gorgonians and sea stars characteristic of deeper Bass Strait waters (ECC 2000; Parks Victoria 2006b; Edmunds *et al.* 2010b). Upper surfaces of arches are covered with kelp and an understorey of red seaweeds (ECC 2000; Edmunds *et al.* 2010b). The undersides and canyon walls provide habitat for sessile invertebrates (ECC 2000; Edmunds *et al.* 2010b). These features make this a popular dive site (Parks Victoria 2006b).

The reef tops in The Arches are covered by a high abundance of brown kelp, *Ecklonia radiata* (Edmunds *et al.* 2010b). Other canopy forming brown algae are either *Phyllospora comosa* or *Sierococcus axillaris*. A variety of thallose red algae and encrusting coralline algae grow as understorey on the reef. The thallose red algae includes, *Sonderopelta coriacea, Phacelocarpus peperocarpus*, *Pterocladia lucida*, *Plocamium angustum*, *P. dilatatum*, *P. mertensii, Gelidium* spp., *Melanthallia obtusata* and in some places *Ballia callitricha* (Edmunds *et al.* 2010b).

The subtidal reef in The Arches has a very low abundance of sessile invertebrates (Edmunds *et al.* 2010b). Nearly all the sessile invertebrates are found on or under the ledges of the vertical reef faces (Edmunds *et al.* 2010b). Encrusting or low profile sponges, less than 10 cm high, along with patches of encrusting soft coral *Erythropodium hicksoni* grow on the ledge edges. The erect gorgonian coral *Mopsella* and the ascidian *Herdmania momus* are the only conspicuous invertebrates apart from sponges (Edmunds *et al.* 2010b). Seastars are the dominant obvious mobile invertebrate in the MS and include *Nectria macrobrachia, Nepanthia troughtoni* and *Tosia magnifica* (Edmunds *et al.* 2010b).

Fish observed on the subtidal reefs in The Arches MS are sea sweep *Scorpis aequipinnis*, barber perch *Caesioperca rasor*, blue throat wrasse *Notolabrus tetricus*, bastard trumpeter *Latridopsis forsteri*, magpie perch *Cheilodactylus nigripes* and the dusky morwong *Dactylophora nigricans* (Edmunds *et al.* 2010b). Other common fish species that have been reported from this MS include the zebra fish *Girella zebra*, snapper *Chrysophrys auratus*, marble fish *Aplodactylus arctidens*, Australian salmon *Arripis truttacea*, scaly fin *Parma victoriae* and Port Jackson shark *Heterodontus portusjacksoni* (Plummer *et al.* 2003). The short-fin mako *Isurus oxyrinchus* is known from surrounding waters and is probably found in the MS (Plummer *et al.* 2003).

The Arches MS provides important feeding habitat for five threatened bird species such as the shy albatross *Thalassarche cauta* and black-browed albatross *T. melanophris* which are listed under the *Flora and Fauna Guarantee* (*FFG*) *Act* (1998) and regarded as vulnerable in Victoria. The MS protects feeding areas for three internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan

(JAMBA). No species of marine flora and fauna are believed to be at their distributional limits within the MS.

Serious threats to the MS include limited ecological knowledge of important processes. Possible oil spills, increased nutrients and sediment from the land, invasive marine pests, seismic testing and resource exploration and exploitation, litter, inadequate management, and climate change all pose serious threats to the integrity of The Arches MS. Measures to address or minimise these threats form part of the management plan for The Arches MS (Parks Victoria 2006b). Specific research aims to increase ecological knowledge about the natural values of, and threats to The Arches MS.

3.2.1 PHYSICAL PARAMETERS & PROCESSES

The Arches MS is 48 hectares in size which makes it the seventh smallest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 17 & Figure 41). The MS is predominately 19 to 25 metres deep limestone reef. It is on a very exposed coastline. The MS is open to the prevailing south-west winds and swells of the Southern Ocean in winter and in spring/summer prevailing south-east winds and swells. The West Wind Drift causes an easterly current which is important for natural processes but also moves discharged fresh water or pollutants through the sanctuary towards the east (Parks Victoria 2006b). Local complex hydrodynamics through underwater canyons and arches are poorly understood (Parks Victoria 2006b). They may change seasonally or after rock falls in the sanctuary (Parks Victoria 2006b). High tides, storms and larger swells also cause alterations in the movement of sand (Parks Victoria 2006b). Tidal variation is 0.9 metres for spring tides and 0.3 metres for neap tides (Plummer *et al.* 2003). Surface water temperatures average 17.5 °C in the summer and 13.5 °C in the winter. Campbell Creek discharges 1 km to the north of The Arches MS (Table 17). There are no artificial structures within the park and sanctuary, but several gas pipelines are located on the seafloor about 3 km to the west of the MS (Parks Victoria 2006b).

The sea floor of The Arches MS consists mainly of limestone reef but includes a submerged labyrinth of arches and canyons similar to some of the well known above-water coastal rock formations (Parks Victoria 2006b). The subtidal reefs and soft sediments in the park and sanctuary are the remnants of an ancient eroding coastline; more recent geological processes have shaped features closer to the surface (Bird 1993). The geology is typical of the Port Campbell Coast to the west (Bird 1993).

There are no known sites of geological or geomorphological significance in The Arches MS (Figure 43). On the coast near The Arches MS there are numerous sites of geological significance (Figure 43). To the north of the MS at Beacon Steps are benches cut into the cliffs by coastal erosion. West of the MS Two Mile Bay has state significant fossil beds, and the Port Campbell australite strew has large numbers of tektites, natural glass formations made by the impact of meteorites. East of the MS is Sentinel Rock a prominent outlying Miocene stack and Goudies Lookout where erosion along relatively closely spaced joints has resulted in two adjoining embayments.

Table 17. Physical attributes of The Arches Marine Sanctuary.

Park Name	The Arches
Conservation status	Marine Sanctuary
Biophysical Region	Otway
Size	48 ha (ranked 18th of 24 MPAs)
Length of coastline	N/A
Geology	limestone
Area with depth:	
5-10m	2 ha
10-20m	43 ha
20-30m	3 ha
Mean tidal variation - spring	0.9 m
Mean tidal variation - neap	0.3 m
Mean water temp - summer	17.0°C
Mean water temp - winter	13.5°C
Adjacent catchment	Urban, Agricultural
Discharges into MNP	None
Nearest major estuary (distance & direction)	Campbell Creek 1 km to the north-west

3.2.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. Detailed mapping of the bathymetry of the MS was carried out by LiDAR (Figure 41). A Remotely Operated Vehicle (ROV) was used to survey two sites in the MS and two sites outside the MS in 2006 (Edmunds *et al.* 2010b). The main habitats present in The Arches MS include subtidal reef and the water column.

The subtidal reefs in The Arches MS are a heterogeneous patchwork of assemblages (Edmunds *et al.* 2010b). Assemblage structures varies over scales of metres to ten metres, usually in accordance with different substratum microhabitats, such as horizontal reef tops, vertical faces, ledge edges and proximity to sand (Edmunds *et al.* 2010b). In 25 to 27 m depth the subtidal reef is a highly structured high profile reef with flat-topped ridges and gullies with 1 – 3 m high steps and ledges supporting a canopy of brown algae (Edmunds *et al.* 2010b). The vertical walls of the reef are deeply undercut with the upper ledges protruding over the gullies. There are some smooth, flat areas between the steps and gullies (Edmunds *et al.* 2010b). The reef faces are highly eroded to form crevices, smaller ledges and undercuts, supporting sessile invertebrate fauna, although there tends to be little colonization in the lower caverns because of what appears to be scouring (Edmunds *et al.* 2010b). There are some patches of sand and rubble in the gullies (Edmunds *et al.* 2010b).

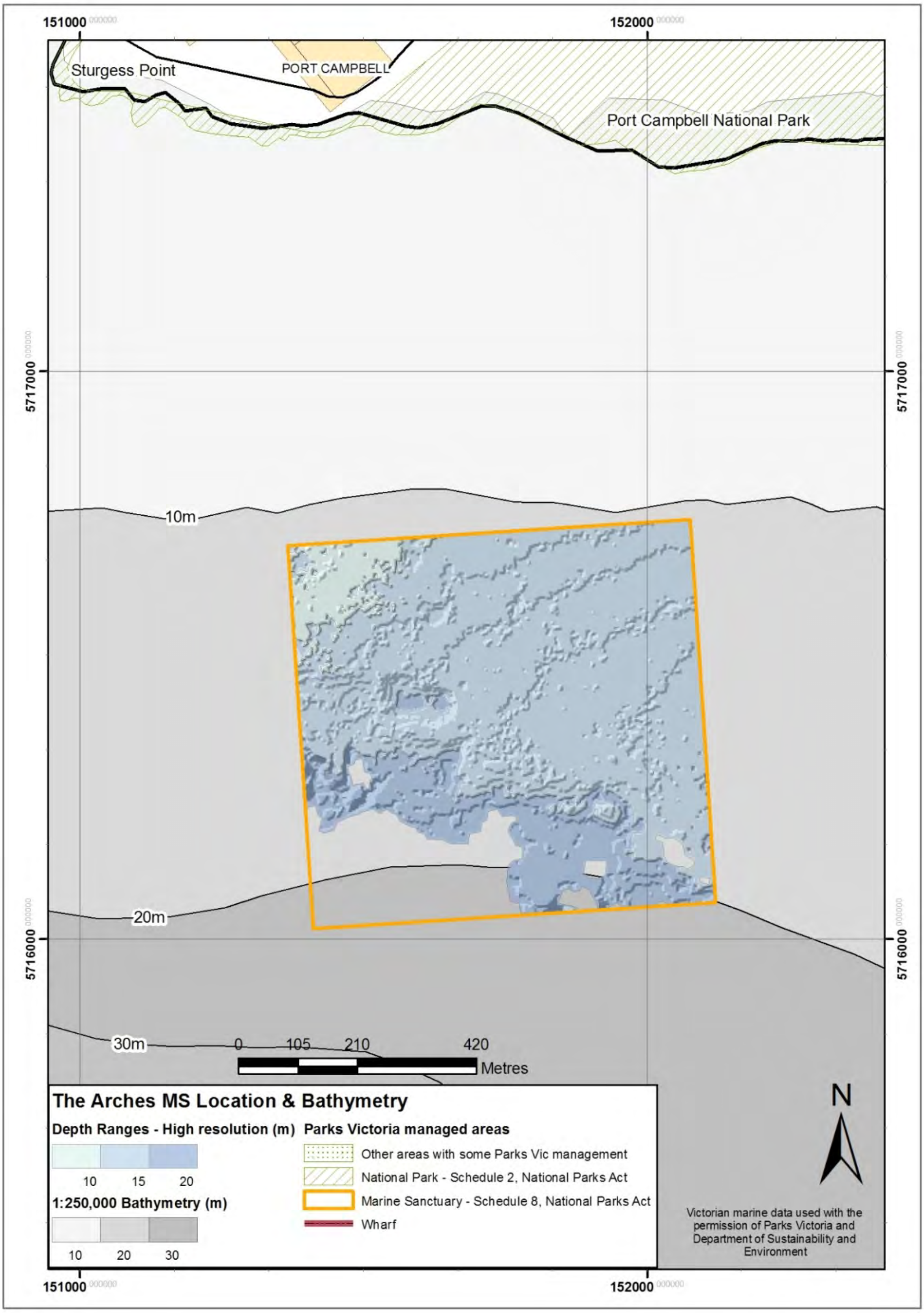


Figure 41. Location map of The Arches Marine Sanctuary with bathymetry. There are no monitoring sites in the MS.

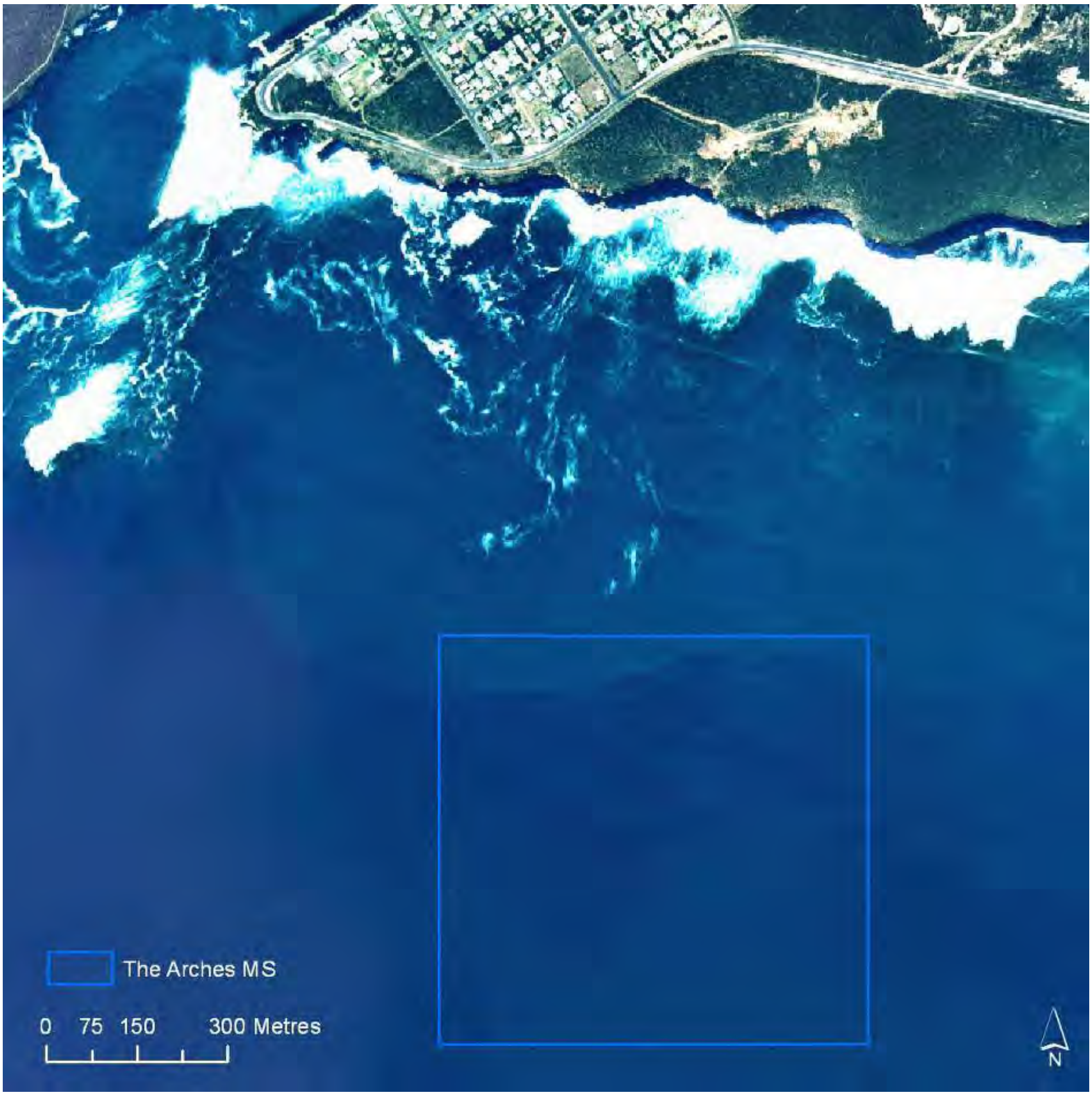


Figure 42. Aerial photo (QASCO 2003) of The Arches Marine Sanctuary showing its proximity the township of Port Campbell. From Ball and Blake (2007).

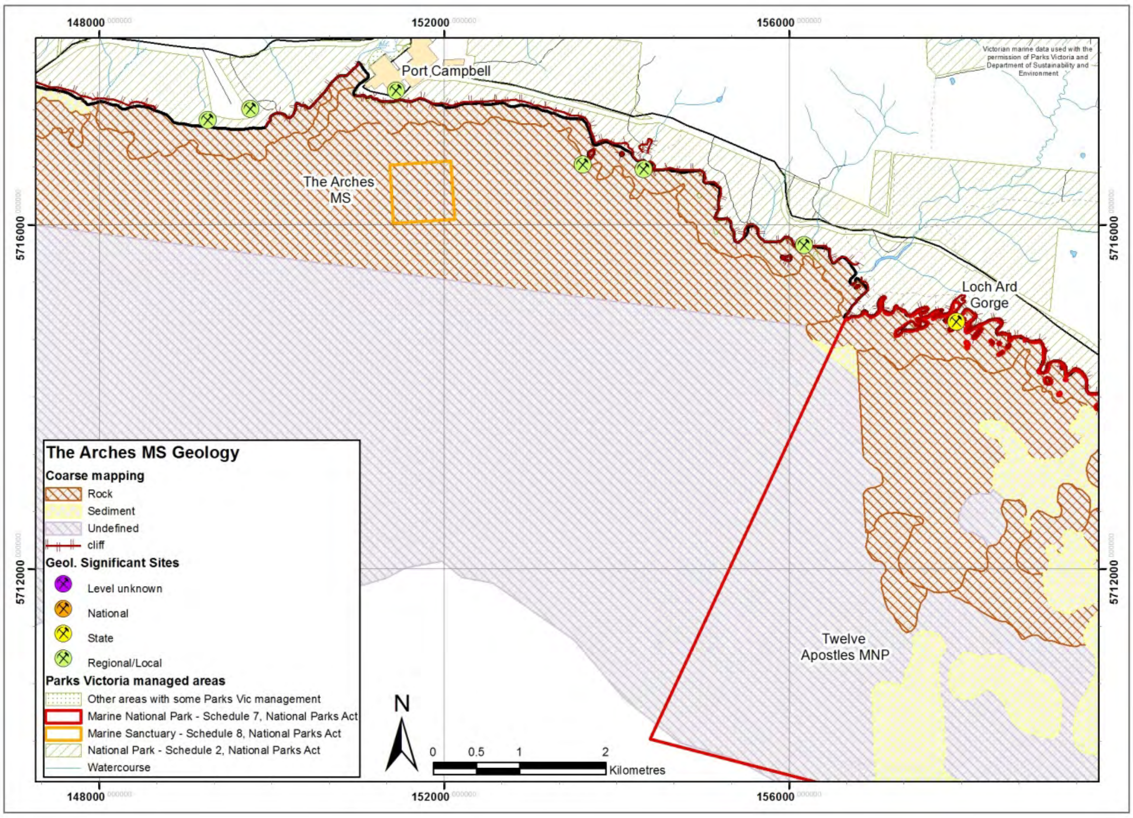


Figure 43. Coarse substrate mapping of The Arches Marine Sanctuary and surrounds, showing nearby sites of geological significance.

3.2.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in descriptive surveys in The Arches MS (Edmunds *et al.* 2010b). There have still been no quantitative surveys of the biota of the pelagic habitats. Nineteen birds and four marine mammals have been recorded in or near the MS (Appendix 1). There are no state significant biotic sites in the MS (Figure 43).

Intertidal

There is no intertidal habitat in The Arches MS.

Subtidal

Soft sediment

Soft sediment is not a dominant feature of the MS and no biological surveys have been undertaken (Plummer *et al.* 2003).

Reef

Subtidal reefs and their assemblages are strongly influenced by the position of the reef, its orientation, slope, depth, exposure and topography (Connell 2007). These physical parameters influence key physical processes such as light, water flow and sedimentation, and biological processes such as foraging and recruitment (Connell 2007). Biotic assemblages of algae and sessile invertebrates can form habitat and food sources for invertebrates and fish. Shallow subtidal reefs are known for their high biological complexity, species diversity and productivity and in addition they have significant economic value through commercial and recreational fishing (outside of MPAs), diving and other tourism activities (Power and Boxshall 2007). Shallow subtidal reefs are often dominated by canopy forming algae. Deep reefs, where light penetration is limited, are often dominated by large sessile invertebrates such as massive sponges, whip corals, soft corals and colonial ascidians (Power and Boxshall 2007). Deep reef assemblages contain a unique combination of organisms and the biological and physical differences mean that deeper areas may also respond differently to threats.

Flora

Seaweeds provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present. The reef tops in The Arches are covered by a high abundance (30 - 50% cover) of brown kelp, *Ecklonia radiata* (Edmunds *et al.* 2010b). Other canopy forming brown algae are either *Phyllospora comosa* (10 - 20 % cover) or *Sierococcus axillaris* (< 10 % cover). A variety of thallose red algae and encrusting coralline algae also grows on the reef. The thallose red algae includes, *Sonderopelta coriacea, Phacelocarpus peperocarpus*, *Pterocladia lucida*, *Plocamium angustum*, *P. dilatatum*, *P. mertensii, Gelidium* spp., *Melanthallia obtusata* and in some places *Ballia callitricha* (Edmunds *et al.* 2010b). The erect coralline, *Haliptilon roseum* is present, along with the brown alga, *Homoeostichus*. Green algae include *Codium* sp., *Caulerpa flexilis* and *C. cactoides*. The Arches MS has a dominance of both thallose red algae and brown seaweeds. The larger brown alga, *Seirococcus axillaris,* was observed at The Arches but not at the Twelve Apostles MNP (Edmunds *et al.* 2010b).

Invertebrate fauna

Descriptive surveys of the deep subtidal reef in The Arches found it has a very low abundance of sessile invertebrates (Edmunds *et al.* 2010b). Nearly all the sessile invertebrates are found on or under the ledges of the vertical reef faces (Edmunds *et al.* 2010b). Most colonies of encrusting or low profile, less than 10 cm high, sponges are found on the ledge edges. The erect gorgonian coral *Mopsella* and the ascidian *Herdmania momus* are conspicuous invertebrates apart from sponges. Patches of encrusting soft coral *Erythropodium hicksoni* are also found on ledge edges. The gorgonian *Pteronisis* has not been observed in the MS (Edmunds *et al.* 2010b). Seastars are the dominant obvious mobile invertebrate in the MS and include *Nectria macrobrachia, Nepanthia troughtoni* and *Tosia magnifica* (Edmunds *et al.* 2010b).

Fish

Fish observed on the deep subtidal reefs in The Arches MS are sea sweep *Scorpis aequipinnis*, barber perch *Caesioperca rasor*, blue throat wrasse *Notolabrus tetricus*, bastard trumpeter *Latridopsis forsteri*, magpie perch *Cheilodactylus nigripes* and the dusky morwong *Dactylophora nigricans* (Edmunds *et al.* 2010b). Other common fish species that have been reported from this MS include the zebra fish *Girella zebra*, snapper *Chrysophrys auratus*, marble fish *Aplodactylus arctidens*, Australian salmon *Arripis truttacea*, scaly fin *Parma victoriae* and Port Jackson shark *Heterodontus portusjacksoni* (Plummer *et al.* 2003). The short-fin mako *Isurus oxyrinchus* is known from surrounding waters and is probably found in the MS (Plummer *et al.* 2003).

Water column

The water column is a large habitat in the MS. It is important in different ways for many organisms including for transit or as a permanent home for particular stages of their life cycle. Organisms that use the water column environment can be broadly grouped into two categories based on mode of movement: either pelagic (actively swimming) or planktonic (drifting with the current). Larger species are often planktonic during early life stages before becoming pelagic as they grow. Smaller species tend to be planktonic but can influence their movement to some extent by controlling their height in the water column. Organisms that make their permanent home in the water column include sea jellies, salps, many fish, and both phytoplankton and zooplankton. Planktonic organisms play an important role in nutrient cycling, dispersal of species and providing food for larger animals, both within the MS and more broadly in the marine environment. The water column is also used by fish, invertebrates and algae for transport and food (and other resources like oxygen). Parks Victoria does not currently monitor the water column as a habitat (Power and Boxshall 2007). As described in the following section a wide variety of seabirds and mammals of conservation significance are found in or near the waters of The Arches MS.

3.2.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is likely to protect and enhance threatened species populations (Power and Boxshall 2007). Whole-of-habitat management may also result in the protection of species not yet identified because of their rarity or cryptic nature (Power and Boxshall 2007).

Flora

No conservation listed marine flora has been recorded in The Arches MS.

Fish

The open waters of The Arches MS are a probable habitat for the FFG listed threatened migratory southern bluefin tuna *Thunnus maccoyii*. Likewise the open waters could be used by the grey nurse shark *Charcharias taurus* which is listed as threatened in Victoria (*FFG*) and critically endangered nationally (*EPBC*). The great white shark *Carcharodon carcharias* threatened in Victoria (FFG) and vulnerable nationally (EPBC) probably also uses the waters of The Arches MS.

Birds

Five conservation listed sea birds have been sighted in or in the immediate surrounds of The Arches MS (Table 18). All are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. The shy albatross *Thalassarche cauta* and black-browed albatross *T. melanophris* are regarded as vulnerable, and the others as near threatened. The two albatross are listed as threatened at the national level. Three migratory birds are recognized internationally under either CAMBA or JAMBA.

Table 18. Conservation listed seabird records from The Arches Marine Sanctuary and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
shy albatross	*Thalassarche cauta*	L	VU	VU		J
black-browed albatross	*Thalassarche melanophris*		VU	VU		J
short-tailed shearwater	*Ardenna tenuirostris*					J
pied cormorant	*Phalacrocorax varius*		NT			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			

L= FFG listed, NT = Near Threatened, VU = Vulnerable, C = Listed under the CAMBA treaty, J = Listed under the JAMBA treaty

Marine mammals and reptiles

Southern right whales *Eubalaena australis*, humpback whales *Megaptera novaeangliae*, and southern elephant seals *Mirounga leonina* have been recorded in or near The Arches MS (Table 19). The southern right whale *E. australis* is listed as critically endangered in Victorian waters and endangered nationally. The humpback whale *M. novaeangliae* is listed as vulnerable at the state and national level. The southern elephant seal *M. leonina* is listed as vulnerable at the national level (Table 19). Australian fur seals *Arctocephalus pusillus doriferus* have been observed in The Arches MS (Plummer *et al.* 2003). Many other animals, such as the state and nationally listed leathery turtle *Dermochelys coriacea*, probably use the MS waters but its remoteness means there are few observations.

Table 19. Conservation listed marine mammal and reptile records from The Arches Marine Sanctuary and surrounds.

		Victorian listing		National listing
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**
southern right whale	*Eubalaena australis*	L	CE	EN
humpback whale	*Megaptera novaeangliae*	L	VU	VU, M
southern elephant seal	*Mirounga leonina*			VU, M
Australian fur seals	*Arctocephalus pusillus doriferus*			L

L= FFG listed, VU = Vulnerable, EN = Endangered, CE = Critically Endangered, M = listed Migratory

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that there are no records of species at their distributional limit, endemic species or rare fauna or flora in The Arches MS (O'Hara and Barmby 2000; O'Hara and Poore 2000).

3.2.5 MAJOR THREATS

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPA's. Through public and agency workshops, the natural values in individual MPA's and the threats that could affect them over the next ten years, were considered and ranked to identify hazards. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Twelve hazards with the potential to be of extreme risk were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Oil spills from offshore platforms or shipping affecting seabirds (water column);
2. Terrestrial events/activities such as floods, fires, droughts, nutrients, (water) extractions, affecting water quality (subtidal reef and water column);
3. Pest plants and animals from recreational boating, ballast water discharge, agriculture, shipping and industry, displacing local species (subtidal reef);
4. “Island-based” management focus affecting marine habitats and communities (all of MS);
5. Funding for management affecting marine communities and habitats (all of MS);
6. Lack of knowledge affecting marine habitats and communities (all of MS);
7. Seismic testing affecting larger (marine) vertebrates (water column);
8. Land-based litter affecting the marine environment (all of MS);
9. Marine debris from elsewhere (*i.e.* beyond parks) resulting in smothering of, entanglement with, or ingestion by marine organisms (subtidal reef and water column);
10. Technology creep (*i.e.* better oil/gas extraction/exploration methods, exploitation of new resources, new ways of accessing resources via bioprospecting, aquaculture etc.) affecting marine communities and habitats (all of MS);
11. Artificial opening of river mouths producing silt plumes resulting in fish kills and sedimentation (subtidal reef); and
12. Government influence on management affecting marine communities and habitats (all of MS).

The introduction of marine pests threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). No introduced species or marine pest has been recorded from The

Arches MS. Japanese kelp *Undaria pinnatifida* has been recently found in Apollo Bay and there are grave concerns about its spread. *Grateloupia turuturu, Caulerpa racemosa* var. *cylindracea* and *Codium fragile* subspecies *fragile* were also recorded in Portland harbour in 2010 (John Lewis pers. comm.). To the east in Flinders Bioregion the Northern Pacific seastar *Asterias amurensis* was found in Anderson Inlet and may have been eradicated in a broad-based community effort in 2004 – 05, led by DSE (Parks Victoria 2006a). *Asterias* was also found at San Remo jetty in late 2011. Further east in the Twofold bioregion the introduced screw shell *Maoricolpus roseus* has been recorded in high densities (Holmes *et al.* 2007b). This species is regarded as a serious threat to the high diversity of infauna that is characteristic of much of Bass Strait (Patil *et al.* 2004; Heislers and Parry 2007). Another species of particular concern is the marine fanworm *Sabella spallanzanii*, (Parks Victoria 2003).

A virus affecting abalone called abalone viral ganglioneuritus has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area and has been confirmed from Discovery Bay MNP to Cape Otway (DPI 2009). It has been confirmed from The Arches MS but long term ecological consequences for rocky reef communities are unknown (DPI 2009).

Climate Change

Climate change represents a serious threat to marine ecosystems (McLeod *et al.* 2009) but specific ecological consequences of accelerating climate change are not well understood in marine systems, particularly in temperate systems. Climate change is predicted to increase water temperature, alter chemical composition (salinity, acidity and carbonate saturation), change circulation and productivity, increase frequencies of extreme weather events and exposure to damaging ultraviolet light (UVB), and increase air temperature, cloud cover and sea levels (conservatively 80 cm by 2100; CSIRO-BoM 2007; Fine and Franklin 2007; VCC 2008; McLeod *et al.* 2009). A combined increase in cloud cover and sea level could result in decreased light availability potentially changing benthic flora. Increased storm surges and ocean current changes also have the potential to change the distribution of fauna and flora and could result in loss of habitats (CSIRO-BoM 2007). Changes in the relationship between climate and annual life-history events may force major change in functional groups and consequent ecosystem function (Fine and Franklin 2007). Climate change is also anticipated to modify species recruitment and habitat connectivity, species interactions and disturbance regimes in the marine environment (CSIRO-BoM 2007; Fine and Franklin 2007).

Measures to address or minimise these threats form part of the management plan for The Arches MS (Parks Victoria 2006b). For example research is being conducted into marine pest species, and investigations into water quality issues have also been conducted. Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

3.2.6 CURRENT RESEARCH AND MONITORING

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring

Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. The research relevant to The Arches MS has been published in Parks Victoria's Technical Series available on Parks Victoria's website (http://www.parkweb.vic.gov.au). As most research in the MS has been carried out under permits issued by DSE, the permit database was also used to identify relevant projects for this report (see Table 20 and Appendix 2).

The Arches MS does not have an ongoing subtidal reef monitoring program. A review of Parks Victoria's monitoring program in relation to conservation outcomes for The Arches will be done by 2013. The major direction includes implementing an expanded and improved monitoring program taking into account knowledge generated since park declaration (Power and Boxshall 2007; Keough and Carnell 2009).

Table 20. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to The Arches Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimizing the allocation of resources for defending Marine Protected Areas against invasive species.
Multiple Research Partners: Marine Monitoring and Marine Natural Values ***Deakin University:*** Jan Barton, Adam Pope and Gerry Quinn Marine Natural Values Reports for the Marine National Parks and Sanctuaries – Version 2.
Museum Victoria: Mark Norman, Julian Finn. ***Parks Victoria:*** Roger Fenwick Under the Lens - Natural History of Victoria's Marine National Park System.
University of Melbourne: Tarek Murshed, Jan Carey, Jacqui Pocklington Conceptual model development for marine habitats.
Ongoing Habitat Mapping Projects
DSE / DPI / Worley Parsons/ Deakin University* LiDAR Mapping Project. Mapping of bathymetry and marine habitats along the Victorian coast

*led by DSE and includes sections of the Marine National Parks and Sanctuaries.

Statewide, the Museum of Victoria is collecting additional data on the marine natural values of Victoria's MPAs. They are gathering information about natural history through video and photos, and using semi-quantitative methods to determine spatial and temporal changes across the system in response to threats, including marine pests and climate change. Jan Carey (University of Melbourne) is conducting research focussing on marine pest species which may impact on park values, and the MPAs which are most at risk of invasion. This will help prioritise Parks Victoria surveillance monitoring efforts to MPAs where there is greatest potential for successful management.

3.2.7 KNOWLEDGE GAPS

The knowledge of the ecological communities of the subtidal reefs is only from a spatially limited descriptive survey and recreational diver observations. There is no quantitative data on fish abundances, distributions or interactions in the subtidal reef or water column habitats. No information exists at present for subtidal soft sediment. Major threats have been identified for The Arches MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.

SUMMARY

Along Victoria's coastline there are 30 Marine Protected Areas (MPAs) that have been established to protect the state's significant marine environmental and cultural values. These MPAs include 13 Marine National Parks (MNPs), 11 Marine Sanctuaries (MSs), 3 Marine and Coastal Parks, 2 Marine Parks, and a Marine Reserve, and together these account for 11.7% of the Victorian marine environment. The highly protected Marine National Park System, which is made up of the MNPs and MSs, covers 5.3% of Victorian waters and was proclaimed in November 2002. This system has been designed to be representative of the diversity of Victoria's marine environment and aims to conserve and protect ecological processes, habitats, and associated flora and fauna. The Marine National Park System is spread across Victoria's five marine bioregions with multiple MNPs and MSs in each bioregion, with the exception of Flinders bioregion which has one MNP. All MNPs and MSs are "no-take" areas and are managed under the *National Parks Act (1975) - Schedules 7 and 8* respectively.

This report updates the first Marine Natural Values Study (Plummer *et al.* 2003) for the MPAs in the Otway bioregion on the west coast of Victoria and is one of a series of five reports covering Victoria's Marine National Park System. It uses the numerous monitoring and research programs that have increased our knowledge since declaration and aims to give a comprehensive overview of the important natural values of each MNP and MS.

The Otway bioregion extends from Cape Jaffa in South Australia to Apollo Bay, past the limit of state waters and to the western Bass Strait islands such as King Island (IMCRA 2006). It has a cool temperate climate and waters, with localised coastal upwellings, which provide nutrient enrichment and increased productivity, making it an important area for seabirds, fur seals and whales. Its high wave energy coastline has headlands of volcanic outcrops and limestone cliffs and extensive, complex deeper reef systems offshore. Sandy beaches and dunes are common in the western region and cliffed shorelines are common elsewhere in the bioregion (IMCRA 2006). The biota of this region consists predominantly of cosmopolitan, southern temperate and western temperate species that are well adapted to the colder, rough water conditions. Fish and plant species-richness are both high compared to other South Australian, Victorian and Tasmanian regions (IMCRA 2006). Plant species diversity is very high, particularly among the red algae.

Within the Otway Bioregion, there are two MNPs, Discovery Bay and Twelve Apostles, and two MSs, Merri and The Arches. All MPAs adjoin the coast, except The Arches MS which is approximately 600m offshore of Port Campbell. Discovery Bay and Twelve Apostles MNPs extend to the state water limit (~5 km offshore). They are 2830 and 7510 hectares respectively, making them the 8^{th} and 2^{nd} largest Victorian MPAs respectively. Merri MS does not extend more than 500m offshore and is 29 hectares in size. The Arches is a square, 48 hectares in size. All the MPAs are over 150 km from Victoria's major population centres of Melbourne and Geelong. The Merri MS is the most accessible MPA with its shores in the city of Warrnambool. The other MPAs can be viewed from land but accessed mostly by boat. The two MNPs abut terrestrial conservation areas; Discovery Bay MNP abuts the Discovery Bay Coastal Park and Twelve Apostles abuts the Port Campbell and the Great Otway National Parks.

Aboriginal tradition indicates that Discovery Bay MNP is part of Gunditjmara *Country* (Parks Victoria 2007a). The Merri MS is part of the sea *Country* of the Gunditjmara and Kirrae Whurrong Aboriginal people (Parks Victoria 2007b). Twelve Apostles MNP and The Arches MS are located within Kirrae Whurrong *Country* (Parks Victoria 2006b). East of the Gellibrand River Twelve Apostles MNP is Gadubanud *Country* (Parks Victoria 2006b).

The rock stacks and intertidal areas within the Twelve Apostles MNP are significant geologically and are listed on the Register of the National Estate (Parks Victoria 2006b). The formations at Pebble Point are also regionally significant. Many other sites near the MPAs are recognised as geologically significant. Pickering Point intertidal reef in Merri MS has been designated a Special Protection Area (Parks Victoria 2007b). The little penguin *Eudyptula minor* colonies in Twelve Apostles MNP and on the islands that Merri MS surrounds are significant biological sites. The wrecks of three wooden sailing barques, the *Jane,* the *Ann* and the *Marie,* are thought to be in the vicinity of Discovery Bay MNP (Parks Victoria 2007a). The wreck of the *Loch Ard* lies within Twelve Apostles MNP near Mutton Bird Island and is listed on the Register of the National Estate (Parks Victoria 2006b)

Knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. High resolution bathymetry mapping has increased our understanding of habitats in all the MPAs except The Arches which has not yet been mapped. All the MPAs, except for The Arches, have intertidal sandy soft sediments and reefs. The intertidal and subtidal reefs are calcarenite except in the nearshore of Discovery Bay MNP which is basalt. All the MPAs have subtidal sandy soft sediments. Discovery Bay and Twelve Apostles MNPs, and The Arches MS have extensive, often sand inundated, deep reef and soft sediments.

The main habitat forming algae on the basalt intertidal reefs in Discovery Bay is Neptune's necklace *Hormosira banksii*. This algae is not so dominant on the calcarenite reefs in Merri MS where sea lettuce *Ulva* sp. and turfing red coralline algae *Corallina officinalis* are dominant. In both MPAs the bull kelp *Durvillaea potatorum* fringes the intertidal reef (Ball and Blake 2007; Monk *et al.* 2008; O'Hara *et al.* 2010). Sessile invertebrates on the intertidal rock platforms in Discovery Bay MNP include the anemones *Aulactinia veratra*, *Actinia tenebrosa* and *Anthothoe albocincta*, the barnacles surf *Catomerus polymerus*, honeycomb *Chamaesipho tasmanica* and rosette *Tetraclitella purpurascens,* and the mussels little black horse *Limnoperna pulex* and beaked *Austromytilus rostratus* (Costa *et al.* 2010; O'Hara *et al.* 2010).

The mobile invertebrate fauna on the intertidal reefs of the MPAs is dominated by molluscs. Common in both Discovery Bay MNP and the Merri MS are the false limpets *Siphonaria diemenensis* and true limpets *Cellana tramoserica* (Cohen 2000; Williams 2004; Evans 2007; Costa *et al.* 2010; O'Hara *et al.* 2010)*.* Discovery Bay intertidal fauna also commonly includes top shells *Austrocochlea* constricta and *A. odontis*, and *Patelloida latistrigata*, black nerite *Nerita atramentosa*, periwinkles *Austrolittorina praetermissa*, *A. unifasciata* and *Bembicium nanum,* and the predatory gastropods *Cominella lineolata*, *Lepsiella reticulata*, and *L. vinosa* (Costa *et al.* 2010; O'Hara *et al.* 2010). In the Merri MS the warrener *Turbo undulatus*, and cartrut shell *Diacthais orbita* are common (Cohen 2000; Williams 2004; Evans 2007)*.* Sea stars, brittle stars, sea urchins, crabs and polychaetes are also found on the intertidal reefs of the MPAs (Plummer *et al.* 2003).

The fish on the intertidal reefs in the MPAs have not been extensively described but usually include the blenny *Parablennius tasmanianus* (Plummer *et al.* 2003). The cling fish *Aspasmogaster tasmaniensis*, and weedfish Johnston's *Heteroclinus johnstoni*, common *Heteroclinus perspicillatus* and crested *Cristiceps australis* have been described from Discovery Bay (Plummer *et al.* 2003).

Sparse beds of the seagrass *Heterozostera* spp grow in 10-30 m on the sandy sediment of Twelve Apostles MNP (Ierodiaconou *et al.* 2007). Crustaceans dominate the infauna of the sandy subtidal sediments in Discovery Bay and Twelve Apostles MNP (Heislers and Parry

2007). The majority of the sandy subtidal sediments in both MNPs are bare of large biota except in deeper waters where a thin veneer of sand covers the reef and sessile invertebrates grow (Holmes *et al.* 2007c; Ierodiaconou *et al.* 2007).

The canopy of the shallow subtidal reefs in the MPAs are dominated by brown algae. In Merri MS crayweed *Phyllospora comosa* and in The Arches MS kelp *Ecklonia radiata* dominate. A mix of both these algae dominate the canopy on the basalt reefs in Discovery Bay MNP. These algae and beds of mixed red, brown or green algae or a combination of algal types and sessile invertebrates are found on Twelve Apostles MNP reefs. In addition, the browns *Scytothalia*, *Sargassum* and giant kelp *Macrocystis pyrifera* grow in Discovery Bay MNP and *Carpomitra costatum* and *Homoeostrichus* sp., grow in more sandy areas in Twelve Apostles (Edmunds *et al.* 2010b). Both thallose and coralline red algae are an important component of algal communities in the MPAs. On the basalt reefs of Discovery Bay MNP mixed red algae and mixed green algae often co-occur, with red algae particularly abundant on the deeper edge of the reef (Holmes *et al.* 2007a). In Twelve Apostles MNP and The Arches MS red algae grows at all depths and includes: *Phacelocarpus peperocarpus*, *Melanthalia obtusata*, *Gelidium asperum*, *Plocamium mertensii* and *Ballia callitricha* (Edmunds *et al.* 2010b). In addition, the red algae *Callophyllus rangiferina*, *Sonderopelta coriacea* and *Haliptilon roseum* are present in the Twelve Apostles MNP and *Sonderopelta coriacea, Pterocladia lucida*, *Plocamium angustum* and *P. dilatatum* are present in The Arches MS (Edmunds *et al.* 2010b). In the Merri MS coralline algae is abundant, as is a relatively diverse community of fleshy red algae (Monk 2006; Crozier *et al.* 2007; Monk *et al.* 2008). The kelp *E. radiata* can extend into moderately deep waters in both Discovery Bay and Twelve Apostles MNPs.

The diversity of the subtidal invertebrates in Merri and The Arches MSs is low compared to other reefs in the bioregion (Crozier *et al.* 2007; Edmunds *et al.* 2010b). The mobile invertebrate community of the subtidal reefs in the MPAs of the Otway bioregion is characterized by southern rock lobster *Jasus edwardsii* and blacklip abalone *Haliotis rubra* (Plummer *et al.* 2003). Seastars are another common mobile invertebrate in the MPAs. In the Twelve Apostles MNP and The Arches MS seastar species include *Nepanthia troughtoni* and *Nectria macrobrachia* (Edmunds *et al.* 2010b). In addition, the seastars *Plectaster decanus*, *Echinaster arcystatus*, and other *Nectria* species are found in Twelve Apostles MNP, while *Tosia magnifica* is found in The Arches MS (Edmunds *et al.* 2010b). The warrener *Turbo undulatus* is abundant in the Merri MS (Monk 2006).

Sessile invertebrates, particularly sponges, become more dominant with depth in the MNPs and The Arches MS (Ierodiaconou *et al.* 2007; Edmunds *et al.* 2010b). In Discovery Bay MNP this includes abundant compact sponges, ascidians, hydroids, and bryozoans along with gorgonian soft corals, hard corals, *Tethya* sponges, zooanthids and the sea whip *Primnoella australasiae* (Holmes *et al.* 2007a; Ierodiaconou *et al.* 2007; Monk *et al.* 2011). In Twelve Apostles MNP sessile invertebrates include isidid gorgonian *Pteronisis* spp., erect sponges, and the large hydroid fan *Solanderia fusca* (Edmunds *et al.* 2010b). The subtidal reef in The Arches has a very low abundance of sessile invertebrates, with nearly all found on or under the ledges of the vertical reef faces (Edmunds *et al.* 2010b). Encrusting or low profile sponges, along with patches of encrusting soft coral *Erythropodium hicksoni* grow on the ledge edges. The erect gorgonian coral *Mopsella* and the ascidian *Herdmania momus* are the only conspicuous invertebrates apart from sponges (Edmunds *et al.* 2010b).

Fish abundant on the subtidal reefs of the MPAs are blue-throated wrasse *Notolabrus tetricus* and rosy wrasse *Pseudolabrus psittaculus*, along with sea sweep *Scorpis aequipinnis* and magpie perch *Cheilodactylus nigripes* (Edmunds *et al.* 2010b; Monk *et al.* 2010). *N. tetricus* is particularly abundant in Merri MS (Monk *et al.* 2008). The Twelve Apostles MNP and The Arches MS fish community also includes dusky morwongs *Dactylophora nigricans,* barber perch *Caesioperca rasor,* bastard trumpeter *Latridopsis* *forsteri* and marble fish *Aplodactylus arctidens.* Marble fish *A. arctidens* is also found in Discovery Bay MNP along with zebra fish *Girella zebra*. In Merri and The Arches MSs zebra fish *G. zebra* and scaly fin *Parma victoriae* are part of the fish community. Twelve Apostles MNP also has senator wrasses *Pictilabrus laticlavius,* butterfly perch *Cheilodactylus lepidoptera,* bullseye *Pempheris multiradiata* and blue morwong *Nemadactylus valenciennesi* but leatherjackets are not abundant (Edmunds *et al.* 2010b). Large schools of purple wrasse *Notolabrus fucicola* and juvenile sea sweep *S. aequipinnis* occur on the nearshore subtidal reefs in Discovery Bay MNP (Plummer *et al.* 2003; Ball and Blake 2007). Blue gropers *Achoerodus* spp. have been observed in the high profile reef systems in 50 m of water west of Cape Duquesne (Ierodiaconou *et al.* 2007). The pot-bellied seahorse *Hippocampus abdominalis* is frequently seen on subtidal reefs in the Merri MS (Parks Victoria 2007b).

All the MPAs support species of high conservation significance. The MPAs and their surrounds provide important feeding and roosting habitat for many threatened shore and sea birds, including 5 species in The Arches MS, 11 in Twelve Apostles MNP, 15 in Discovery Bay MNP and 51 in Merri MS. Within the Twelve Apostles MNP there is a major breeding colony of little penguins *Eudyptula minor* which is of state biotic significance. On the islands that Merri MS surrounds is a small colony of *E. minor*. Numerous marine species are found at the limit of their distribution range within individual MPAs. In Discovery Bay 7 species, including algae and invertebrates are believed to be at the edge of their distributional range. One species, a brittle star is presumed to be at its western limit in Twelve Apostles MNP. Eight species of algae are believed to be at their distributional limit in Merri MS but none are known from The Arches MS. Only one endemic species is known from the MPAs in the bioregion, the southern hooded shrimp *Athanopsis australis* in Discovery Bay MNP.

The two large MNPs have a large amount of open water, which is habitat to conservation listed marine mammals such as southern right whales *Eubalaena australis.* Blue whales *Balaenoptera musculus* are common in Discovery Bay MNP and humpback whales *Megaptera novaeangliae* in Twelve Apostles MNP; both whales are conservation listed. The intertidal reef in both MNPs provides occasional haul-out area for state vulnerable New Zealand *Arctophoca forsteri* and Australian fur seals *Arctocephalus pusillus doriferus*. The southern elephant seals *Mirounga leonina* has also been sighted in Discovery Bay MNP. Large whales are not found within the smaller shallower MSs, however they still provide important habitat for smaller marine mammals.

Specific threats to individual MPAs have been identified. Generally the limited ecological knowledge, and as a consequence inadequate management, are seen as a serious threat to the MPAs. Poaching of abalone or illegal fishing is a threat within the MPAs, as are invasive marine pests. Commercial vessels that pass near or through the waters of the MPAs also pose a threat due to the risk of oil spills. Seismic testing for oil and gas are also seen as a threat to the MPAs' marine natural values. Increased nutrients and sediments through land use or waste discharge pose a threat to water quality in the MPAs. Litter and marine debris pose a threat to marine biota.

The introduction of foreign species or marine pests, by recreational or commercial vessels, threatens the integrity of marine biodiversity and may also reduce the social and economic benefits derived from the marine environment. Species of particular concern include the New Zealand screw shell *Maoricolpus roseus,* Northern Pacific seastar *Asterias amurensis*, marine fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile (subsp fragile)*. Japanese kelp *Undaria pinnatifida* has recently been found in Apollo Bay harbour and there are grave concerns about its spread to other MPAs on the west coast. Other pests including *Grateloupia turuturu, Caulerpa racemosa* var. *cylindracea* and *Codium fragile* ssp. *fragile* were also recorded in Portland harbour in 2010 (John Lewis pers. comm.).

Abalone viral ganglioneuritus has been slowly spreading killing a large percentage of abalone in infected areas from Discovery Bay MNP to Cape Otway. It could have serious long term ecological consequences for subtidal reef communities in the bioregion. Recreational and commercial boats and diving can be a vector for this virus.

Climate change represents a serious threat to marine ecosystems but the specific ecological consequences are not well understood in marine systems. Increased sea levels, water and air temperature, cloud cover, ultraviolet light exposure and frequency of extreme weather events are predicted. Changes in the chemical composition (salinity, acidity and carbonate saturation), circulation and productivity of the seas are also predicted. These predicted changes have the potential to impact all marine habitats, causing loss of habitats, decreases in productivity and reproduction and distribution of species. A number of species are at the limit of their distributional range in the bioregion and such species would be particularly vulnerable to climate change. Measures to address or minimize these threats form part of the management plans for the MPAs. Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria’s capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria’s Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007-2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007-2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. Ongoing shallow subtidal reef monitoring occurs in Merri MS, the reefs in the other MPAs are too deep for this method. Statewide projects are currently underway to photograph and document MPA marine natural values, to determine which MPAs are most at risk from introduced species and to detect poaching.

Detailed bathymetry mapping has been completed for Discovery Bay and Twelve Apostles MNPs, and Merri and The Arches MSs. In Discovery Bay and Twelve Apostles MNPs multibeam sonar mapping has also allowed predictive modelling of the distribution and extent habitats and biota in deeper areas. In Discovery Bay MNP aerial photography has also been used to map shallow substrates. Detailed substrate and habitat maps have also been developed for Merri MS using community based mapping methods. For The Arches MS our knowledge of its basic habitats, their distribution and extent, is limited. Most of our detailed knowledge about the flora and fauna of the MPAs is from the intertidal and shallow subtidal reef surveys. Only Merri MS has a subtidal reef monitoring program and no MPAs in the Otway region currently have an intertidal reef monitoring program. For MPAs without monitoring programs we have a limited understanding of their marine natural values. A large gap in our understanding of the natural values of Otway bioregion MPAs is the intertidal soft sediment and open waters. Whilst threats to the MPAs have been identified we have limited knowledge of the affect of those threats on the natural values.

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APPENDIX 1

Compilation of species from databases from:

- the Atlas of Victorian Wildlife (Fauna 100, records within 5km of all MPAs, excluding terrestrial areas)
- the first Marine Natural Values reports; (MAFRI MNV v1, all MPAs except The Arches MS);
- MAVRIC (Monitoring and Assessment of Victoria's Rocky Intertidal Coast – Discovery Bay MNP only);
- PV intertidal reef monitoring program (IRMP 02-04 none sampled);
- PV subtidal reef monitoring program (SRMP_All, Merri MS only); and
- The Sea Search volunteer monitoring program (Merri MS only).

Summary of number of species listed by data source and MPA:

Source	Habitat(s)	Discovery Bay MNP	Merri MS	The Arches MS	Twelve Apostles MNP
Fauna100_5kmSea	All	41	99	23	34
MAFRI distribution MNV v1	All	9	8		1
MAFRI endemic MNV v1	All	1			
MAVRIC	Rocky Intertidal	59			
IRMP 02-04	Rocky Intertidal				
SRMP_All	Rocky Subtidal		83		
Seasearch20090326	Rocky Intertidal		24		

A “1” in the respective column indicates a record from that MPA. Some species listed in the body of the report above were not included in these datasets at the time of compilation. DBay – Discovery Bay MNP; Mer – Merri MS; Arch – The Arches MS; 12Ap – Twelve Apostles MNP.

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
Green algae	Caulerpaceae	*Caulerpa brownii*	Green alga	1			
		Caulerpa flexilis	Green alga		1		
		Caulerpa flexilis var. *muelleri*	Green alga		1		
		Caulerpa longifolia	Green alga		1		
	Codiaceae	*Codium fragile*	Dead man's fingers	1			
		Codium pomoides	Green alga		1		
		Codium sp.	Green alga		1		
	Palmellaceae	*Palmoclathrus stipitatus*	Green alga	1			
	Ulvaceae	*Enteromorpha intestinalis*	Green alga	1			
		Enteromorpha sp.	Green alga		1		
		Ulva sp.	Sea lettuce		1		
	Alariaceae	*Ecklonia radiata*	Common kelp		1		
Total green algae				**4**	**8**	**0**	**0**
Brown algae	Chordariaceae	*Chordaria cladosiphon*	Brown alga	1			
	Cystoseiraceae	*Acrocarpia paniculata*	Brown alga		1		
		Carpoglossum confluens	Brown alga		1		
		Cystophora platylobium	Brown alga		1		
	Dictyotaceae	*Chlanidophora microphylla*	Brown alga		1		
		Dictyota dichotoma	Brown alga		1		
		Homeostrichus olsenii	Brown alga		1		
		Homeostrichus sinclairii	Brown alga		1		
		Lobospira bicuspidata	Brown alga		1		
		Padina fraseri	Brown alga		1		
		Zonaria sp.	Brown alga		1		
		Zonaria turneriana	Brown alga		1		
	Durvillaeaceae	*Durvillaea potatorum*	Bull kelp	1			
	Ectocarpaceae	*Ectocarpus* sp.	Brown alga		1		
	Hormosiraceae	*Hormosira banksii*	Neptune's necklace	1	1		
	Lessoniaceae	*Macrocystis pyrifera*	Kelp		1		
		Macrocystis pyrifera	Kelp	1			

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
	Scytosiphonaceae	*Colpomenia sinuosa*	Globe algae	1	1		
	Seirococcaceae	*Phyllospora comosa*	Brown alga		1		
	Sporochnaceae	*Carpomitra costata*	Brown alga		1		
		Perithalia caudata	Brown alga		1		
	Stypocaulaceae	*Halopteris* sp.	Brown alga		1		
Total brown algae				**5**	**19**	**0**	**0**
Red algae	Areschougiaceae	*Areschougia congesta*	Red alga		1		
	Bonnemaisoniaceae	*Asparagopsis armata*	Red alga		1		
		Delisea pulchra	Red alga		1		
		Ptilonia australasica	Red alga		1		
	Ceramiaceae	*Antithamnion verticale*	Red alga		1		
		Ballia callitricha	Red alga		1		
		Ceramium monacanthum	Red alga	1			
		Ceramium sp.	Red alga		1		
		Euptilota articulata	Red alga		1		
		Pterothamnion squarrulosum	Red alga		1		
		Ptilocladia vestita	Red alga	1			
		Ptilotia hannafordi	Red alga		1		
	Champiaceae	*Champia* sp.	Red alga		1		
	Corallinaceae	*Amphiroa anceps*	Red alga		1		
		Cheilosporum sagittatum	Red alga		1		
		Corallina officinalis	Red alga		1		
		Haliptilon roseum	Red alga		1		
		Lithophyllum johansenii	Red alga		1		
		Mastophoropsis canaliculata	Red alga		1		
		Metagoniolithon radiatum	Red alga		1		
		Metamastophora flabellata	Red alga		1		
		Spongites hyperellus	Red alga	1			
		Unidentified encrusting corallines	Red alga		1		
		Unidentified erect corallines	Red alga		1		
	Delesseriaceae	*Hemineura frondosa*	Red alga		1		
	Erythrotrichiaceae	*Erythrotrichia ligulata*	Red alga		1		

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
	Gelidiaceae	*Capreolia implexa*	Red alga	1			
		Gelidium asperum	Red alga		1		
		Gelidium australe	Red alga		1		
		Gelidium pusilllum	Red alga		1		
		Pterocladia capillacea	Red alga		1		
		Pterocladia lucida	Red alga		1		
	Gigartinaceae	*Gigartina densa*	Red alga	1			
	Gracilariaceae	*Melanthalia abscissa*	Red alga		1		
		Melanthalia obtusata	Red alga		1		
	Halymeniaceae	*Grateloupia ovata*	Red alga		1		
		Polyopes constrictus	Red alga		1		
	Hypneaceae	*Hypnea ramentacea*	Red alga		1		
	Kallymeniaceae	*Callophyllis cervicornis*	Red alga		1		
		Callophyllis rangiferina	Red alga		1		
	Liagoraceae	*Helminthocladia beaugleholei*	Red alga	1			
	Nizymeniaceae	*Nizymenia australis*	Red alga		1		
	Peyssonneliaceae	*Sonderopelta coriacea*	Red alga		1		
	Phacelocarpaceae	*Phacelocarpus alatus*	Red alga		1		
		Phacelocarpus peperocarpos	Red alga		1		
	Plocamiaceae	*Plocamium angustum*	Red alga		1		
		Plocamium costatum	Red alga		1		
		Plocamium dilatatum	Red alga		1		
		Plocamium mertensii	Red alga		1		
		Plocamium preissianum	Red alga		1		
	Rhodomelaceae	*Echinothamnion hystrix*	Red alga		1		
		Laurencia botryoides	Red alga	1			
		Laurencia elata	Red alga		1		
		Laurencia filiformis	Red alga	1	1		
	Rhodymeniaceae	*Botryocladia obovata*	Red alga		1		
		Cordylecladia furcellata	Red alga		1		
		Erythrymenia minuta	Red alga		1		
		Rhodymenia australis	Red alga		1		

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
		Rhodymenia obtusa	Red alga		1		
	Sarcodiaceae	*Trematocarpus concinnus*	Red alga	1			
	Solieriaceae	*Solieria robusta*	Red alga		1		
	UnknownFamily	Unidentified filamentous red algae	Red alga		1		
		Unidentified thallose red algae	Red alga		1		
Total red algae				**9**	**55**	**0**	**0**
Cnidaria	Actiniidae	*Actinia tenebrosa*	Anemone	1	1		
		Aulactinia veratra	Anemone	1	1		
		Oulactis muscosa	Anemone	1			
		Phlyctenanthus australis	Anemone	1			
	Sagartiidae	*Anthothoe albocincta*	Anemone	1			
Total cnidarians				**5**	**2**	**0**	**0**
Polychaetes	Serpulidae	*Galeolaria caespitosa*	Tubeworm	1			
Total polychaetes				**1**	**0**	**0**	**0**
Barnacles	Catophragmidae	*Catomerus polymerus*	Surf barnacle	1			
	Chthamalidae	*Chamaesipho tasmanica*	Honeycomb barnacle	1			
	Tetraclitidae	*Tetraclitella purpurascens*	Acorn barnacle	1			
Total barnacles				**3**	**0**	**0**	**0**
Decapod crustaceans	Alpheidae	*Athanopsis australis*	Snapping shrimp	1			
	Grapsidae	*Leptograpsus variegatus*	Swift-footed shore crab	1			
Total decapod crustaceans				**2**	**0**	**0**	**0**
Chitons	Ischnochitonidae	*Ischnochiton australis*	Chiton	1			
		Ischnochiton elongatus	Chiton	1			
		Ischnochiton variegatus	Chiton	1			
	Mopaliidae	*Plaxiphora albida*	Chiton	1			
Total chitons				**4**	**0**	**0**	**0**
Gastropods	Buccinidae	*Cominella lineolata*	Whelk	1	1		
	Epitoniidae	*Opalia australis*	Gastropod	1			
	Fissurellidae	*Clypidina rugosa*	Keyhole limpet	1			
		Notomella candida	Keyhole limpet	1			
	Littorinidae	*Austrolittorina praetermissa*	Periwinkle	1			

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
		Austrolittorina unifasciata	Periwinkle	1	1		
		Bembicium melanostoma	Periwinkle		1		
		Bembicium nanum	Periwinkle	1	1		
	Lottiidae	*Lottia mixta*	Limpet	1			
		Notoacmea alta	Limpet	1	1		
		Notoacmea flammea	Limpet	1			
		Notoacmea mayi	Limpet	1			
		Notoacmea petterdi	Limpet	1			
		Patelloida alticostata	Limpet	1	1		
		Patelloida latistrigata	Limpet	1	1		
		Patelloida victoriana	Limpet	1			
	Mitridae	*Mitra carbonaria*	Mitre shell	1			
	Muricidae	*Dicathais orbita*	Gastropod	1			
	Muricidae	*Lepsiella reticulata*	Gastropod	1			
		Lepsiella vinosa	Gastropod	1			
	Nacellidae	*Cellana solida*	Limpet	1			
		Cellana tramoserica	Limpet	1	1		
	Neritidae	*Nerita atramentosa*	Nerite	1			
	Patellidae	*Patella peronii*	Patellid limpet	1			
	Siphonariidae	*Siphonaria diemenensis*	Pulmonate limpet	1	1		
		Siphonaria funiculata	Pulmonate limpet	1			
		Siphonaria zelandica	Pulmonate limpet	1			
	Trochidae	*Austrocochlea constricta*	Ribbed top shell	1	1		
		Chlorodiloma adelaidae	Top shell	1			
		Chlorodiloma odontis	Top shell	1			
		Diloma concamerata	Wavy top shell	1			
	Turbinidae	*Turbo undulatus*	Common warrener (Turban shell)	1	1		
Total gastropods				**31**	**11**	**0**	**0**
Bivalves	Mytilidae	*Brachidontes rostratus*	Beaked mussel	1			
		Xenostrobus pulex	Mussels	1	1		
Total bivalves				**2**	**1**	**0**	**0**
Echinoderms	Asteriidae	*Smilasterias multipara*	Sea Star	1			

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
	Asterinidae	*Parvulastra exigua*	Sea Star		1		
		Patiriella calcar	Sea Star	1			
	Ophiacanthidae	*Ophiacantha heterotyla*	Brittle Star				1
Total echinoderms				**2**	**1**	**0**	**1**
Fish	Aplodactylidae	*Aplodactylus arctidens*	Marblefish		1		
	Cheilodactylidae	*Cheilodactylus nigripes*	Magpie Perch		1		
	Dinolestidae	*Dinolestes lewini*	Longfin Pike		1		
		Diodon nichthemerus	Globefish		1		
	Girellidae	*Girella zebra*	Zebrafish		1		
	Labridae	*Dotalabrus aurantiacus*	Castelnau's Wrasse		1		
		Notolabrus fucicola	Purple Wrasse		1		
		Notolabrus tetricus	Bluethroat Wrasse		1		
		Pictilabrus laticlavius	Senator Wrasse		1		
		Pseudolabrus psittaculus	Rosy Wrasse		1		
	Odacidae	*Odax cyanomelas*	Herring Cale		1		
	Pemperididae	*Pempheris multiradiata*	Bigscale Bullseye		1		
	Pomacentridae	*Parma victoriae*	Scalyfin		1		
	Scorpididae	*Scorpis aequipinnis*	Sea Sweep		1		
Total fish				**0**	**14**	**0**	**0**
Birds	Anatidae	*Cygnus atratus*	Black Swan		1		1
	Ardeidae	*Ardea ibis*	Cattle Egret		1		
		Ardea intermedia	Intermediate Egret		1		
		Ardea modesta	Eastern Great Egret		1	1	1
		Ardea pacifica	White-necked Heron		1		
		Botaurus poiciloptilus	Australasian Bittern		1		1
		Nycticorax caledonicus	Nankeen Night Heron		1		
	Charadriidae	*Charadrius bicinctus*	Double-banded Plover		1		
		Charadrius mongolus	Lesser Sand Plover		1		
		Charadrius ruficapillus	Red-capped Plover	1	1		
		Elseyornis melanops	Black-fronted Dotterel		1	1	
		Erythrogonys cinctus	Red-kneed Dotterel		1		
		Pluvialis fulva	Pacific Golden Plover		1		

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
		Pluvialis squatarola	Grey Plover		1		
		Thinornis rubricollis	Hooded Plover	1	1		1
		Vanellus miles	Masked Lapwing	1	1		1
	Ciconiiformes	*Egretta garzetta*	Little Egret		1		1
		Egretta novaehollandiae	White-faced Heron		1		1
	Diomedeidae	*Diomedea exulans*	Wandering Albatross	1	1		1
		Thalassarche cauta	Shy Albatross	1	1	1	1
		Thalassarche chlororhynchos	Yellow-nosed Albatross	1	1		
		Thalassarche chrysostoma	Grey-headed Albatross		1		
		Thalassarche melanophris	Black-browed Albatross	1	1	1	1
	Haematopodidae	*Haematopus fuliginosus*	Sooty Oystercatcher	1	1		
		Haematopus longirostris	Pied Oystercatcher	1	1		
	Hydrobatidae	*Garrodia nereis*	Grey-backed Storm-Petrel		1		
		Oceanites oceanicus	Wilson's Storm Petrel	1	1		
		Pelagodroma marina	White-faced Storm-Petrel		1		
	Laridae	*Chlidonias hybridus*	Whiskered Tern		1		
		Chlidonias leucopterus	White-winged Black Tern		1		
		Chroicocephalus novaehollandiae	Silver Gull	1	1	1	1
		Gelochelidon nilotica	Gull-billed Tern		1		
		Hydroprogne caspia	Caspian Tern	1	1		
		Larus dominicanus	Kelp Gull		1		
		Larus pacificus	Pacific Gull	1	1		
		Sterna bergii	Crested Tern	1	1	1	
		Sterna paradisaea	Arctic Tern	1			
		Sternula nereis	Fairy Tern		1		
	Meliphagidae	*Epthianura albifrons*	White fronted Chat		1		1
	Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican		1	1	
	Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant	1	1	1	1
		Phalacrocorax carbo	Great Cormorant	1	1	1	1
		Phalacrocorax fuscescens	Black-faced Cormorant	1	1	1	1

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
		Phalacrocorax sulcirostris	Little Black Cormorant	1	1		1
		Phalacrocorax varius	Pied Cormorant		1	1	
	Podicipedidae	*Podiceps cristatus*	Grest Crested Grebe		1		
		Poliocephalus poliocephalus	Hoary-headed Grebe		1		1
	Procellariidae	*Aphrodroma brevirostris*	Kerguelen Petrel	1	1		1
		Ardenna carneipes	Flesh-footed Shearwater	1			
		Ardenna grisea	Sooty Shearwater	1	1		
		Ardenna tenuirostris	Short-tailed Shearwater	1	1	1	1
		Daption capense	Cape Petrel		1		
		Fulmarus glacialoides	Southern Fulmar		1		
		Halobaena caerulea	Blue Petrel	1	1		1
		Macronectes giganteus	SouthernGiant-Petrel	1	1		
		Pachyptila belcheri	Slender-billed Prion	1	1		
		Pachyptila desolata	Antarctic Prion	1	1		
		Pachyptila salvini	Salvin's Prion	1			
		Pachyptila turtur	Fairy Prion		1		
		Pelecanoides urinatrix	Common Diving-petrel		1		
		Pterodroma lessonii	White-headed Petrel		1		
		Pterodroma macroptera	Great-winged Petrel		1		
		Puffinus assimilis	Little Shearwater	1			
		Puffinus gavia	Fluttering Shearwater		1		
		Puffinus huttoni	Hutton's Shearwater	1			
	Psittacidae	*Neophema chrysogaster*	Orange-bellied Parrot		1	1	
		Neophema chrysostoma	Blue-winged Parrot		1	1	1
	Rallidae	*Fulica atra*	Eurasian Coot		1		1
		Gallinula ventralis	Black-tailed native hen		1		
		Gallirallus philippensis	Buff-banded Rail		1	1	
		Porzana fluminea	Australian Spotted Crake		1		
		Porzana pusilla	Baillon's Crake		1		
		Porzana tabuensis	Spotless Crake		1		
	Recurvirostridae	*Cladorhynchus leucocephalus*	Banded Stilt		1		
	Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt		1		1

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
	Scolopacidae	*Actitis hypoleucos*	Common Sandpiper		1		
		Arenaria interpres	Ruddy Turnstone		1		
		Calidris acuminata	Sharp-tailed Sandpiper		1		
		Calidris alba	Sanderling		1		
		Calidris canutus	Red Knot		1		
		Calidris ferruginea	Curlew Sandpiper		1		
		Calidris ruficollis	Red-necked Stint		1		
		Calidris tenuirostris	Great Knot		1		
		Gallinago hardwickii	Latham's snipe		1		
		Heteroscelus brevipes	Grey-tailed Tattler		1		
		Limosa lapponica	Bar-tailed Godwit		1		
		Tringa nebularia	Common Greenshank		1		
	Spheniscidae	*Eudyptes chrysolophus*	Macaroni Penguin	1			
		Eudyptes pachyrhynchus	Fjordland Penguin		1	1	
		Eudyptes sclateri	Erect-crested Penguin				1
		Eudyptula minor	Little Penguin	1	1	1	1
	Stercorcariidae	*Stercorarius parasiticus*	Arctic Jaeger		1		
		Stercorarius skua	Great Skua		1		
	Sulidae	*Morus serrator*	Australasian Gannet	1	1	1	1
	Threskiornithidae	*Platalea regia*	Royal Spoonbill		1		
		Plegadis falcinellus	Glossy Ibis				1
		Threskiornis molucca	White Ibis		1	1	
Total birds				**33**	**89**	**19**	**27**
Mammals	Balaenidae	*Eubalaena australis*	Southern Right Whale	1	1	1	1
	Balaenopteridae	*Balaenoptera musculus*	Blue Whale	1	1		
		Megaptera novaeangliae	Humpback Whale		1	1	1
	Delphinidae	*Delphinus delphis*	Common Dolphin	1			
		Globicephala melas	Long-finned Pilot Whale		1		1
		Orcinus orca	Killer Whale			1	1
		Tursiops truncatus	Bottlenose Dolphin		1		1
	Neobalaenidae	*Caperea marginata*	Pygmy Right Whale				1
	Otariidae	*Arctophoca forsteri*	New Zealand Fur-seal				1

Biotic group	Family	Species	Common Name	DBay	Mer	Arch	12Ap
		Arctocephalus pusillus dorferus	Australian Fur-seal	1	1		
		Arctophoca tropicalis	Subantarctic Fur-seal		1		
	Phocidae	*Hydrurga leptonyx*	Leopard Seal	1	1		
		Lobodon carcinophagus	Crabeater Seal		1		
		Mirounga leonina	Southern Elephant Seal	1	1	1	
	Physeteridae	*Physeter macrocephalus*	Sperm Whale	1			
Total mammals				**7**	**10**	**4**	**7**

APPENDIX 2

Completed research, mapping and monitoring projects carried out under *National Parks Act 1975* research permits in or relevant to Otway bioregion with associated reports. Research Partner Panel (and RPP-like) research projects, mapping projects and monitoring surveys were implemented in partnership with, or commissioned by, Parks Victoria. Several other research projects were also carried out independently under *National Parks Act 1975* permits.

1. Discovery Bay MNP

Completed RPP (and RPP-like) Projects and Associated Reports
Department of Primary Industries: Anthony Plummer, Liz Morris, Sean Blake, David Ball Marine Natural Values Study. Victorian Marine National Parks and Sanctuaries. Plummer, A., Morris, L., Blake, S. and Ball, D. (2003). Marine Natural Values Study, Victorian Marine National Parks and Sanctuaries. Parks Victoria Technical Series No. 1, Parks Victoria, Melbourne.
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Parks Victoria is responsible for managing the Victorian protected area network, which ranges from wilderness areas to metropolitan parks and includes both marine and terrestrial components.

Our role is to protect the natural and cultural values of the parks and other assets we manage, while providing a great range of outdoor opportunities for all Victorians and visitors.

A broad range of environmental research and monitoring activities supported by Parks Victoria provides information to enhance park management decisions. This Technical Series highlights some of the environmental research and monitoring activities done within Victoria's protected area network.

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