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Marine Natural Values Study (Vol 2)

Marine Protected Areas of the Central Victoria Bioregion

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***Parks Victoria**

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 Central Victoria bioregion on the central 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 Central Victorian Bioregion extends along the open coast from Apollo Bay to Cape Liptrap and out to the limit of Victorian State waters in Bass Strait. It contains two MNPs, Point Addis and Bunurong, and five small MSs, Marengo Reefs, Eagle Rock, Point Danger, Barwon Bluff and Mushroom Reef. It has a temperate climate, a shore characterised by cliffs and sandy beaches and a steep sea bed. It is relatively exposed to swells and weather from the south-west. Its biota is 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. Ship wrecks occur within all the MPAs except Eagle Rock and Mushroom reef.

High resolution bathymetry mapping has increased our understanding of habitats in the shallow waters of all the MPAs, and for the whole of Point Addis MNP. All the MPAs in the Central Victoria bioregion have intertidal rocky reef and some shallow subtidal reef. The shallow subtidal rocky reefs in Bunurong MNP are extensive. Only Point Addis and Bunurong MNPs have deep subtidal reef. The reefs in the MPAs are predominately limestone or sandstone, with some basalt in Eagle Rock, Barwon Bluff and Mushroom Reef MSs. All, except Marengo Reefs MS, have intertidal soft sediment habitat or beaches interspersed amongst rocky headlands. Wrack material in this habitat contributes to the detrital cycle and is a significant source of food for many invertebrates and shore birds. All the MPAs have some subtidal soft sediment habitat, which can have very high numbers of invertebrate species living on and in it. Subtidal soft sediment and open water are the dominant habitat types in Point Addis and Bunurong MNPs, but intertidal and shallow subtidal rocky reef are the dominant habitat in the five MSs.

On the intertidal reefs the dominant habitat is the brown alga Neptune's necklace *Hormosira banksii*. Algal turf, coralline algae, sea lettuce *Ulva sp.* and the mussel *Limnoperna pulex* can also form intertidal habitats. In Bunurong MNP, and Eagle Rock and Point Danger MSs sand can cover the intertidal reef. Bull kelp *Durvillaea potatorum* grows on the intertidal reef edge in Point Addis MNP, and Marengo Reefs, Eagle Rock, Barwon Bluff and Mushroom Reef MSs. The mobile intertidal reef fauna in the MPAs is dominated by molluscs. The striped conniwink *Bembicium nanum* and pulmonate limpet *Siphonaria spp.* are abundant along with various other limpet species. The top shell *Austrocochlea constricta* is particularly abundant in all the MSs. In the two MNPs and Barwon Bluff MS the periwinkles *Nodolittorina acutispira* and *N. unifasciata* are abundant. The black nerite *Nerita atramentos* is abundant amongst the basalt boulders in Eagle Rock and Mushroom Reef MSs. Mushroom Reef MS has one of the most diverse rocky reef assemblages in Victoria, the Bunurong coast has a very high diversity of chitons, but little is known about the intertidal biota of Marengo Reefs MS.

On the shallow subtidal reef of the MPAs the algae canopy can be mixed brown algae, crayweed *Phyllospora comosa,* kelp *Ecklonia radiata* or giant kelp *Macrocystis pyrifera.* The algal assemblage of Ingoldsby Reef in Point Addis MNP is particularly diverse. Bunurong MNP algal assemblage is unusual with a high diversity of red and brown algae species and a low abundance or absence of the large browns such as *P. comosa* and *E. radiata.* The understorey at both Marengo Reefs and Eagle Rock MSs has very few species and a low cover of red and green algae. *P. comosa* does not grow in Point Danger MS.

Abundant blacklip abalone *Haliotis rubra* characterise the invertebrate assemblage of the MPAs subtidal reefs. The warrener *Turbo undulatus* and a diverse variety of sea stars are abundant in Point Addis and Bunurong MNPs. The elephant snail *Scutus antipodes, T. undulatus* and cartrut whelk *Dicathais orbita* are common in Barwon Bluff MS. Marengo Reefs MS is characterised by a low abundance of the purple urchin *Heliocidaris erythrogramma,* and Eagle Rock MS by low numbers of all invertebrates other than *H. rubra*. Point Danger MS has a high diversity of invertebrates, and particularly opisthobranchs (sea slugs). The black- and white- gastric-brooding seastar *Smilasterias multipara* is an important natural value of Mushroom Reef MS.

The subtidal reef fish assemblage has not been described for Point Danger or Mushroom Reef MSs. In the other MPAs the blue-throated wrasse *Notolabrus tetricus* is common, as are the Victorian scalyfin *Parma victoriae,* yellow striped leather jacket *Meuschenia flavolineata* and sea sweep *Scorpis aequipinnis,* except in Marengo Reefs MS. Herring cale *Odax* cyanomelas is abundant in all these MPAs but not in Point Addis MNP. The purple wrasse *N. fucicola* is abundant in Point Addis and Bunurong MNPs, and particularly abundant in Marengo Reefs MS. Other fish species such as the senator wrasse *Pictilabrus laticlavius,* horseshoe leatherjacket *M. hippocrepis* magpie morwong *Cheliodactylus nigripes* and zebra fish *Girella zebra* occur in all the MPAs but in varying abundances.

The seagrass *Amphibolis antarctica* grows subtidally in all MPAs except Marengo Reefs and Eagle Rock MSs. It also grows in intertidal rock pools in Bunurong MNP, Barwon Bluff and Mushroom Reef MSs. Its stems and fronds support sessile invertebrates, including large colonies of bryozoans and hydroids. The seagrass *Heterozostera nigricaulis* grows in sparse beds on shallow sandy sediment beyond the surf zone in the west of Point Addis MNP. In Mushroom Reef MS *Zostera* sp. grows on the subtidal soft sediment.

Deep water soft sediments in Point Addis MNP have unique assemblages of sponges, bryozoans, ascidians and hydroids. Its rhodolith beds have a high diversity of algal, invertebrate and fish species. In Bunurong MNP the deep reefs are dominated by sponges, stalked ascidians and bryozoans.

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, from 13 species in Marengo Reefs MS and up to 31 in Bunurong MNP. The endangered hooded plover *Thinornis rubricollis* has been recorded from both Point Danger and Barwon Bluff MSs but is not known to breed in either MS. The MPAs are also important for many migratory birds, with 6 species in Marengo Reefs MS to 18 in Barwon Bluff MS. Numerous marine species are found at the limit of their distribution range within individual MPAs, from over 37 species in Mushroom Reef MS to none in Barwon Bluff MS. Three crustaceans are believed to be endemic to Mushroom Reef MS.

The two MNPs have large amounts of open water which is habitat for conservation listed marine mammals such as southern right whales *Eubalaena australis.* Blue whales

Balaenoptera musculus have been sighted in Point Addis MNP and humpback whales *Megaptera novaeangliae* in Bunurong MNP. Other marine mammals sighted in both Point Addis and Bunurong MNP are the bottlenose dolphin *Tursiops spp.*, Australian fur seal *Arctocephalus pusillus doriferus* and leopard seal *Hydrurga leptonyx.* In addition the long-finned pilot whale *Globicephala melas* and killer whale *Orcinus orca* have been sighted in Point Addis MNP, and the common dolphin *Delphinus delphis* in Bunurong MNP. The smaller shallower MSs provide important habitat for small marine mammals. Marengo Reefs MS is a protected haul out for the Australian fur seals *A. pusillus doriferus* and Eagle Rock MS intertidal platforms are used as occasional haul-out areas. The endangered warm water vagrant sea turtle the pacific or olive ridley *Lepidochelys olivacea* has been sighted in or near Point Addis MNP and probably occurs offshore in Bunurong MNP too.

The introduction of foreign species or marine pests, by recreational or commercial vessels, threatens the integrity of marine biodiversity. It is presumed that the introduced green shore crab *Carcinus maenas* occurs on the intertidal reefs of all the MPAs. 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 ecological consequences for subtidal reef communities if it spreads into the Central Victoria bioregion.

Recreational boating has also been identified as posing a threat to seagrass beds, soft sediments and shallow subtidal reefs through propeller and anchor scour. Disturbance of wildlife, shore birds by vehicles, people or dogs; or hauled out seals by boats are also a threat in the MPAs. Poaching of abalone or fish is also a threat to subtidal reefs. Commercial vessels pose a threat due to the risk of oil spills. Damage through trampling and illegal collection also poses threats to the highly accessible intertidal reefs in the MPAs. Water quality in the MPAs may be threatened by increased nutrients and sediments from land use or waste discharge.

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. Changes in the chemical composition, 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.

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 occurs in Point Addis and Bunurong MNPs, and Marengo Reefs and Eagle Rock MSs. Intertidal monitoring is conducted in all the MPAs in the bioregion, except Marengo Reefs and Eagle Rock MSs. Other statewide projects are currently underway to photograph and document their marine natural values, and also to determine which MPAs are most at risk from introduced species and to detect poaching.

Since declaration considerable advancement has been made in identifying and understanding the marine natural values of the Central Victoria bioregion. There are still major gaps in our knowledge. Comprehensive knowledge of basic habitats, their distribution and extent, is limited to shallow waters except in Point Addis. Monitoring changes in flora and fauna over time is limited to intertidal and shallow subtidal reef habitats. 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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FIGURES

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ACRONYMS

AME - Australian Marine Ecology
AMSA – Australian Maritime Safety Authority
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
SPA – Special Protection Area
SRMP - Subtidal Reef Monitoring Program
VCC – Victorian Coastal Council
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).

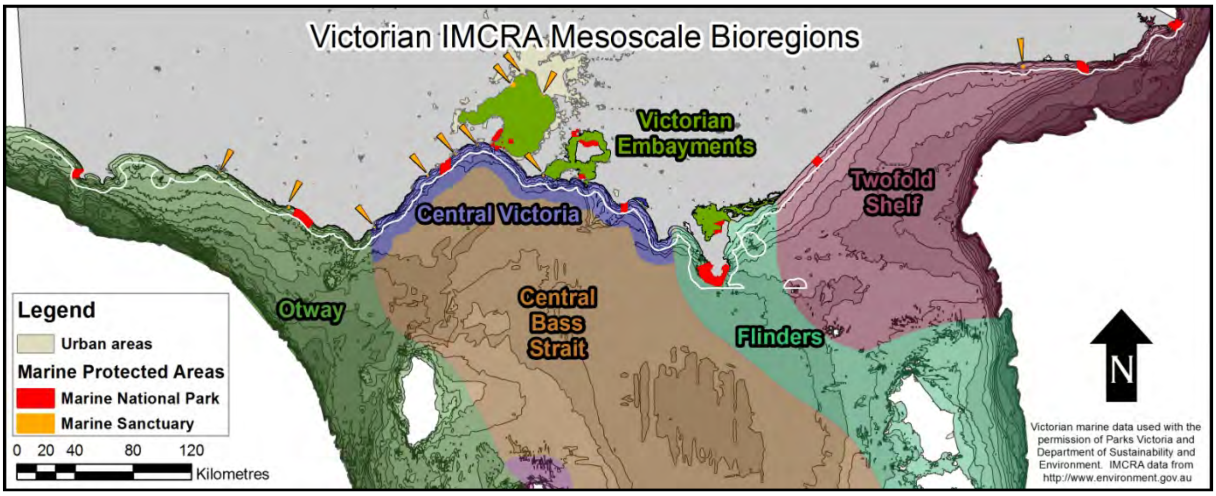


Figure 1. Locations of IMCRA mesoscale (*i.e.* 100-1000km) bioregions (IMCRA 2006)

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 Central Victoria 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 Central Victoria bioregion.

1.3 Structure

This report firstly describes the Central Victoria 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)
- 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:

- Intertidal and Subtidal Reef Marine Monitoring Programs (IRMP and SRMP, Australian Marine Ecology for PV).
- Sea Search Community Based Monitoring Program (PV)
- 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 (< 10 m) 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 10 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 flora and fauna in MPAs of Central Victoria bioregion (Appendix 1).

1.5 Central Victorian Bioregion

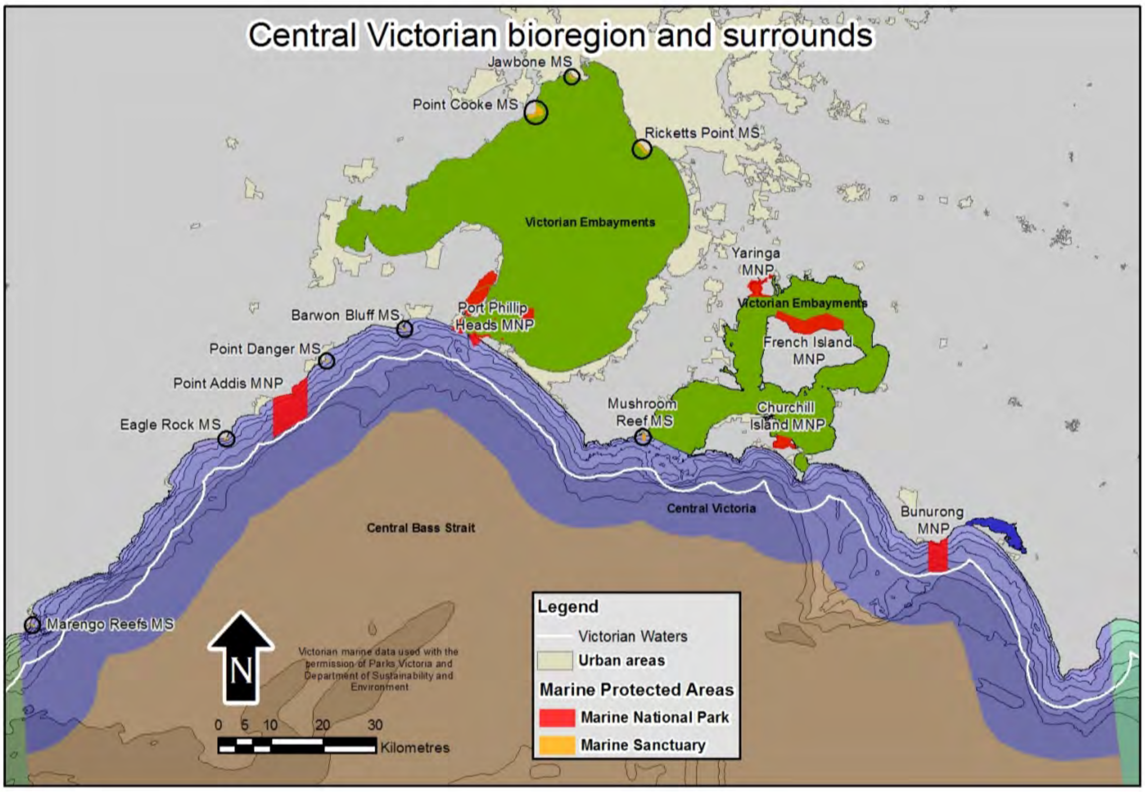


Figure 2. Central Victoria with IMCRA mesoscale bioregions, Marine National Parks and Marine Sanctuaries.

The Central Victoria bioregion extends from Apollo Bay to Cape Liptrap and out to the limit of Victorian State waters (*i.e.* 3 nm; Figure 2). 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. In addition, there is the Bunurong Marine Park.

This Bioregion 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 (mean annual sea-surface 15^{o}), and wave energy is moderate (IMCRA 2006). Tides change from twice to four times a day from west to east (IMCRA 2006).

The habitats in this Bioregion 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).

Sheltered rock platforms and shallow subtidal reefs have a mixed algal assemblage including various green, brown and red algae (IMCRA 2006). The more exposed coasts are fringed with *Durvillaea* with mixed *Phyllospora* and *Ecklonia* assemblages on subtidal reefs. Small beds of seagrass *Amphibolis antarctica* on reefs trap sand and provide habitat in sheltered locations. Many western species have their eastern distribution limit within central Victoria particularly on the eastern edge of the bioregion between Bunurong MNP (Central Victoria) and Wilsons Promontory (Flinders) MNPs (O'Hara 2000b; O'Hara 2002a; IMCRA 2006).

1.6 Other Victorian Bioregions

The Otway Marine bioregion extends from Cape Jaffa in South Australia to Apollo Bay and the western Bass Strait islands such as King Island (Figure 1; IMCRA 2006). In Victoria it contains two MNPs, Discovery Bay and Twelve Apostles, and two MSs, Merri and The Arches. It has a cool temperate climate and waters, with localised coastal upwellings in the west. 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. 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). 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). For many macroalgal 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).

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. 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 Point Addis Marine National Park

Point Addis MNP is about 25 km south-west of Geelong. It is 4420 hectares and extends from high water mark to three nautical miles (~5 km) offshore within the continental shelf. It extends along nine km of coastline east of Anglesea to Bells Beach abutting the Great Otway National Park (Figure 3). Point Addis is a prominent headland in the middle of the park. Point Addis, Southside and Bells Beach are major access points to the MNP.

Aboriginal tradition indicates that Point Addis MNP area is part of the Country of the Wathaurung people who maintain a long association with this region (Parks Victoria 2005).

Important natural values of Point Addis MNP are its sandy beaches, with their high wave-energy shoreline socially valued for surfing, especially at Bells Beach (Carey *et al.* 2007b). Other natural values are the intertidal rocky limestone reefs with abundant rockpools and associated biota. Subtidal reefs are recognised for their diverse and abundant fish and macrophyte biota, in particular Ingoldsby Reef which includes the iconic and protected weedy sea-dragon *Phyllopteryx taeniolatus* (ECC 2000; Carey *et al.* 2007b). Seagrass beds of *Amphibolis antarctica,* and the soft sediment habitats have abundant epibenthos providing shelter for fish (Carey *et al.* 2007b). Subtidal rhodolith beds with their high diversity of algal, invertebrate and fish species are an important natural value of Point Addis MNP (Parks Victoria 2005). Deep water (40 to 50 m) soft sediments have been recognized for their unique assemblages of sponges, bryozoans, ascidians and hydroids (LCC 1996).

Point Addis MNP provides important feeding and roosting habitat for several 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 11 internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Three crustaceans are endemic to the MS. The presence of Australian fur seals *Arctocephalus pusillus doriferus* and bottlenose dolphin *Tursiops spp.* are also important natural values of Point Addis MNP, they are protected under the *Environment Protection Biodiversity Conservation (EPBC) Act (1999)* and the *Wildlife Act (1975)*. Two species of marine flora believed to be at their distributional limits within the MNP. Point Addis limestone outcropping at Point Addis is a geological feature of statewide significance.

Coastal areas such as the Point Addis MNP are subject to many external influences and potential threats. Lack of ecological knowledge, invasive marine pests, illegal fishing, trampling, physical damage from recreational boats, freshwater discharges, litter, oil spills, disturbance of birds and seals and climate change all pose serious threats to the integrity of Point Addis MNP (Carey *et al.* 2007b). Measures to address or minimise these threats form part of the management plan for Point Addis MNP (Parks Victoria 2006b).

Figure 3. Rock pool on the intertidal reef in Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

2.1.1 PHYSICAL PARAMETERS & PROCESSES

Point Addis MNP is 4420 hectares in size which makes it the third largest of the 24 Marine National Parks or Sanctuaries in Victoria (Figure 4). Shoreline geology is Anglesea sandstone cliffs, containing two outcrops of the geologically significant Point Addis limestone. The bases of the cliffs have sandy beaches that are inundated at high tide, with intertidal platforms where the Point Addis limestone outcrops (Bird 1993). For a list of key physical attributes see Table 1.

Point Addis MNP has steep sloping bathymetry with a maximum depth of 58 metres (data from Holmes *et al.* 2007a; Figure 4). Bathymetry data collected as a part of the habitat mapping program indicates the presence of old coastal landforms on the sea floor of the park, including an old river course, a lake and old shore lines (Holmes *et al.* 2007a). Tides are microtidal (< 2 m) and the climate has a distinct cold wet winter. Both the coastal exposure and wave energy is high. The Leeuwin current is the most prominent influence on water movement, causing a northeasterly current through the park and sanctuaries towards Port Phillip Heads (Parks Victoria 2005). Subtidal reefs in Point Addis MNP are predominantly sandstone and limestone (Crozier *et al.* 2007). Bells Beach is a steep, sandy, south-east facing beach behind a bouldery shore (Bird 1993). At Bells Beach the predominate south-westerly swell is refracted, and remains high and steep over the shelving sea floor and breaks from west to east (Bird 1993). No major estuaries run directly into the park, with 8 small intermittent streams discharging within the park boundaries (Table 1). The catchment that drains into these streams is predominately agricultural with some urbanization. The Great Otway National Park borders the MNP, with two large reserves extending inland, Eumeralla Flora Reserve and Iron Bark Basin Reserve.

Table 1. Physical attributes of the Point Addis Marine National Park.

Park Name	**Point Addis**
Conservation status	Marine National Park
Biophysical Region	Central Victoria
Size	4420 ha (ranked 3rd of 24)
Length of coastline	~ 9 km
Shoreline geology	Sandstone & limestone
Area with depth:	
Less than 10m	568 ha
Comprising: <5 m (high res)	*(226 ha)*
5-10 m (high res)	*(326 ha)*
*0 - 10 m (low res)**	*(16 ha)*
10-20 m	764 ha
20-30 m	786 ha
30-40 m	894 ha
40-50 m	858 ha
50-60m	546 ha
60-70m	1 ha
Mean tidal variation - spring	1.7 m
Mean tidal variation - neap	0.9 m
Mean water temp - summer	17.5°C
Mean water temp - winter	13.5°C
Adjacent catchment	Agricultural, Urban
Discharges into MNP	8 intermittent creeks
Nearest major estuary (distance & direction)	Anglesea River 2.1 km West Spring Creek 4.2 km East

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

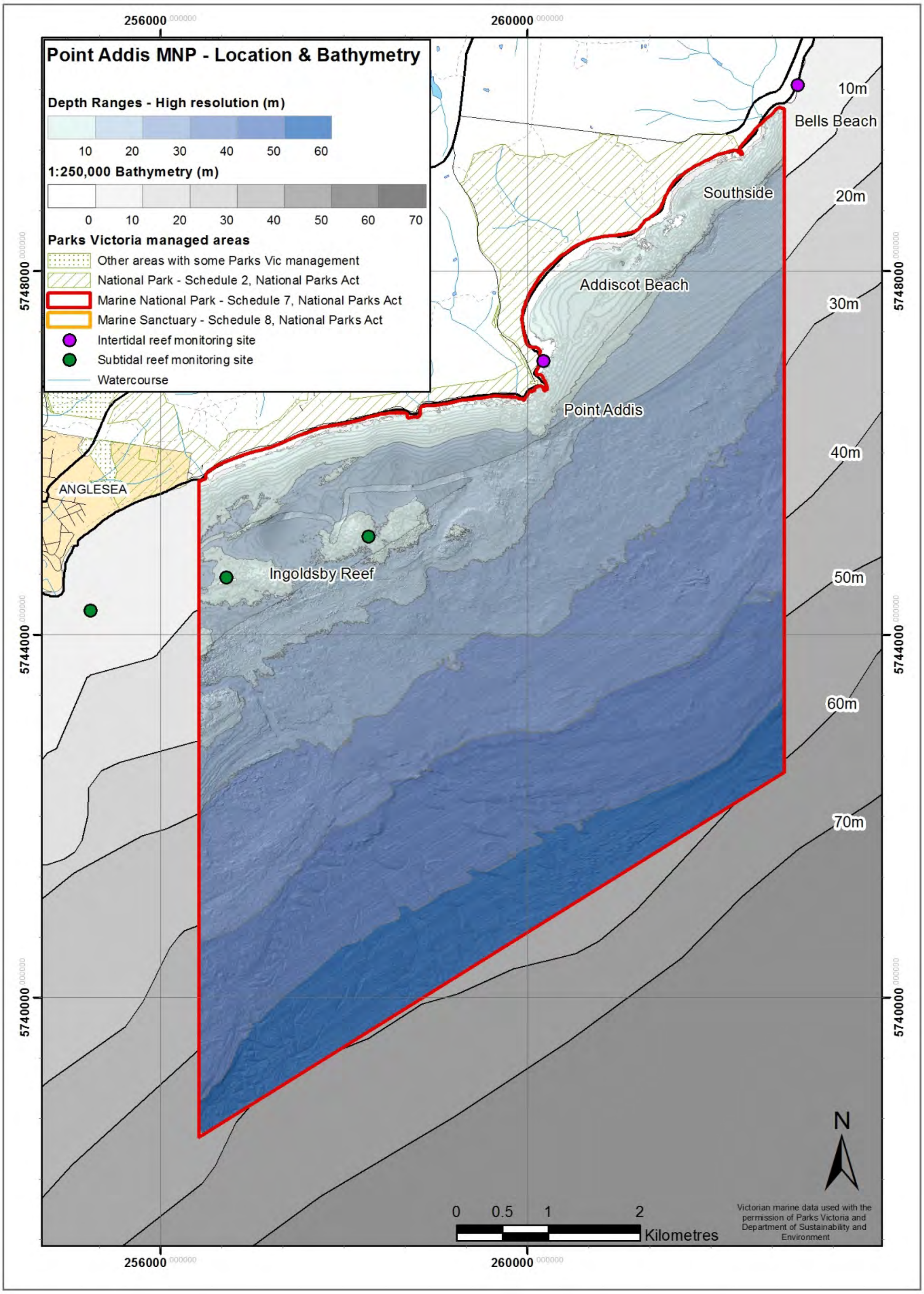


Figure 4. Location map of Point Addis Marine National Park with high resolution and 1:250,000 bathymetry.

Figure 5. Aerial photo of the coast of Point Addis Marine National Park (QASCO 27/8/02). Figure from Ball and Blake (2007b).

2.1.2 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 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 Point Addis MNP include intertidal soft sediment and reef (Figure 6), extensive subtidal soft sediment and reef, and open ocean (Figure 7).

LiDAR mapping of the coastline has been done but it is limited by depth to shallow habitats (Figure 4). The majority of the intertidal and subtidal habitat of the Point Addis MNP has been mapped by remote sensing and detailed acoustic surveys. The intertidal and shallow subtidal (to 22m) habitats were mapped from 2002 and 2004 aerial photography (Figure 5, Figure 8) and satellite imagery (Ball and Blake 2007b). The subtidal area was ground truthed in 2004 with underwater video. The intertidal area was ground truthed in 2005 with shore visits. Descriptions of the intertidal and subtidal reef habitats were also made as part of the monitoring programs of Stewart *et al.* (2007b) and Crozier *et al.* (2007). In 2004 the deep (>15 m) subtidal substrate and biota was surveyed (Figure 7, Figure 9) and mapped acoustically by Holmes *et al.* (2007a). Underwater video transects allowed the substrate and biota to be predictively modeled for the areas not surveyed.

The intertidal zone is primarily sand beach, with some large areas of rock platform at Point Addis, Addiscot Beach, Jarosite Headland and Bells Beach (Figure 4; Ball and Blake 2007b). The main intertidal reef at Point Addis is a large and undulating intertidal platform that extends east from the base of cliffs (Stewart *et al.* 2007b). The platform is relatively low and large areas of the reef remain inundated during some tidal cycles. It is relatively exposed to wave action (Stewart *et al.* 2007b).

West of Point Addis the inshore subtidal substratum is generally bare sediment (Figure 4; Ball and Blake 2007b). Subtidal reefs in Point Addis MNP are predominantly sandstone and limestone (Crozier *et al.* 2007). Near the western border of the park at approximately 250 m offshore, a band of patchy low profile reef formed by emergent coal runs parallel with the shore at depths of between 3.5 – 8.5 m. Mobile sand in this area regularly buries and uncovers the reef. Beyond this, there are extensive areas of patchy low profile reef and rubble, ranging in depth from approximately 7 – 13 m (Ball and Blake 2007b). Approximately 1.3 km offshore, the reef becomes high profile and broken around Ingoldsby Reef. Ingoldsby Reef rises from 10 m deep sea floor approximately two kilometres from the shoreline and is 240 m long and 40 m wide and contains both intertidal and subtidal reef (Beanland 1985). High profile broken reef occurs directly south of Point Addis, and is comprised of large boulders close to shore. Further offshore the depth drops away relatively quickly leading to continuous low profile broken reef. Towards Addiscot Beach, the inshore reef is low profile and continuous. Offshore in the centre of the bay at depths of 5–7 m the reef becomes broken and patchy. East of Addiscot Beach there is extensive low profile, continuous, solid reef running from depths of approximately 2 m down to 15 m (Ball and Blake 2007b). The reef in the vicinity of Bells Beach is shallower, patchy, having a broken and rubbly texture.

Based on surveys and predictive modelling, in deep waters (> 15 m) soft sediment covers 22 sq. km of the MNP, reef 6 sq. km, and mixed reef and sediment an additional 11 sq. km (Holmes *et al.* 2007a; Figures 4 and 5). Reef is concentrated in the inshore region, dominating the substrate to approximately 2.5 km from the shoreline. It varies from high relief, including overhangs and vertical surfaces, to flat pavement structure. The majority is solid or continuous reef dominated by common kelp (*Ecklonia*; Figure 9). At approximately 3 km from shore and 35 m water depth, soft sediment becomes dominant, with outcrops of low profile reef (Figure 7). The deeper water sediment is predominantly coarse grained, with coarse-scale ripples. In the southwest, there is a large area of sediment with fine-scale ripples (Holmes *et al.* 2007a; Holmes *et al.* 2008).

Figure 6. Intertidal reef platform in Point Addis Marine National Park. Photo by AME.

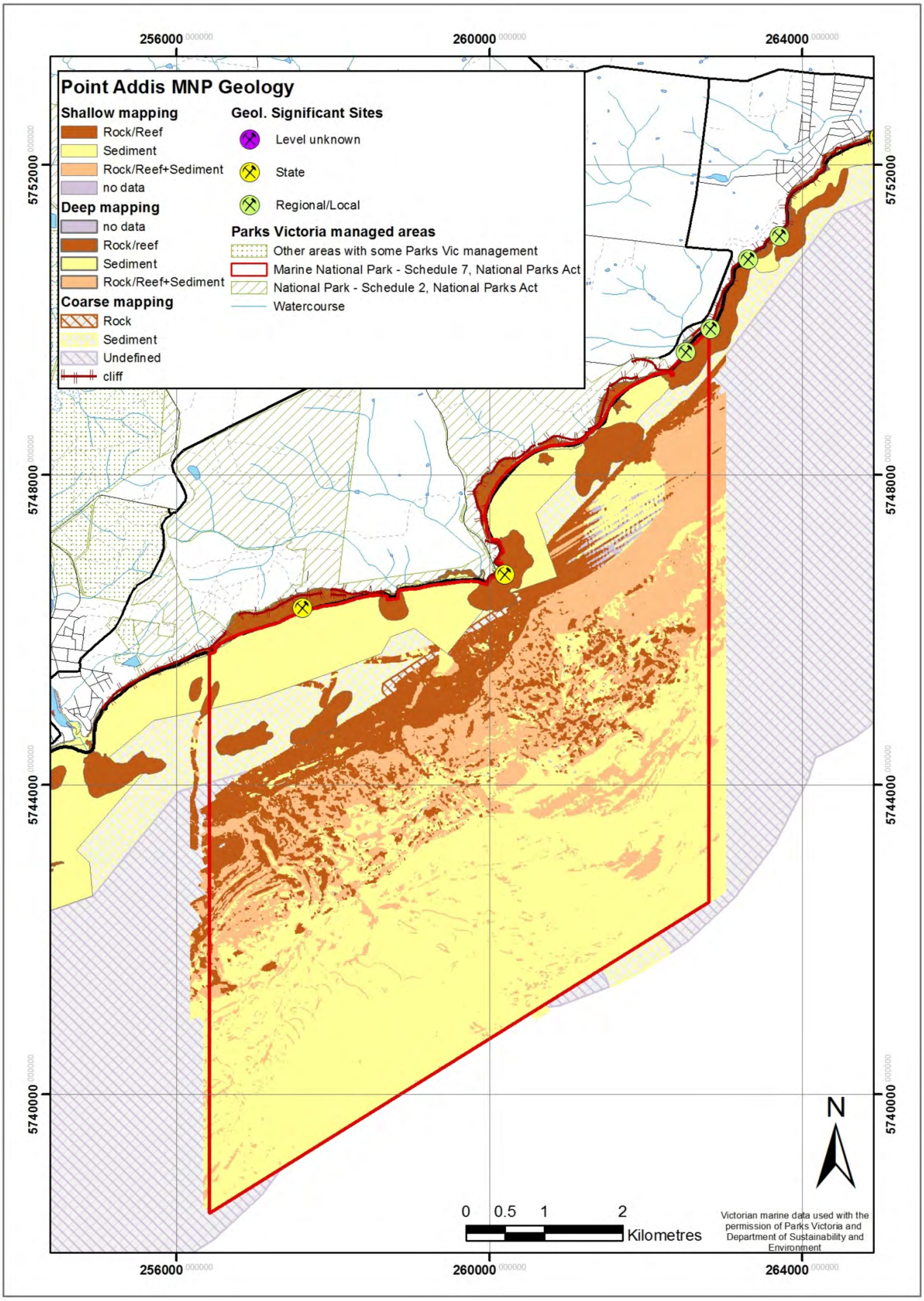
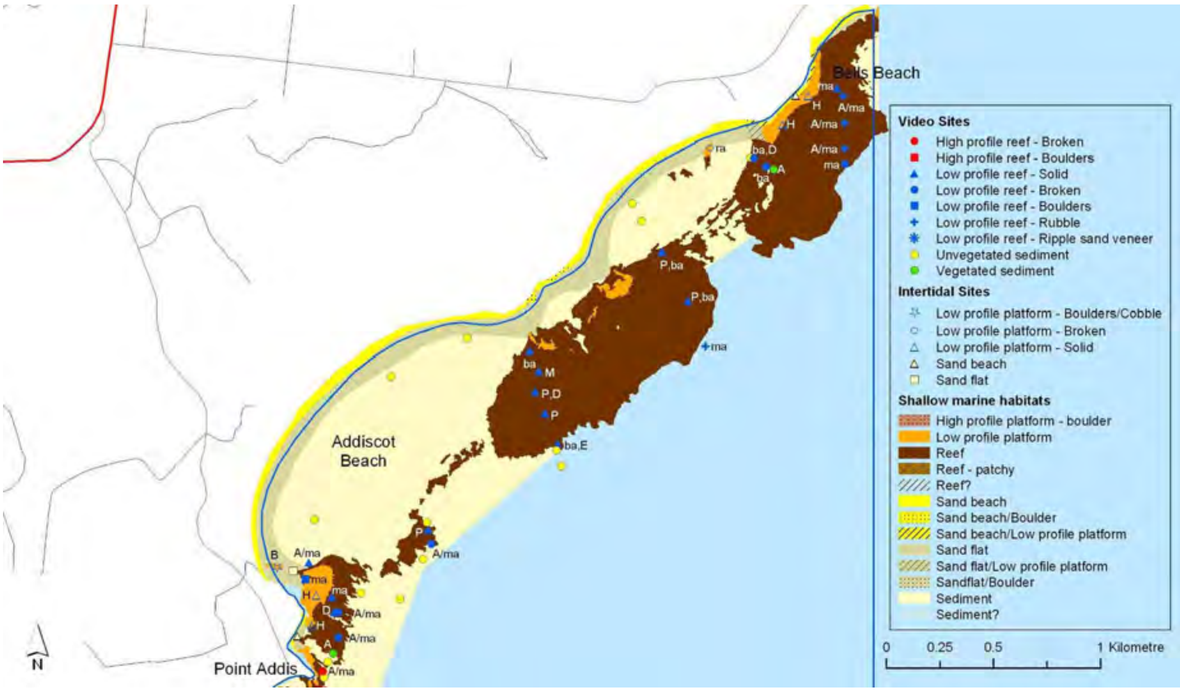
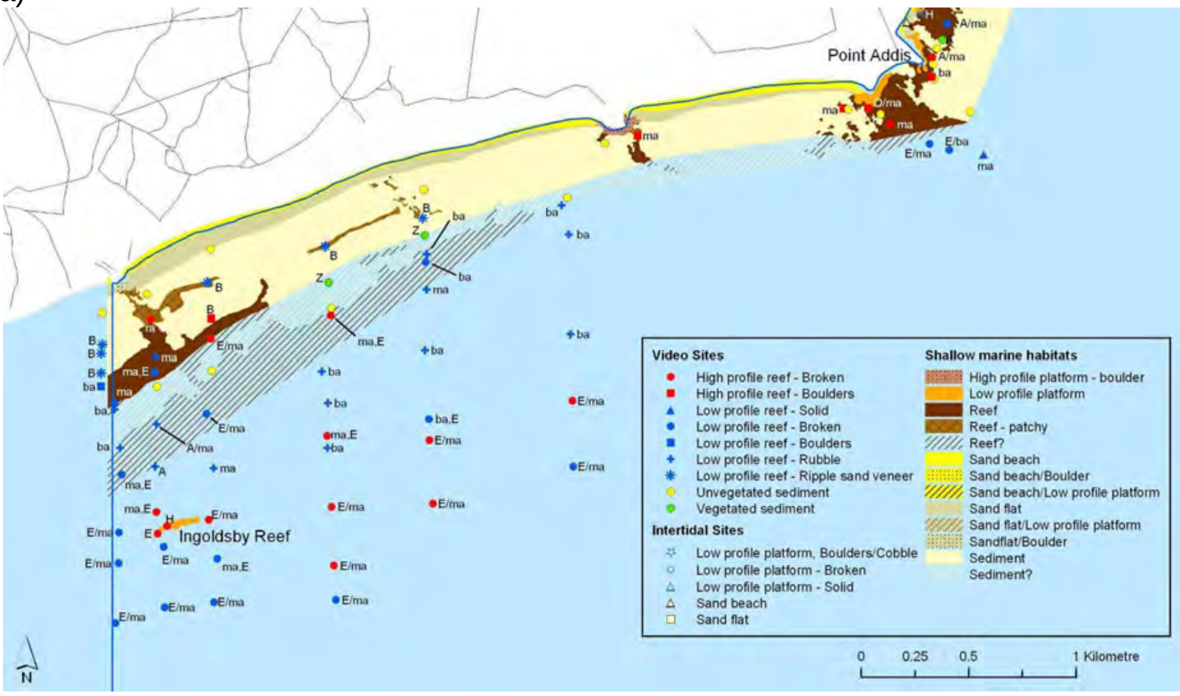


Figure 7. Substrate types and sites of geological significance in and near the Point Addis Marine National Park.



a)



b)

Figure 8. Detailed habitat mapping of the a) east and b) west shallow habitats of Point Addis Marine National Park from Ball and Blake (2007b). A = *Amphibolis antarctica,* B = bare substrate, ba = mixed brown algae, D = *Durvillaea potatorum,* E = *Ecklonia radiata,* H = *Hormosira banksii,* M = *Macrocystis pyrifera,* ma = mixed algae and P = *Phyllospora comosa.*

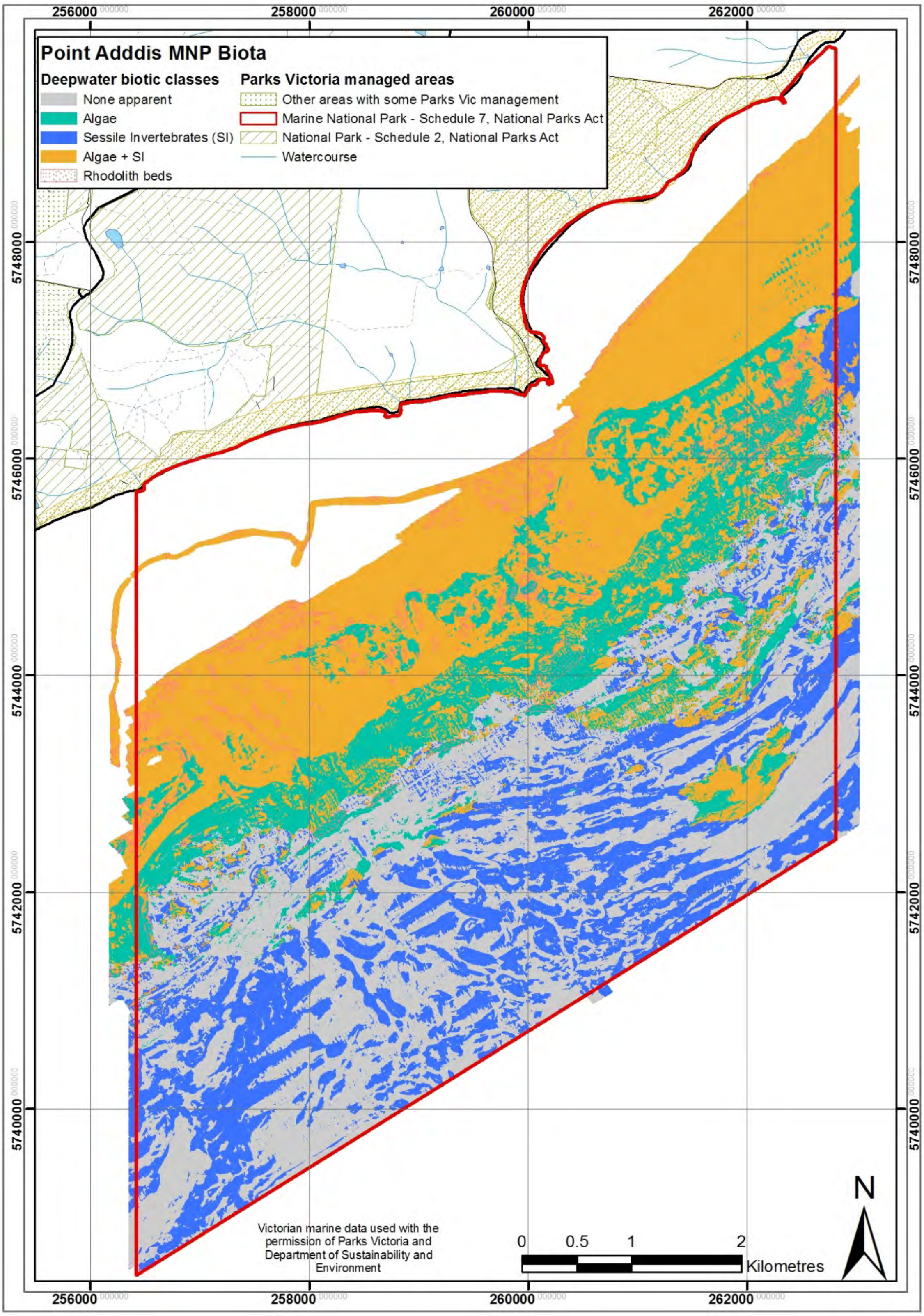


Figure 9. Biota mapped in and near the Point Addis Marine National Park. No significant biota sites were recorded in the extent of this map. Note the Rhodolith beds in amongst the algae and sessile invertebrates.

2.1.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) there have been several intertidal and subtidal reef monitoring and habitat mapping surveys conducted in the MNP (Ball and Blake 2007b; Crozier *et al.* 2007; Gilmour and Edmunds 2007; Holmes *et al.* 2007a; Stewart *et al.* 2007b; Holmes *et al.* 2008; Edmunds *et al.* 2010; Porter and Wescott 2010). Red algae dominate the diversity of macroalgae, gastropods the invertebrates and birds the vertebrates from recorded number of species in Point Addis MNP (Table 2, Appendix 1). No surveys exist for sandy beaches, the open water habitat, with little data on fish abundances, distributions or interactions except in shallow subtidal reef habitats.

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

Biotic group	Number of species
Macrophytes	**194**
Blue-green algae	1
Green algae	26
Brown algae	67
Red algae	98
Lichens	1
Seagrasses	1
Invertebrates	**69**
Cnidaria	6
Polychaetes	2
Barnacles	5
Decapod crustaceans	1
Chitons	3
Gastropods	46
Bivalves	5
Sea slugs	1
Vertebrates	**97**
Fish	33
Birds	54
Reptiles	2
Mammals	8

Intertidal

Soft sediment

Sandy beaches are important intertidal soft sediment habitat. Flora is restricted to macroalgae drift and macroalgal epiphytes (Figure 10). 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 10. Macroalgae on a beach in Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

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, water cover and wave exposure. Intertidal rocky reefs in the MNP are generally steep boulder-fields. There is great spatial and temporal variability in the life histories of the organisms and the environmental processes in intertidal 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. Some mobile species of animals, particularly chitons, brittlestars, opisthobranchs and gastropods are predominately found under boulders (Underwood and Chapman 2004). Space on which to live and food are often resources in short supply on intertidal reefs (Underwood and Chapman 2004). There is is an intertidal reef monitoring program in Point Addis MNP.

Figure 11. Intertidal reef platform dominated by the brown algae Neptune's necklace *Hormosira banksii* in Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

Macroalgae and Aggregating Sessile Invertebrates

The intertidal reefs in Point Addis MNP are mainly covered by foliose and filamentous algae (Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010; Porter and Wescott 2010). The predominant cover is the brown alga Neptune's necklace *Hormosira banksii,* which can cover up to 60 % of the intertidal platform (Stewart *et al.* 2007b; Porter and Wescott 2010; Figure 11). Several green algae also grow on the intertidal reef including *Ulva* spp and *Enteromorpha* spp (Gilmour and Edmunds 2007). Algal turf can be common with coverage of up to 12 % (Stewart *et al.* 2007b). There is a relatively high species richness of other seaweeds although in very low abundances (< 1 % cover; Stewart *et al.* 2007b). The epiphytic brown algae *Nothea anomala* can be found on *H. banksii* (Gilmour and Edmunds 2007).

The predominant species of aggregating sessile invertebrates is the tube worm *Galeolaria caespitosa* which formed small patches in the mid to high shore region (Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010). The mat forming mussels *Limnoperna pulex* and *Austromytilus rostratus* also grow on the reef (Gilmour and Edmunds 2007; Figure 12).

Mobile Invertebrates

Fourty-five species of invertebrates have been found on the intertidal reefs in Point Addis MNP, molluscs are by far the most diverse with 35 species (Costa *et al.* 2010; O'Hara *et al.* 2010; Figures 14 and 15). Grazers and deposit feeders are typical of reefs that have extensive areas of rubble, cobbles and boulders (Porter and Wescott 2010). The limpets *Siphonaria* spp, *Patelloida alticostata, Notoacmea mayi* and *Clypidina rugosa* (Figure 13), the periwinkles *Nodolittorina acutispira* and *N. unifasciata* and the conniwink *Bembicium nanum* are common at Point Addis MNP (Gilmour and Edmunds 2007, Stewart *et al.* 2007b, Edmunds *et al.* 2010). Gastropods common at other intertidal reefs in the Central bioregion, such as *Austrocochlea constricta* and *Cellana tramoserica,* are recorded at low densities at Point Addis MNP (Gilmour and Edmunds 2007). The beach slug *Onchidella patelloides*, which usually shelters during daylight, can be common across the shore (Gilmour and Edmunds 2007).

Fish

Intertidal fish communities have not been surveyed at Point Addis MNP.

Figure 12. Black mussels *Limnoperna pulex* on the intertidal reef in Point Addis Marine National Park.Photo by Jan Barton, Deakin University.

Figure 13. Limpets *Siphonaria diemenensis* and *Patelloida alticostata* and blue-green algae *Rivularia sp.* on an intertidal boulder in Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

Figure 14. The predatory cartrut welk *Dicathius orbita* in a rock pool in Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

Figure 15. Black nerite *Nerita atramentosa* on the intertidal reef in Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

Subtidal

Subtidally there have been over 90 algal, two seagrass, 35 invertebrate and 34 fish species recorded in Point Addis MNP (Beanland 1985; O'Hara 2000a; Ball and Blake 2007b; Crozier *et al.* 2007; Holmes *et al.* 2007a).

Soft sediment

Flora

In the western region of the park patches of very sparse seagrass *Heterozostera nigricaulis,* grow on shallow sandy sediment, beyond the surf zone, at a depth of approximately 8 m (Ball and Blake 2007b).

Some deep soft sediments have major rhodolith beds (Figures 16 and 17), which are hard, ball like structures formed by red coralline algae. These beds cover several square kilometres in depths ranging from 25 to 45 m (Figure 9), with the most extensive beds in 26 to 39 m depths (Holmes *et al.* 2007a; Holmes *et al.* 2008).

Invertebrate fauna

Over much of the deep soft sediment (Figure 7, Figure 9) there are sessile invertebrates such as ascidians, soft corals, sponges and gorgonians in low densities (Holmes *et al.* 2007a). Large dense clumps of sponges, hydroids, ascidians and bryozoans have been observed on coarse sand in 50 m depth (Parks Victoria 2003). These clumps of sessile invertebrates are approximately 0.5 m high and 2 m across, and provide habitat for fishes and other animals (Parks Victoria 2003).

Benthic infauna in the deep soft sediments includes polychaetes, molluscs, crustaceans, cnidarians, pycnogonids and echinoderms (Heislers and Parry 2007). Crustaceans dominate the taxa for all depths, representing more than half (*i.e.* 11 – 14) of the twenty most abundant families (Heislers and Parry 2007). The majority of crustaceans were amphipods and cumaceans, while isopods and ostracods were also common. Polychaetes represented the bulk (*i.e.* 5 – 9) of the remaining families while molluscs were poorly represented (*i.e.* 0 - 1 families). Nine families are common in all depth classes, including four amphipod families (Phoxocephalidae, Caprellidae, Urohaustoriidae and Ampeliscidae), three polychaete families (Spionidae, Syllidae and Paraonidae) and two cumacean families (Gynodiastylidae and Diastylidae) (Heislers and Parry 2007). Proboscis worms (Nemertea) are common to all depth classes. The total number of species per site increases with depth with more species at 20 m than at 10 m (Heislers and Parry 2007).

Fish

No surveys have been conducted of deep soft sediment fish fauna. Video surveys have shown Ling (possibly *Genypterus tigerinus*) at a depth of 49 m on a coarse sand flat bottom in a clump of sessile invertebrates composed of sponges, with some hydroid, ascidians and bryozoans (Plummer *et al.* 2003).

Figure 16. Rhodolith bed on deep soft sediments in Point Addis Marine National Park

Figure 17. Rhodoliths in Point Addis Marine National Park.

Reef

Subtidal reefs 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. 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

The low profile shallow reef in 7 – 13 m depth west of Point Addis is generally dominated by mixed algae and the kelp *Ecklonia radiata* (Ball and Blake 2007b; Figure 18). The reef close to shore off Point Addis is dominated by the bull kelp *Durvillaea potatorum* (Ball and Blake 2007b). Further offshore in deeper waters the reef is dominated by mixed algae and *E. radiata*. Towards Addiscot Beach, the inshore reef is dominated by *D. potatorum* and mixed algae. Towards the centre of the bay at depths of 5 – 7 m crayweed *Phyllospora comosa* dominates the solid reef areas. East of Addiscot Beach in 2 m to 15 m depth the low profile reef was dominated by mixed brown algae, with giant kelp *Macrocystis pyrifera*, *P. comosa*, *D. potatorum* and *E. radiata* all present (Ball and Blake 2007b).

Figure 18. A typical shallow reef in Point Addis Marine National Park dominated by various brown algae species.

The canopy of the subtidal reef sites at Ingoldsby and The Olives are dominated by kelp *E. radiata* and/or *Seirococcus axillaris* and *Acrocarpia paniculata* (Crozier *et al.* 2007). There is relatively low cover of other brown algal species, which included *Cystophora retroflexa* and *Sargassum* species. Understorey species include up to seven species of the green *Caulerpa* spp. (Crozier *et al.* 2007). Understorey species also include the red coralline alga *Haliptilon roseum* and smaller fleshy red algae *Ballia callitricha*, *Areschougia congesta* and *Plocamium* spp (Crozier *et al.* 2007). One study of Ingoldsby Reef found 114 species of algae (Beanland 1985).

Monospecific beds of the seagrass *Amphibolis antarctica* (Figure 19) grow in 11.5 m in areas of rubble reef in the west of the park and in 5-7 m on broken reef in the bay off Addiscot Beach (Ball and Blake 2007b). Mixed *A. antarctica* and algae dominate the offshore reef east of Point Addis towards Addiscot Beach and around Bells Beach. O'Hara (2000a) observed large brown, green and red algae interspersed amongst the *A. antarctica*, including *Cystophora, Sargassum* and *Caulerpa* species. The seagrass also supported over 10 algal epiphytes, including *Dictyopteris muelleri*, *Mychodea hamata*, other red algae and corallines (O'Hara 2000a). Holmes *et al.* (2007a, 2008) found the deep reef within 2.5 km of the coast was dominated by common kelp *E. radiata* (Figure 9).

Figure 19. Seagrass *Amphibolis antarctica* growing in a rock pool in Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

Invertebrate fauna

The invertebrate community of the subtidal reefs at Ingoldsby and The Olives largely consists of blacklip abalone *Haliotis rubra*, warrener *Turbo undulatus* and a variety of sea stars (Crozier *et al.* 2007). Point Addis MNP has a relatively diverse assemblage of echinoderms including *Nectria macrobrachia*, *N. multispina*, *Nepanthia troughtoni* and *Holopneustes porosissimus,* with *N. macrobrachia* the most common (Crozier *et al.* 2007). The invertebrate species richness and diversity is higher at Point Addis than Eagle Rock and the Marengo Reef MS (Crozier *et al.* 2007; Figure 21).

The overhangs at Ingoldsby Reef are dominated by ascidians, gorgonians, hydroids and sponges whilst eroded, low profile reefs support a diverse range of sponges (Figures 2, 24 and 25), with some bryozoans, colonial ascidians, green lipped *Haliotis laevigata* and black lipped *H. rubra* abalone and rock lobster *Jasus edwardsii*.

O'Hara (2000a) found *A. antarctica* stems and fronds support sessile invertebrates, including large colonies of *Amathia woodsii* (bryozoan), *Stereotheca elongata*, and *Amphisbetia minima* (hydroids). The bryozoan *Electra flagellum*, which is obligate on *A. antarctica* stems, is common, while *Electra pilosa* was present on the tips of *Cystophora* fronds. Sponges and ascidians are not common. The mobile epiphytic invertebrates are numerically dominated by micro-molluscs, including *Stenochiton cymodocealis* and *Asteracmea stowae* which are restricted to *A. antarctica* seagrass. There are four species of pycnogonids (sea spiders). The *A. antarctica* seagrass beds have relatively few species of polychaetes, echinoderms or crustaceans. Small majid (decorator) crabs are common amongst the bryozoans.

In deeper areas, the reef was dominated by sessile invertebrates, particularly sponges (Figure 5; Holmes *et al.* 2007a).

Figure 20. Sponges on deep subtidal reef Point Addis Marine National Park.

Fish

Fish species richness on Ingoldsby and The Olives subtidal reefs varied from between seven and 19 species (Crozier *et al.* 2007; Figure 23). The common fish species includes blue-throated wrasse *Notolabrus tetricus*, purple wrasse *N. fucicola,* sea sweep *Scorpis aequipinnis* yellow tailed leatherjacket *Meuschenia flavolineata* and horseshoe leatherjacket

M. hippocrepis (Crozier *et al.* 2007). Herring cale *Odax cyanomelas* is present in low abundance (Crozier *et al.* 2007). Ingoldsby Reef has high fish species diversity (Crozier *et al.* 2007). Schools of short-finned pike *Sphyraena novaehollandiae* were observed during benthic mapping (Ball and Blake 2007b). As reported in Plummer *et al.* (2003) many other species pass through the park, including yellowtail kingfish *Seriola lalandi* and species of salmon.

No surveys have been conducted of deep reef fish fauna.

Figure 21. Cuttlefish in Point Addis Marine National Park.

Water column

The water column as a whole is the largest habitat in the MNP and 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, mammals and reptiles of conservation significance are found in the waters of Point Addis MNP (Figure 22).

Figure 22. Point Addis Marine National Park. Photo by Jan Barton, Deakin University.

2.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is also 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 Point Addis MNP (Parks Victoria 2005).

Fish

No conservation listed fish have been recorded in the Point Addis MNP.

Birds

Twenty-six conservation listed shore and sea birds have been sighted in or in the immediate surrounds of Point Addis MNP (Table 3). Ten birds are recognized as threatened in Victoria, listed under the *Flora and Fauna Guarantee (FFG) Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Seven birds are listed as threatened at both the state and national level and one at the national level *EPBC Act 1999*. Eleven birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). An area of state significant shorebird habitat is present along the shore at this Marine National Park, running from Anglesea River to Bones Road, Winki Pop (Figure 9).

Marine mammals and reptiles

The blue whale *Balaenoptera musculus* and the southern right whale *Eubalaena australis,* have been recorded in or near the Point Addis MNP (Table 4). Both are listed as critically endangered in Victorian waters and endangered nationally. Both are listed under the Bonn convention as migratory species and have been observed to pass through the park, are not known to feed or calve in the park. Killer whale *Orcinus orca*, also a Bonn convention listed migratory species has also been reported in the MNP. There has been one recorded sighting of the endangered warm water vagrant sea turtle the pacific or olive ridley *Lepidochelys olivacea* (*EPBC Act 1999*) in or near the Point Addis MNP. The long-finned pilot whale *Globicephala melas*, bottlenose dolphin *Tursiops spp.*, Australian fur seal *Arctocephalus pusillus doriferus* and leopard seal *Hydrurga leptonyx* have been observed in the waters in and around the MNP.

Table 3. Conservation listed shorebird and seabird records from Point Addis Marine National Park and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
fairy tern	*Sternula nereis*	L	EN			
little egret	*Egretta garzetta*	L	EN			
caspian tern	*Hydroprogne caspia*	L	NT		C	J
hooded plover	*Thinornis rubricollis*	L	VU			
royal spoonbill	*Platalea regia*		VU			
white-faced storm-petrel	*Pelagodroma marina*		VU			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
pacific gull	*Larus pacificus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
pectoral sandpiper	*Calidris melanotos*		NT			J
southern giant-petrel	*Macronectes giganteus*	L	VU	EN		
wandering albatross	*Diomedea exulans*	L	EN	VU		J
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		
sooty albatross	*Phoebetria fusca*	L		VU		
blue petrel	*Halobaena caerulea*			VU		
common tern	*Sterna hirundo*				C	J
pomarine jaeger	*Stercorarius pomarinus*				C	J
red-necked stint	*Calidris ruficollis*				C	J
ruddy turnstone	*Arenaria interpres*				C	J
sharp-tailed sandpiper	*Calidris acuminata*				C	J
arctic jaeger	*Stercorarius parasiticus*					J
short-tailed shearwater	*Ardenna tenuirostris*					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

Table 4. Conservation listed marine mammal records from Point Addis Marine National Park and surrounds.

		Victorian listing		National listing	International convention
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**Bonn**
blue whale	*Balaenoptera musculus*	L	CR	EN	L
southern right whale	*Eubalaena australis*	L	CR	EN	L
killer whale	*Orcinus orca*			L	L
Australian fur seals	*Arctocephalus pusillus doriferus*			L	

L = listed, EN = endangered, CR = critically endangered

Species at distributional limit

Two red algae are thought to be near their distributional limits in Point Addis MNP (Table 5). Porter and Wescott (2010) found thirteen regionally uncommon taxa on the intertidal reef of Point Addis

Table 5. Biota with distributional limits located at or near the Point Addis Marine National Park (O'Hara and Barmby 2000; O'Hara 2002a).

Order	Family	Species	Common name	Category
Rhodymeniales	Rhodymeniaceae	*Rhodymenia verrucosa*	red algae	PE
Rhodymeniales	Rhodymeniaceae	*Webervanbossea splachnoides*	red algae	PW

PW = presumed to be at or near western limit, PE = presumed to be at or near eastern limit

Table 6. Regionally uncommon species for the Surf Coast region found on the rocky shores of Point Addis Marine National Park (Porter and Wescott 2010).

Invertebrates		Algae	
General name	**Scientific name**	**General name**	**Scientific name**
chiton	*Ischnochiton veriegatus*	green algae	*Caulerpa cactoides*
chiton	*Ischnochiton versicolor*	green algae	*Cladostephus spongiosis*
crustacea	*Halicarcinus*	green algae	*Codium pomoides*
crustacea	*Tesseropora rosea*	brown algae	*Colpomenia sinuosa*
echinoderm	*Holopneustes* sp	brown algae	*Cystophora grevillei*
echinoderm	*Tosia australis*	brown algae	*Splancidium rugosum*
gastropod	*Clanculus* sp		
gastropod	*Haliotis* sp		

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 MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 years, were considered and ranked. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Sixteen hazards, with the potential to be extreme were identified in Point Addis MNP (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. Lack of ecological knowledge about hydrology, habitats, population dynamics including recruitment, geomorphology and sand movement, and fisheries management leading to less effective management of communities and habitats (all park)
2. New and emerging marine pests, including pathogens, displacing local species and causing ecological change (potentially all park)
3. Illegal harvesting (organised poaching) of abalone and other molluscs (particularly those considered a delicacy in some cultures) leading to decreased population viability and flow-on effects to other organisms (shallow subtidal reefs)
4. Increased nutrients and heavy metals from sewage outfall causing any loss of seagrass or reef (biota) (Anglesea outfall to west of park)
5. Trampling and disturbance to intertidal platforms causing greater than natural variability in communities and change in species assemblages *e.g.* composition and cover (intertidal reef)
6. Increased shore-based development leading to increases in small boating activity which may cause physical damage to habitats and communities greater than that caused naturally (shallow subtidal soft sediment and reef).
7. Man-made discharges of freshwater/stormwater (freshwater component only) from outfalls and estuaries (the latter due to increased mechanical opening) leading to changes in subtidal communities greater than natural variation (shallow subtidal soft sediment and reef on the western and eastern borders of the MNP)
8. Increased shore-based development leading to increased cost of management and consequent effects on park communities and habitats (all park).
9. Plastic and other litter from sea or land leading to injury or death of resident or transient organisms and thus reduced community viability (all park)
10. Moderate (*i.e.* not major spill from ship) oil pollution from sea, either deliberate or accidental, having sublethal effects on biota in more than 5% of a park (intertidal soft sediment and reef, shore and sea birds, marine mammals and reptiles)
11. Dogs, horses and vehicles reducing viability of populations of birds and seals (intertidal soft sediment and reef)
12. Physical damage, pollution or cleanup impacts of a ship accidents sufficient to invoke an AMSA response (intertidal soft sediment and reef, shore and sea birds, marine mammals and reptiles)

Porter and Wescott (2010) conducted research on the values, uses and impacts on intertidal reefs in the Surf Coast Shire, including Point Addis MNP. Point Addis intertidal reef had the lowest use of the surveyed reefs. Use was high where intertidal reefs were used to access surf breaks and highest during holiday periods. Collecting of intertidal biota was observed for all shores within the study area including MPAs, and spearfishing was observed at Point Addis intertidal reef. The gastropod species at risk from collecting pressure, *Turbo undulatus, Austrocochlea constricta,* and *Dicathais orbita,* had a smaller mean size on high use shores. Foot traffic, through trampling, is impacting on plant cover, and hence community structure, of high use shores on the Surf Coast.

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 although it is thought that the introduced green shore crab *Carcinus maenas* is probably within the MNP. To the east, within Central Victoria 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). 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). Japanese kelp *Undaria pinnatifida* has been recently found in Apollo Bay and there are grave concerns about its spread. 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 near Cape Otway, approximately 72 km to the west (DPI 2009). It is not in the Point Addis MNP but its spread into the park 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, 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). Two species of algae are at the eastern or western limit of their distributional range at Point Addis MNP and such species would be particularly vulnerable to climate change.

The outputs from the workshops have informed Parks Victoria in their management planning process and prioritization of research gaps (Parks Victoria 2005). Measures to address or minimise these threats form part of the management plan for Point Addis MNP (Parks Victoria 2006b). For example research has targeted marine pest species, water quality issues and intertidal reef use which may impact on 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.

Figure 23. Six-spined leatherjacket *Meuschenia freycineti* in Point Addis Marine National Park.

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 Point Addis 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 7 and Appendix 2).

Point Addis MNP has an ongoing intertidal reef monitoring program (IRMP). The IRMP in and around the Point Addis MS began in 2004 with the explicit aim to track changes in invertebrates and macro-algae abundances due to human use, trampling and fossicking, of the platforms (Power and Boxshall 2007). A site in the MNP and reference site outside of the MNP (Figure 4) have been surveyed over four census events (Edmunds *et al.* 2004; Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010). The monitoring involves surveying a single reef during a single low tide, targeting the predominant substratum type at each intertidal reef (Hart and Edmunds 2005). The survey is conducted along transects running from the high to the low shore. The density of non-sessile invertebrates and the percentage cover of macroalgae and aggregated sessile invertebrates are surveyed within quadrats along the transects (Hart and Edmunds 2005).

Keough and Carnell's (2009) preliminary analysis of the IRMP data from two census events up to 2006 was done at the Central Victoria bioregion level, including Mushroom Reef, Point

Danger and Barwon Bluff MSs and, Point Addis MNP. The analysis compared sites within MPAs to reference sites outside the MPAs post declaration. They found there was no significant difference in species richness and number of species between MPA and reference sites (Keough and Carnell 2009). Limitations of Keough and Carnell's (2009) analysis include no pre-declaration sampling, the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). A targeted analysis of IRMP monitoring data in relation to conservation outcomes for the park and review of the monitoring design will be done by 2013.

The shallow subtidal reef monitoring program (SRMP; Edmunds and Hart 2003) in and around the Point Addis MNP began in 2003. Since that time two shallow offshore reefs, Ingoldsby and The Olive, in the MNP and two reference sites, Anglesea and Phyco's reef, outside of the MNP (Figure 4) have been surveyed over three census events (Hart *et al.* 2004; Hart *et al.* 2005a; Crozier *et al.* 2007). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth < 10 m (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water.

Table 7. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Point Addis Marine National Park.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising 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. ***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: 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 Intertidal Reef Monitoring Program ***Community Based Monitoring*** ReefWatch - Great Victorian Fish Count

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

Keough and Carnell's (2009) preliminary analysis of the SRMP data from the two census events up to 2006 was done at the Central Victoria bioregion level, including Point Addis MNP, Eagle Rock and Marengo Reefs MS. The analysis compared sites within MPAs to reference sites outside the MPAs. They found there was no significant difference in species richness and number of species between MPA and reference sites for the Central Victoria bioregion (Keough and Carnell 2009). The abundances of algae inside and outside the various MPAs showed a complex set of results. *Haliptilon roseum* displayed greater percentage cover overall at the MPA sites, which seemed primarily driven by greater abundances at Eagle Rock and Marengo MS. *Halopteris* spp. displayed a greater percentage cover in MPA sites at both Eagle Rock and Point Addis, but the opposite pattern at Marengo. Algal species *Acrocarpia paniculata*, *Ballia callitricha*, *Ecklonia radiate*, *Gelidium asperum*, *Phacelocarpus peperocarpus*, *Plocamium angustum P. dilatatum* and *Rhodymenia australis* all tended to show a pattern of significantly greater abundance at the reference sites compared to the Eagle Rock and Marengo MS sites but not for Point Addis MNP. A similar pattern occurs for herring cale *Odax cyanomelas* and the predatory dogwelk *Dicathais orbita.* Blacklip abalone *Haliotis rubra* and warrener *Turbo undulatus* showed no statistical effect of the MPAs, but displayed greater mean abundances at Eagle Rock MS and Point Addis MNP (Keough and Carnell 2009).

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 MNP area against future threats to biodiversity and natural processes.

Figure 24. A sponge garden on deep subtidal reef in Point Addis Marine National Park.

A targeted analysis of SRMP monitoring data 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 (Keough *et al.* 2007; Power and

Boxshall 2007; Keough and Carnell 2009). Point Addis SRMP will now be monitored on a five year cycle with two consecutive annual surveys (Power and Boxshall 2007).

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

There is little quantitative information on the ecological communities for many habitats. For example, little is known about the intertidal soft sediment communities, or fish in intertidal reefs, subtidal soft sediment and deep subtidal reefs. By volume the majority of Point Addis MNP is contained in pelagic habitat of which nothing is known. While species diversity is an important indicator of community richness and health, only intertidal and shallow subtidal reefs have relatively comprehensive species lists. Major threats have been identified for Point Addis MNP but we have limited knowledge of the effect on natural values, particularly ecological communities.

Figure 25. Sessile invertebrates on deep subtial reef in Point Addis Marine National Park.

2.2 Bunurong Marine National Park

Bunurong MNP is located six kilometres south-west of Inverloch in South Gippsland. It extends from the high water mark to three nautical miles (~ 5 km) offshore, along 6 km of coastline east of Cape Patterson to just east of Eagles Nest (Figures 26 - 29). It is contained within the continental shelf and is 2046 hectares in size which makes it the tenth largest of the 24 Marine National Parks or Sanctuaries in Victoria (Figure 28). It abuts the Bunurong Coastal Reserve along its full length and on either side of it is the Bunurong Marine Park. Access points to the MNP are The Oaks, Twin Reefs, Shack Bay and Eagles Nest (Figure 28).

Aboriginal tradition indicates that the Bunurong MNP is part of the *Country* of the Boon Wurrung people, who are traditionally and culturally associated with the planning area (Parks Victoria 2006a). Several groups assert traditional ownership of the area (Parks Victoria 2006a).

The marine life in the Bunurong MNP is regarded as special, due to the unusual set of environmental conditions that occur in the MNP (O'Hara 2002b). Important natural values include the extensive intertidal sandstone rock platforms and shallow subtidal rocky reefs which extend several kilometres from shore (Carey *et al.* 2007b). This is different to much of the Victorian coastline, which is either characterised by a very narrow strip of rocky reef or flanked by offshore reefs composed of boulders, cobbles or low limestone ridges (O'Hara 2002b). Bunurong MNP rocky reefs have a diverse brown algal assemblage (Edmunds *et al.* 2003). The algal asemblages that occupy the shallow subtidal reefs are rich in species, particularly species of red and brown algae (O'Hara 2002b; Parks Victoria 2006a; Stewart *et al.* 2007a). They also have the highest diversity of intertidal and shallow subtidal invertebrate fauna for eastern Victoria (Carey *et al.* 2007b). Common invertebrate fauna are the blacklip abalone *Halitiotis rubra*, the warrener *Turbo undulatus* and a variety of seastars (Edmunds *et al.* 2003). The common fish assemblages include blue-throated wrasse *Notolabrus tetricus*, purple wrasse *Notolabrus fucicola*, senator wrasse *Pictilabrus laticlavius* and sea sweep *Scorpis aequipinnis* (Edmunds *et al.* 2003). The habitat forming beds of seagrass *Amphibolis antarctica* on rocky reefs are another important natural value. The presence of marine mammals such as humpback whales *Megaptera novaeangliae*, southern right whales *Eubalaena australis* and the subantartic fur seals *Arctocephalis troplicalis* are also considered important due to their threatened status under the commonwealth *Environment Protection Biodiversity Conservation (EPBC) Act 1999*, and whales are also listed as threatened under the *Flora and Fauna Guarantee (FFG) Act 1988.*

In addition, a number of marine flora and fauna species have only been recorded from the Bunurong area, or reach their eastern distributional limits within the park, and are regarded as important natural values in the Bunurong MNP Management Plan (Parks Victoria 2006a). The sponge, stalked ascidians and bryozoan communities on the deep subtidal reefs have also been identified as important natural values for the Bunurong MNP (LCC 1996; Parks Victoria 2003).

Coastal areas such as the Bunurong MNP are subject to many external influences and potential threats. Invasive marine pests, disturbance of shorebirds, inadequate resources, trampling, reduced water quality, illegal fishing and climate change all pose serious threats to the integrity of Bunurong MNP (Carey *et al.* 2007b) Measures to address or minimise these threats form part of the management plan for Bunurong MNP (Parks Victoria 2006a).

Figure 26. Shack Bay looking across to Eagles Nest in Bunurong Marine National Park. Photo by Jan Barton, Deakin University.

2.2.1 PHYSICAL PARAMETERS & PROCESSES

Bunurong MNP's shoreline geology is sandstone and mudstone (Bird 1993; Figure 27). It has a gently sloping bathymetry with the intertidal and subtidal rock platforms extending out to sea as a sloping rocky plain (Leach *et al.* 2002; O'Hara 2002b; Stewart *et al.* 2007a). The MNP has a maximum depth of 56 m (data from Leach *et al.* 2002; Figure 28, Figure 29). Unlike most of Victoria's adjoining coast, the Bunurong MNP coast is protected from the storm waves of the Southern Ocean (O'Hara 2002b). The tidal and wave currents are relatively small along the coast (ASR 2008).

No major estuaries run directly into the park, with one small intermittent stream discharging within the park boundaries (Figure 28, Figure 29, Table 8). Substantial springs and seepage of water occur at the base of the cliffs along the whole of the Bunurong coast (Stewart *et al.* 2007a). The discharge from the Powlett River and Western Port Bay, west of Cape Paterson, and Anderson Inlet, east of the Bunurong coast can influence the water quality in the park (Stewart *et al.* 2007a). Freshwater inputs to the Bunurong region generally cause reduced visibility conditions through particulates, colouration or triggering plankton blooms through nutrient influx (Stewart *et al.* 2007a). The catchment of Bunurong MNP is predominately agricultural with some urbanization.

Table 8. Physical attributes of the Bunurong Marine National Park.

Park Name	Bunurong
Conservation status	Marine National Park
Biophysical Region	Central Victoria
Size	2050 ha (ranked 10th of 24)
Length of coastline	~5.72 km
Shoreline geology	Sandstone/mudstone
Area with depth:	
Less than 10m	116 ha
Comprising: <5 m (high res)	*(48 ha)*
5-10 m (high res)	*(65 ha)*
*0 - 10 m (low res)**	*(3 ha)*
10-20 m	255 ha
20-30 m	417 ha
30-40 m	346 ha
40-50 m	589 ha
50-60m	325 ha
Mean tidal variation - spring	2.1 m
Mean tidal variation - neap	1.3 m
Mean water temp - summer	17.5°C
Mean water temp - winter	13°C
Adjacent catchment	Agricultural and urban
Discharges into MNP	1 small intermittent stream, springs & seeps from base of cliffs
Nearest major estuary (distance & direction)	Western Port 28km west Powlett River 2.2km west Anderson Inlet 3.8km east

Figure 27. Intertidal reef at Twin Reef, Bunurong Marine National Park. Photo by Jan Barton, Deakin University

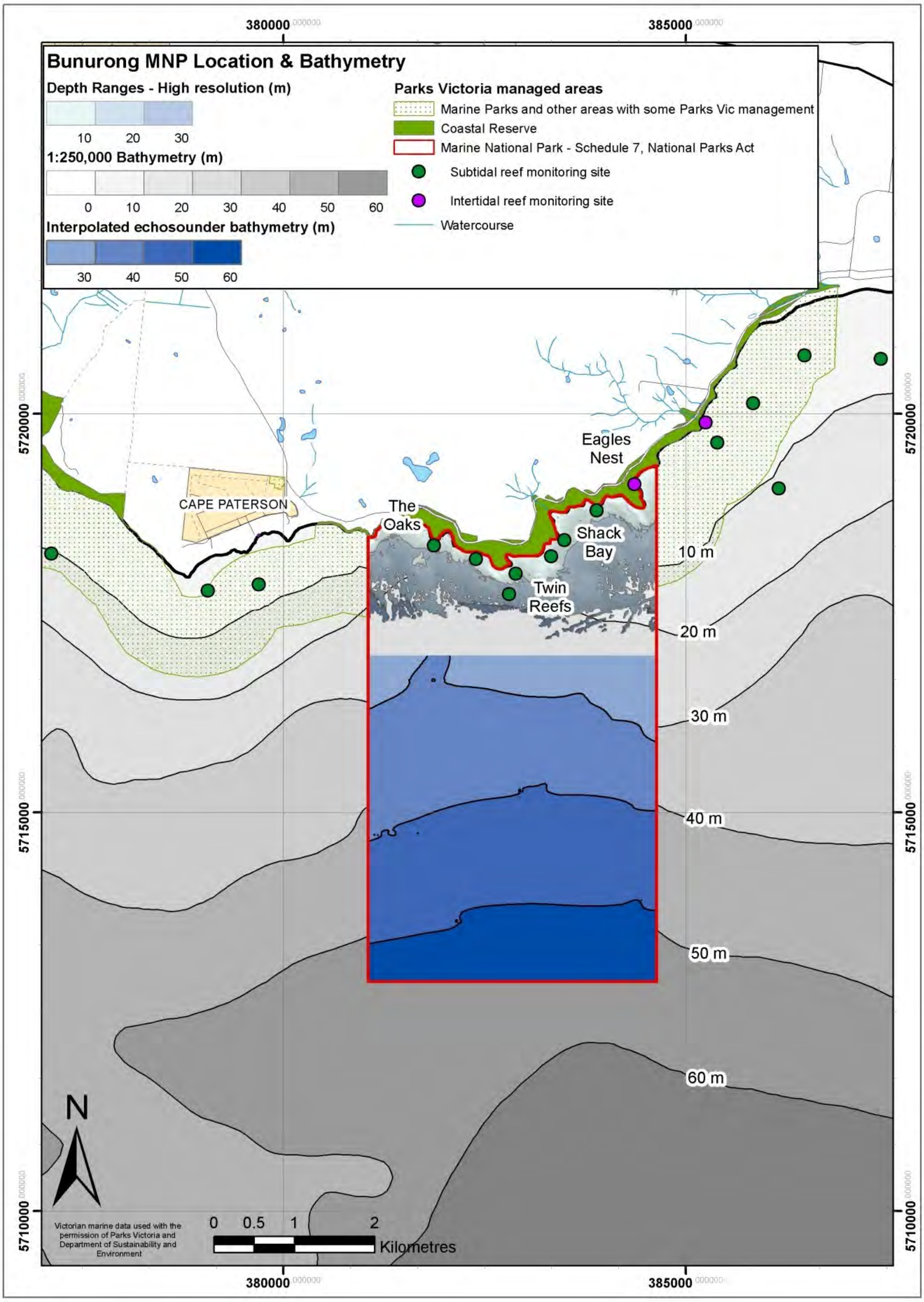


Figure 28. Location map of Bunurong Marine National Park with high resolution and 1:250,000 bathymetry. Intertidal and subtidal reef monitoring sites inside and outside the MNP are shown.

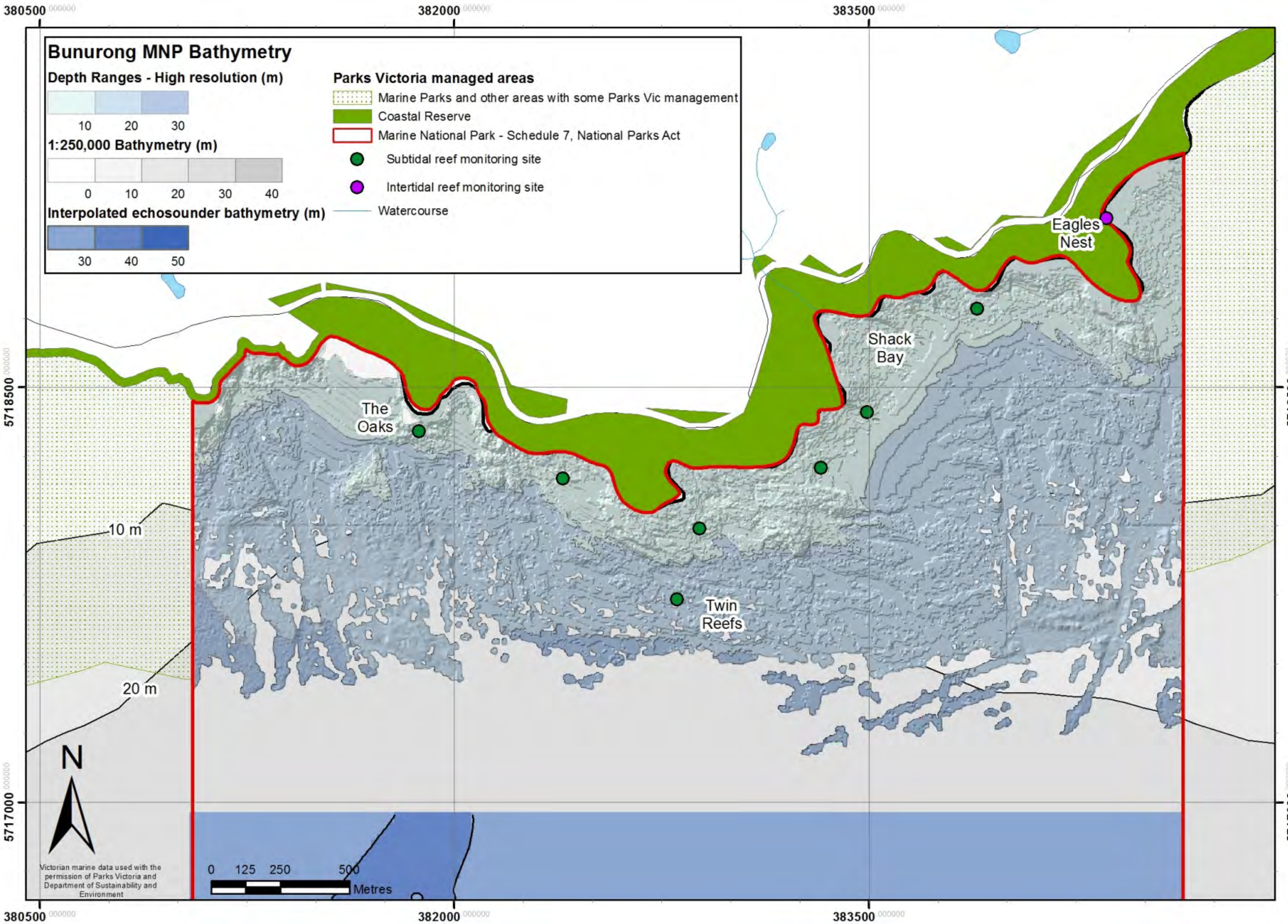


Figure 29. Detail of the near shore high resolution and 1:250,000 bathymetry in Bunurong Marine National Park. Intertidal and subtidal reef monitoring sites inside the MNP are shown.

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 target management activities, including emergency response, monitoring and research effectively. 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 Bunurong MNP include some intertidal soft sediment and extensive intertidal reef (Figure 30), subtidal soft sediment and reef, and open ocean. The distribution of habitats in Bunurong MNP was mapped and reported in a report edited by Ferns and Hough (2002). The intertidal and shallow subtidal areas were mapped from satellite and aerial photo by Ferns *et al.* (2002). Deep subtidal substrate was mapped hydroacoustically by (Leach *et al.* 2002) with substrate mapping confirmed with video transects by Roob and Ferns (2002).

Much of the inshore reef is flat with a lot of mobile sand patches in between (slightly) higher sections (Edmunds *et al.* 2003). There is a variety of exposed and sheltered habitats and exposure decreases from west to east (Edmunds *et al.* 2003). In the shallow subtidal region the seafloor of the Bunurong coast slopes gradually seaward (Leach *et al.* 2002). Locally prominent topographic features such as ridges are evident and form seaward extensions off Eagles Nest (Leach *et al.* 2002). Beds of the seagrass *Amphibolis antarctica* occur in Shacks Bay and Eagle Rock (O'Hara 2000a).

In the deep subtidal (> 10 m) low profile reef covered with sheets of sand dominate the waters at 15 - 20 m depth (Roob and Ferns 2002). This low profile reef then grades to high profile reef at approximately 20 m which eventually grades back to low profile reef at approximately 30 - 35 m (Figure 31). The high-profile reef has ledges, some extending for many tens of metres, and deep gullies that are often filled with sand (Leach *et al.* 2002). In deeper water (> 35 m), low profile reef eventually grades or breaks up into mosaic patches of large cobbles, pebbles, granules and sand. Throughout the deeper waters, varying mixtures of cobbles, pebbles, granules and sand predominate. In the south-central section of the survey area, large beds dominated by fine to medium sand occur. These sandy beds lack significant quantities of cobbles, pebbles or granules (Leach *et al.* 2002; Roob and Ferns 2002).

Figure 30. The limpet *Cellana tramoserica* on intertidal reef at Bunurong Marine National Park. Photo by AME.

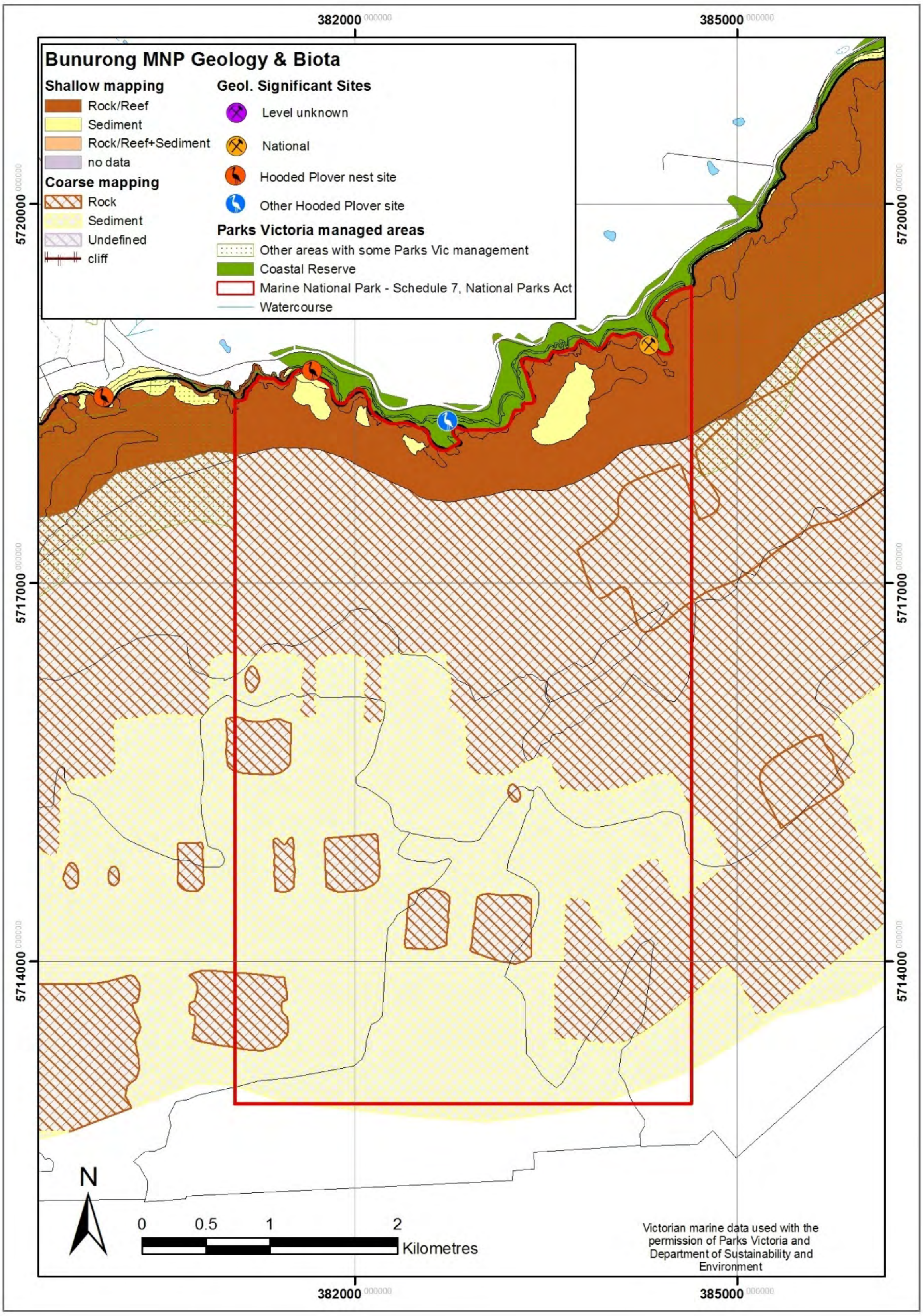


Figure 31. Substrate mapping of Bunurong Marine National Park showing sites of geological and biological significance.

2.2.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) there have been several intertidal and subtidal reef monitoring and habitat mapping surveys conducted in the Bunurong MNP (Hart and Edmunds 2005; Gilmour and Edmunds 2007; Stewart *et al.* 2007a; Stewart *et al.* 2007b). Brown and red algae dominate the diversity of macrophytes, gastropods the invertebrates and fish and birds the vertebrate species recorded in Bunurong MNP (Table 9, Appendix 1). No new surveys exist for the ecological communities of sandy beaches, intertidal soft sediments, with little new data on fish abundances, distributions or interactions except in shallow subtidal reef habitats. No information exists at present for water column assemblages.

Table 9. Summary of the number of species in major biotic groups from surveys in Bunurong Marine National Park.

Biotic group	Number of species
Macrophytes	**166**
Blue-green algae	4
Green algae	33
Brown algae	73
Red algae	85
Seagrasses	3
Invertebrates	**114**
Cnidaria	6
Polychaetes	3
Barnacles	7
Decapod crustaceans	8
Chitons	7
Gastropods	64
Bivalves	5
Cephalopods	1
Echinoderms	13
Vertebrates	**103**
Ascidian	1
Fish	51
Birds	44
Mammals	7

Intertidal

Soft sediment

Flora is restricted to macroalgae drift and macroalgal epiphytes (Figure 32). 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. Infaunal zonation is unpredictable and temporally variable but some generalisations can be made (Haynes and Quinn 1995). Dipteran insects are confined to the upper beach zone and polychaetes are confined to the lower beach zone with crustacean species spanning the entire beach. The most common infauna species is the dipteran *Chaetocoelopa sydneyensis*. Other common species include the coleopteron *Sphargeris physodes*, the isopods *Pseudolana cocinna* and *Actaecia thomsoni*, the amphipods *Talorchestia* cf *novaehollandiae* and *Exoediceroides maculosus*, and the polychaetes

Magelona sp. and *Scolelepis lamellicincta*. The intertidal soft sediment is an important feeding and roosting habitat for shorebirds.

Figure 32. Intertidal soft sediment at The Oaks in Bunurong MNP. Photo by Jan Barton, Deakin University.

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, water cover and wave exposure. Intertidal rocky reefs in the MNP are generally steep boulder-fields. There is great spatial and temporal variability in the life histories of the organisms and the environmental processes in intertidal 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. Some mobile species of animals, particularly chitons, brittlestars, opisthobranchs and gastropods are predominately found under boulders (Underwood and Chapman 2004). Space on which to live and food are often resources in short supply on intertidal reefs (Underwood and Chapman 2004). There is is an intertidal reef monitoring program in Bunurong MNP.

Macroalgae and Aggregating Sessile Invertebrates
One species of seagrass, *Amphibolis antarctica*, and 30 species of algae, including 17 species of brown algae have been recorded from the intertidal reefs of Bunurong MNP (Costa *et al.* 2010; O'Hara *et al.* 2010). Macroalgal cover site is dominated by a low cover of Neptune's necklace *Hormosira banksii* (Gilmour and Edmunds 2007; Pritchard *et al.* 2011b). Small patchily distributed algal turf and the blue-green algae *Symploca* sp. are also present. The green algae *Enteromorpha compressa*, brown algae *Nothea anomala* and branched coralline red algae *Corallina officinalis* also occur in low abundance. The desiccation tolerant *Gelidium pusillum* can form dense mats of flattened tangled growth on the seaward edge of exposed rocks and boulders (Plummer *et al*. 2003). Various other genera of brown algae including *Ectocarpus* spp., *Caulocystis* spp. and *Padina* spp., the green algae *Chaetomorpha darwinii, Codium* spp and *Caulerpa* spp and encrusting coralline red algae can also be present on the intertidal reef (Plummer *et al*. 2003). Patches of the mat forming flea mussel *Limnoperna pulex* are common on the reef. Sand inundation of the intertidal reef varies over time.

Mobile Invertebrates
Fifty-eight species of invertebrates have been recorded from the intertidal reef in Bunurong MNP, molluscs being by far the most diverse with 41 species (Costa *et al.* 2010; O'Hara *et al.* 2010). The periwinkle *Nodilittorina unifasciata* is the most common species at the Eagles Nest site with a density of 598 m^2 (Gilmour and Edmunds 2007). This species is more common at the high shore end and often co-occurs with a similar but smaller species *Nodilittorina acutispira*. The striped conniwink *Bembicium nanum* (Figure 33) is another abundant species which occurs across the shore in high densities. Less dense is the pulmonate limpet *Siphonaria* spp (Figure 34), which occurs across the shoreline (Gilmour and Edmunds 2007; Pritchard *et al.* 2011b). The predatory gastropods *Dicathais orbita*, *Cominella lineolate*, and *Lepsiella vinosa* are present but in low densities. The seastar *Pateriella exigua* can also be found on the intertidal reef (Gilmour and Edmunds 2007; Pritchard *et al.* 2011b). There is a wide array of other fauna, including anemones, barnacles, crabs, sea squirts, urchins and blue ring octopus found on the intertidal reef (Appendix 1). A considerable diversity of isopods are recorded from the area (Plummer *et al.* 2003). The Bunurong coast has a very high diversity of chitons including endemic species (O'Hara 2002a).

Fish
The most common fish species inhabiting large intertidal rock pools are the toadfish *Tetractenos glaber* (Figure 35) and the small and cryptic horned blenny *Parablennius tasmanianus* and dragonet *Bovichtus angustifrons* (Plummer *et al.* 2003).

Figure 33. Striped-mouth conniwink *Bembicium nanum* on the intertidal reef of Bunurong Marine National Park. Photo taken by AME.

Figure 34. Limpets *Siphonaria diemenensis* (left) and *Cellana tramoserica* (right) and the flea mussel *Limnoperna pulex* on intertidal reef in Bunurong Marine National Park. Photo taken by AME.

Figure 35. Toadfish *Tetractenos glaber* in rockpool in Bunurong Marine National Park. Photo by Jan Barton, Deakin University.

Subtidal
Soft sediment
There are some shallow and extensive deep sandy beds within the Bunurong MNP and these are predominantly inhabited by infauna (small crustaceans and worms that burrow into the sand) and bottom-dwelling skates and rays (Parks Victoria 2003). Depth and sediment affect the distribution of benthic fauna along the Victorian coast. Coleman *et al.* (2007) found that species richness was greater at 40 metres compared to 10 or 20 metres depth, and greater in medium to coarse sands compared to fine sands. Their coastal survey of benthic fauna did not include the benthos of Bunurong MNP but included one grab sample off Cape Patterson in 40 metres depth. A 0.1 m^2 grab sample contained 115 individuals and 55 species consisting mainly of polychaetes and crustaceans (Coleman *et al.* 2007).

Fish such as mullets, hardyheads and salmon Australian *Arripis trutta* are offshore of sandy beaches and are usually transient (Plummer *et al.* 2003). The seagrass *Amphibolis antarctica* is considered an important habitat for some fish species, including pike *Sphyraena novaehollandiae* and King George whiting *Sillaginodes punctata* (Parks Victoria 2003). Seagrass beds support a variety of fish species including goatfish *Upeneichthys vlamingii*, silver belly *Parequula melbournensis*, pipefishes *Stigmatopora nigra*, *S. argus*, *Siphonognathus attenuatus*, blue-throated wrasse *Notolabrus tetricus*, goby *Nesogobius* spp., weedfishes *Heteroclinus* spp., *Cristiceps* spp., and toothbrush leatherjacket *Acanthaluteres vittiger*. Several species of mullet, flathead and snapper *Chrysophrys auratus*, tailor *Pomatomus saltator* and barracouta *Thyrsites atun* are also common in the area (Plummer *et al.* 2003). Numerous sharks (Figure 36), including gummy *Mustelus antarcticus*, school *Galeorhinus australis*, common saw *Pristiophorus cirratus*, southern saw *P. nudipinnis*, angel *Squatina australis* and elephant *Callorhynchus milii* are likely to occur in the Bunurong MNP (Plummer *et al.* 2003).

Figure 36. The draughtboard shark *Cephaloscyllium laticeps* over subtidal reef in Bunurong Marine National Park. Photo by AME.

Reef

Subtidal reefs 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. Deep reefs, where light penetration is limited, are often dominated by large sessile invertebrates such as massive sponges (Figure 41), whip corals, soft corals and colonial ascidians. Biotic assemblages can form habitat and food sources for invertebrates and fish.

Flora

The underwater reefs of the Bunurong are different from elsewhere in Victoria. The algal communities that occupy the shallow subtidal reefs are rich in species, particularly species of red and brown algae (O'Hara 2002b; Stewart *et al.* 2007a; Pritchard *et al.* 2011a; Figure 37). This is mainly due to the low abundance or absence of the large kelps such as *Ecklonia radiata* and *Phyllospora comosa* that occupy most other inshore reefs in Victoria, which has allowed a variety of smaller species to thrive without competition from large kelps for space and light (O'Hara 2002b). Medium-sized brown algal species such as *Seirococcus axillaris*, *Cystophora* species, *Sargassum* species and *Acrocarpia paniculata* predominate (O'Hara 2002b; Stewart *et al.* 2007a; Pritchard *et al.* 2011a). A major decrease in the giant kelp *Macrocystis pyrifera* has been observed in the Bunurong MNP and surrounding area, a trend reflected at many other subtidal reefs along the south east Australian coast (Stewart *et al.* 2007a; Pritchard *et al.* 2011a). Possible causes of this decline include a rapid succession of El Niño events in the late 1980s and early 1990s (affecting water temperature and nutrient levels), a long-term increase in average sea temperature (1°C over the last 40 years) and changes to coastal nutrient inputs (Stewart *et al.* 2007a).

The predominant green algae are *Caulerpa brownii* and *C. flexilis*, however these species are relatively low in abundance. Other predominant components of the algal assemblages include the seagrass *Amphibolis antarctica*, coralline algae such as *Haliptilon roseum* and *Metagoniolithon radiatum*, and the red algae *Areschougia congesta*, *Plocamium angustum* and *Phacelocarpus peperocarpus* (Pritchard *et al.* 2011a). The seagrass *A. antarctica* inhabits shallow (< 7 m depth) moderately exposed reef which has a low profile and is adjacent to sand (Parks Victoria 2003). *A. antarctica* beds can support numerous epiphytes including *Lobospira bicuspidata, Dicranema revolutum* and other red algae (O'Hara 2000a). The abundance of most algal species can be variable through time, considerably large fluctuations have been observed for *A. antarctica* and *Cystophora* species (Pritchard *et al.* 2011a).

Invertebrate fauna

Over 250 species of invertebrates are identified from the Bunurong MPA, but the final count is likely to be at least 10 times higher (O'Hara 2002b). Bunurong is not noted for its large abundances of rock lobster or sea-urchins (O'Hara 2002b), however a significant rock lobster population has been observed during subtidal reef monitoring surveys. Subtidal reef invertebrate community is largely composed of the blacklip abalone *Halitiotis rubra*, the warrner *Turbo undulatus* and a variety of sea stars, particularly *Patiriella brevispina, Nectria ocellata* and *Tosia australia* (Pritchard *et al.* 2011a). Other commonly encountered species include greenlip abalone *H. laevigata* and the cartrut whelk *Dicathais orbita* (Pritchard *et al.* 2011a). The tufting algae provides shelter to numerous small worms, snails, sea spiders, pill bugs, hoppers, shrimps and crabs (O'Hara 2002b). As with most of the Bunurong coast, chitons can be numerous and diverse on subtidal reefs (O'Hara 2000a). At 40 m deep the

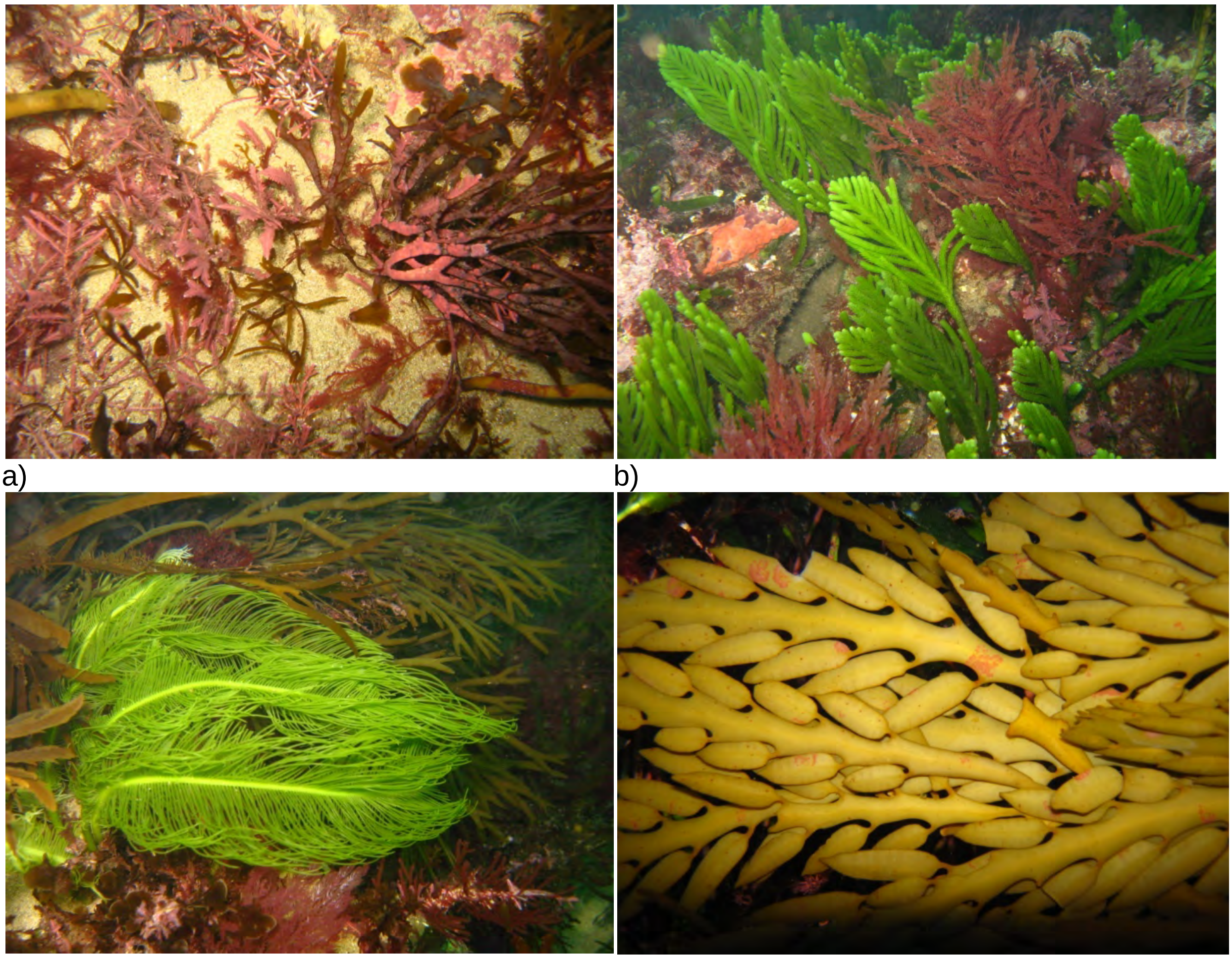


Figure 37. Subtidal reefs in Bunurong Marine National Park have a diverse algal community: a) Sonders red forkweed *Rhodymenia sonderi,* rosy coralline *Haliptilon roseum* and radiate coralline *Metagoniolithon radiatum;* b) congested mopweed *Areschougia congesta* and Muller's fern caulpera *Caulerpa flexilis var. muelleri*; c) bristled crayweed *Seirococcus axillaris* long filament caulerpa *Caulerpa longifolia;* and d) flat-lobed cystophora *Cystophora platylobium.* Photos by AME.

reefs of Bunurong MNP have a sparse cover of sponges and stalked ascidians *Pyura spinifera* (Parks Victoria 2003).

Fish

Nearly 90 different species of fish are reported from the Bunurong area, including seadragons and well-camouflaged weed-fish that hide amongst the algal fronds (O'Hara 2002b). The subtidal reef fish assemblage primarily consists of blue-throated wrasse *Notolabrus tetricus*, purple wrasse *Notolabrus fucicola*, senator wrasse *Pictilabrus laticlavius* and sea sweep *Scorpis aequipinnis* (Pritchard *et al.* 2011a). Other common species include the scaly fin *Parma victoriae*, magpie perch *Cheilodactylus nigripes*, herring cale *Odax cyanomelas*, zebra fish *Girella zebra* (Figure 38) and a variety of leatherjackets (Pritchard *et al.* 2011a). The draughtboard shark *Cephaloscyllium laticeps* (Figure 36) occurs in the MNP (Pritchard *et al.* 2011a).

Water column

The water column as a whole is the largest habitat in the MNP and is important in different ways for many organisms for, transit, some stages of their life cycles or as a permanent home. 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 much plankton, both animals and algae. Others, including mammals, birds, fish, invertebrates and algae live on and near hard surfaces but use the water column for transport and food (and other resources like oxygen). 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. Parks Victoria does not currently monitor the water column as a habitat (Power and Boxshall 2007).

Figure 38. Zebra fish *Girella zebra* over macroalgae covered subtidal reef in Bunurong Marine National Park. Photo by AME.

2.2.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing marine ecological communities within the MNP, rather than threatened species, is also 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 have been recorded in the Bunurong MNP (Parks Victoria 2006a).

Invertebrates

The sea cucumber *Pentocnus bursatus* (Echinodermata) is FFG listed in Victoria, known from only around Cape Patterson (O'Hara 2002a). It is a benthic suspension feeder found in amongst algal tufts on shallow rock platforms and broods its young (O'Hara 2002a).

Fish

No conservation listed fish have been recorded in the Bunurong MMNP.

Birds
Thirty-one conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Bunurong MNP (Table 10). Fifteen are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Seven birds are listed at both the state and national level, one at the national level *EPBC Act 1999*. Fourteen birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). The hooded plover has been recorded as breeding on the beaches of the MNP, at The Oaks (Figure 8, Plummer *et al.* 2003). Two other shorebirds, the red-capped plover *Charadrius ruficapillus* and the white-fronted chat *Epthianura albifrons*, are recorded as breeding in the Bunurong MNP or its immediate surrounds, neither bird is listed as threatened.

Marine mammals and reptiles
The southern right whale *Eubalaena australis* and humpback whale *Megaptera novaeangliae* have been recorded in or near the Bunurong MNP. The southern right whale is listed as critically endangered in Victorian waters and endangered nationally. The humpback whale is listed as vulnerable at the state and national level (Table 11). Both are listed as migratory species under the Bonn convention, they have been observed to pass through the park and are not known to feed or calf there. The nationally vulnerable subantarctic fur seal *Arctophoca tropicalis* has also been recorded in the MNP. The bottlenose dolphin *Tursiops truncates*, common dolphin *Delphinus delphis*, Australian fur seal *Arctocephalus pusillus doriferus* (Figure 39) and leopard seal *Hydrurga leptonyx* have been observed in the waters in and around the park.

Figure 39. The Australian fur seal *Arctocephalus pusillus doriferus* in Bunurong Marine National Park. Photo by AME.

Table 10. Conservation listed shorebird and seabird records from Bunurong Marine National Park and surrounds.

Common name	Scientific name	Victorian listing FFG	Victorian listing VROTS	National listing EPBC	International treaty CAMBA	International treaty JAMBA
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
common diving-petrel	*Pelecanoides urinatrix*		NT			
pacific gull	*Larus pacificus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
white-fronted tern	*Sterna striata*		NT			
hardhead	*Aythya australis*		VU			
royal spoonbill	*Platalea regia*		VU			
white-faced storm-petrel	*Pelagodroma marina*		VU			
eastern curlew	*Numenius madagascariensis*		NT		C	J
grey plover	*Pluvialis squatarola*		NT		C	J
Latham's snipe	*Gallinago hardwickii*		NT		C	J
white-bellied sea-eagle	*Haliaeetus leucogaster*		VU		C	
hooded plover	*Thinornis rubricollis*	L	VU			
little tern	*Sternula albifrons*	L	VU		C	J
wandering albatross	*Diomedea exulans*	L	EN	VU		J
shy albatross	*Thalassarche cauta*	L	VU	VU		
yellow-nosed albatross	*Thalassarche chlororhynchos*	L	VU	VU		
southern giant-petrel	*Macronectes giganteus*		VU	EN		
northern giant-petrel	*Macronectes halli*		NT	VU		
black-browed albatross	*Thalassarche melanophris*		VU	VU		
fairy prion	*Pachyptila turtur*		VU	VU		
blue petrel	*Halobaena caerulea*			VU		
common tern	*Sterna hirundo*				C	J
curlew sandpiper	*Calidris ferruginea*				C	J
pomarine jaeger	*Stercorarius pomarinus*				C	J
red-necked stint	*Calidris ruficollis*				C	J
ruddy turnstone	*Arenaria interpres*				C	J
sharp-tailed sandpiper	*Calidris acuminata*				C	J
arctic jaeger	*Stercorarius parasiticus*					J
short-tailed shearwater	*Ardenna tenuirostris*					J

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

Table 11. Conservation listed marine mammal records from Bunurong Marine National Park and surrounds.

Common name	Scientific name	Victorian listing FFG	Victorian listing VROTS	National listing EPBC	International convention Bonn
humpback whale	*Megaptera novaeangliae*	L	VU	VU	L
southern right whale	*Eubalaena australis*	L	CR	EN	L
subantarctic fur seal	*Arctophoca tropicalis*			VU	
Australian fur seals	*Arctocephalus pusillus doriferus*			L	

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

Figure 40. Intertidal reef at Eagles Nest in Bunurong Marine National Park. Photo by AME.

Species distribution information

A new species of the brown algae *Zonaria* has been collected during subtidal monitoring but unfortunately, the specimen appears to be sterile, limiting the taxonomic description (Stewart *et al.* 2007a). The brown algae *Myriodesma tuberosa* has been recorded in MNP representing a range extension or an anomalous individual (Stewart *et al.* 2007a). The known range for *Myriodesma tuberosa* is Israelite Bay, WA, to Port Elliot, SA, and it is apparently rare (Womersley 1987).

Assessment of distribution, endemism and rarity of biota across the state (O'Hara and Barmby 2000; O'Hara 2002a) found that Bunurong MNP had twenty-one biota recorded or presumed to be at their distributional limit (Table 12). Fourteen species including brown algae, green algae, sea cucumbers, a seastar, a chiton and crabs have been recorded as being at their easterly limit of their distribution in Bunurong MNP plus an additional eight species are presumed to be at their eastern limit of distribution, and one the crab *Wollastoniella mucranata* is presumed to be at it western limit of its distribution.

Table 12. Biota with distributional limits located at or near the Bunurong Marine National Park (O'Hara 2002a; (O'Hara and Barmby 2000). (RE – recorded to be at eastern limit, PW – presumed to be at or near western limit, PE – presumed to be at or near eastern limit in MNP).

Order	Family	Species	Common name	Category
Derbesiales	Derbesiaceae	*Pedobesia clavaeformis*	Green algae	RE
Brachyura	Leucosiidae	*Phlyixia dentifrons*	Crab	RE
Brachyura	Pilumnidae	*Pilumnus monilifer*	Crab	RE
Asteroidea	Oreasteridae	*Nectria saoria*	Seastar	RE
Holothuroidea	Chiridotidae	*Taeniogyrus roebucki*	Sea Cucumber	RE
Holothuroidea	Cucumariidae	*Neocnus bimarsupiis*	Sea Cucumber	RE
Holothuroidea	Cucumariidae	*Pentocnus bursatus*	Sea Cucumber	RE
Holothuroidea	Cucumariidae	*Squamocnus aureoruber*	Sea Cucumber	RE
Polyplacophora	Ischnochitonidae	*Ischnochiton (Haploplax) thomasi*	Chiton	RE
Fucales	Sargassaceae	*Sargassum heteromorphum*	Brown algae	RE
Corallinales	Corallinaceae	*Jania pusilla*	Red algae	RE
Gigartinales	Areschougiaceae	*Erythroclonium angustatum*	Red algae	RE
Gigartinales	Areschougiaceae	*Erythroclonium muelleri*	Red algae	RE
Caulerpales	Udoteaceae	*Rhipiliopsis peltata*	Green algae	PE
Brachyura	Majidae	*Naxia spinosa*	Crab	PE
Ophiuroidea	Ophiacanthidae	*Ophiacantha shepherdi*	Brittle star	PE
Polyplacophora	Chitonidae	*Chiton (Rhyssoplax) oruktus*	Chiton	PE
Ceramiales	Ceramiaceae	*Hirsutithallia mucronata*	Red algae	PE
Ceramiales	Ceramiaceae	*Wollastoniella mucranata*	Red algae	PE
Gigartinales	Dicranemataceae	*Tylotus obtusatus*	Red algae	PE
Brachyura	Majidae	*Tumulosternum wardi*	Crab	PW

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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 MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 years were considered and ranked. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Eleven hazards with the potential to be extreme 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. Introduction and establishment of new or existing exotic species, leading to competition with or predation on native species (potentially all park);
2. Dogs off-lead disturbing hooded plovers, resulting in decreased plover populations (intertidal soft sediment);
3. Lack of political commitment resulting in insufficient resources (money & staff) for Parks Victoria to effectively manage the park (*i.e.* to monitor, manage and implement actions) (potentially all park);
4. Inappropriate coastal development (strip development on existing farm land) adjacent to the park leading to increased trampling in intertidal areas (intertidal reef and soft sediment);
5. Increased residential development in the broader catchment, leading to increased trampling of intertidal biota, causing disruption to the food chain (intertidal reef (Figure 40) and soft sediment);
6. Inappropriate coastal development, strip development on existing farm land, adjacent to the park leading to reduced water quality (intertidal reef and soft sediment, shallow subtidal);
7. Lack of effective (*i.e.* well-resourced) and broadly-based education (*i.e.* ecosystem focused) of park and agency staff, the general community and park visitors (potentially whole park);
8. Increased nutrients from agricultural runoff in the Bunurong coastal plains catchment, resulting in altered ecosystem function in subtidal reef communities (intertidal and shallow subtidal habitats);
9. Increased residential development in the broader catchment, leading to increased urban storm water runoff, and thus reduced water quality relative to background (intertidal and shallow subtidal habitats);
10. Insufficient resourcing *of* relevant agencies for enforcement (*e.g.* no-take zones, bag limits) leading to altered ecosystem functioning (via changes to community structure etc) (intertidal reef, shallow subtidal reef and open water); and
11. Poaching of abalone, rock lobster or aquarium species resulting in decreased populations of the target species (shallow subtidal reef).

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 (Parks Victoria 2003). At present there have been no recordings of marine pests in the MNP although it is thought that the introduced green shore crab *Carcinus maenas* is probably within the MNP. Immediately to the east, in Flinders bioregion, the Northern Pacific seastar *Asterias amurensis* was found at Point Norman and Anderson Inlet and may have been eradicated in a broad-based community effort in 2004 – 05, led by DSE (Parks Victoria 2006a), and has also recently been found at San Remo jetty. 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). Other species of particular concern include the marine fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile (subsp. fragile)* (Parks Victoria 2003).

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 dessication, 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 large number of species are at the eastern limit of their distributional range at Bunurong MNP and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in Wilsons Promontory MNP, has increased its range down the east coast of Australia to Tasmania and that increase is thought to be linked to climate change with the EAC extending further south (Banks *et al.* 2010).

Measures to address or minimise these hazards form part of the management plan for Bunurong MS (Parks Victoria 2006a). For example research is being conducted into marine pest species, which may impact on park natural values. Studies of visitor traffic to the Bunurong area and found the intertidal reefs at Eagles Nest had the highest visitation rates (Gilmour and Edmunds 2007). 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 41. Encrusting ruffled orange sponge on the subtidal reef in Bunurong Marine National Park. Photo by AME.

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 Bunurong 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 13 and Appendix 2).

Bunurong MNP has an ongoing intertidal reef monitoring program (IRMP). The IRMP in and around the Bunurong MNP began in 2005 with the explicit aim to track changes in invertebrates and macro-algae abundances due to human use, including trampling and fossicking, of the platforms (Power and Boxshall 2007). A site in the MNP and reference site outside of the MNP (Figure 28) have been surveyed over five census events (Edmunds *et al.* 2004; Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010; Pritchard *et al.* 2011b). The monitoring involves surveying a single reef during a single low tide, targeting the predominant substratum type at each intertidal reef (Hart and Edmunds 2005). The survey is conducted along transects running from the high to the low shore. The density of non-sessile invertebrates and the percentage cover of macroalgae and aggregated sessile invertebrates are surveyed within quadrats along the transects (Hart and Edmunds 2005). Bunurong IRMP data was not part of Keough and Carnell's (2009) preliminary analysis of the IRMP data.

The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003) in and around the Bunurong MNP began in 1999. Since that time 6 sites in the MNP and 6 reference sites outside of the MNP (Figure 28) have been surveyed over 11 census events (Edmunds *et al.* 2003; Stewart *et al.* 2007a; Pritchard *et al.* 2011a). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than 10 metres (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water.

Preliminary analysis of the SRMP subtidal reef monitoring data to 2006 by Keough and Carnell (2009) has assessed changes in the park since declaration by comparing subtidal reef MNP sites to reference sites outside of the MNP (Figure 28). Preliminary analysis found there were no significant differences in overall species richness and abundance between MNP and reference sites post-declaration of the MNP (Keough and Carnell 2009). Limitations to the preliminary analysis were the relatively short time since declaration (four years) and the corresponding small data set (Keough and Carnell 2009). Bunurong region has a long history of marine protection and limited differences between the MNP and reference sites would be expected.

Table 13. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Bunurong Marine National Park.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising 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. ***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: 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.
University of Tasmania: Graham Edgar (+ other university and industry partners). Biotic connectivity within the temperate Australian marine protected area network at three levels of biodiversity - communities, populations and genes.
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 Intertidal Reef Monitoring Program

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

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 MNP area against future threats to biodiversity and natural processes.

A targeted analysis of monitoring data 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 (Keough *et al.* 2007; Power and Boxshall 2007; Keough and Carnell 2009). Bunurong MNP will now be monitored in two consecutive years followed by a three year gap until the next surveys.

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.

2.2.7 KNOWLEDGE GAPS

There is good substrate mapping for Bunurong MNP but there is little quantitative data on marine habitat distribution. Likewise there is no quantitative information on the ecological communities for many habitats. Nothing is known of the water column communities, with little known about fish in intertidal soft sediment and reef (Figure 42), subtidal soft sediment, and deep subtidal reef habitats.

Major threats have been identified for Bunurong MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.

Figure 42. Intertidal reef at Twin Reef in Bunurong Marine National Park. Photo by Jan Barton, Deakin University.

3 Marine Sanctuaries

3.1 Marengo Reefs Marine Sanctuary

Marengo Reefs MS is the one of five Marine Sanctuaries in the Central Victoria Bioregion, which also contains Point Addis, and Bunurong Marine National Parks. It is approximately 220 km south-west of Melbourne, 2.5 km south-west of Apollo Bay, and 80 m offshore from Haley Point, Marengo. Marengo Reefs MS covers 12.5 hectares and surrounds and includes a reef system known as Little Henty Reef. Two sections of the reef, known as the Inner Reef and the Outer Reef, are usually exposed, and separated by a narrow channel known as 'The Gap' (Parks Victoria 2007b). Marengo Reefs MS is accessible by boat from Apollo Bay, sea kayak, swimming or, occasionally at very low tide, walking to the Inner Reef (Parks Victoria 2007b).

Aboriginal tradition indicates that the Marengo Reefs MS is part of *Country* of Gadubanud people. Other Aboriginal communities, including the Kirrae Wurrung, Framlingham Aboriginal Trust, Wathaurung Aboriginal Cooperative and the Southern Otways Indigenous Group have an association with the coastal region of this area (Parks Victoria 2007b).

Important natural values of Marengo Reefs MS are its intertidal and subtidal rocky reefs with many microhabitats and a high diversity of algal, invertebrate and fish species (Carey *et al.* 2007b). Subtidal reef habitat contains bull kelp *Durvillaea potatorum*, many other seaweeds, and a rich community of invertebrates including sea urchins, soft corals and sponges (ECC 2000; Carey *et al.* 2007b). Subtidal soft sediment and associated communities make up a small but important part of the MS around the Inner Reef (Carey *et al.* 2007b). The Outer Reef is a significant haul out area for the Australian fur seal *Arctocephalus pusillus doriferus* (Figure 43). As such it is a listed site of state biotic significance and Special Protection Area (SPA) with restricted access to limit disturbance to seals (Figure 47).

Bull kelp *D. potatorum* is the dominant algae around the edge of the intertidal reef with some *Phyllospora comosa* (Plummer *et al.* 2003; Ball and Blake 2007b). Over 108 intertidal invertebrates, including 9 seastar, 5 barnacles, 7 crab and 52 mollusc species, have been recorded in Marengo Reefs MS (Plummer *et al.* 2003). Subtidal soft sandy sediment surrounds the Inner Reef within the MS but there is no specific information on its biota (Plummer *et al.* 2003; Ball and Blake 2007b).

The canopy forming subtidal reef algae at Marengo Reefs MS is generally crayweed *Phyllospora comosa* changing to bull kelp *Durvillaea potatorum* in shallower waters (Ball and Blake 2007b; Crozier *et al.* 2007). There is also a relatively diverse assemblage of smaller brown algal species including *Cystophora retorta, C. moniliformis,* and *Acrocarpia paniculata* (Crozier *et al.* 2007). The understorey has very few species and a very low cover of red and green algae, contributing to its low diversity of algal species overall (Crozier *et al.* 2007). Subtidal reef invertebrate assemblages have high abundance of the blacklip abalone *Haliotis rubra* and low abundance of the purple urchin *Heliocidaris erythrogramma* (Crozier *et al.* 2007). Like the algal community the invertebrate community in the MS is similar to Eagle Rock MS and less diverse than that found at Point Addis (Crozier *et al.* 2007).

Common fish at Marengo Reefs MS are blue-throated wrasse *Notolabrus tetricus* and purple wrasse *N. fucicola,* the latter is more abundant at Marengo Reefs MS than in other Central Victoria bioregion MPAs (Crozier *et al.* 2007). Other fish species include herring cale *Odax cyanomelas,* magpie morwong *Cheliodactylus nigripes,* and in low abundance the horseshoe leatherjacket *Meuschenia hippocrepis* (Crozier *et al.* 2007). The Victorian scalyfin *Parma victoriae,* yellow striped leather jacket *Meuschenia flavolineata* and sea sweep *Scorpis aequipinnis* are found on other reefs in the Central Victoria bioregion but are absent from recent surveys at Marengo Reefs MS (Crozier *et al.* 2007; Keough and Carnell 2009).

Marengo Reefs MS provides limited feeding and roosting habitat for several threatened bird species such as the eastern great egret *Ardea modesta*, which is listed under the *Flora and Fauna Guarantee* (*FFG*) *Act* (1998) and regarded as vulnerable in Victoria. The MS protects feeding and roosting areas for species of national environmental significance under the *Commonwealth Environment Protection and Biodiversity Conservation* (*EPBC*) *Act* (1999) and species that are listed under the Japan–Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA, Parks Victoria 2007b). Nine species of marine flora and fauna are believed to be at their eastern or western distributional limits within the MS.

The 1858 wreck of the wooden barque international trader *Grange*, and the 1923 wreck of the wooden ketch coastal trader *Wollomai* occur in the MS. Remains of the *Grange* hull and *Wollomai* windlass and some decking can been seen underwater (Parks Victoria 2007b).

Small coastal areas such as the Marengo Reefs MS are subject to many external influences and potential threats. Illegal fishing, disturbance of birds and seals, increasing sediment and nutrients from the increasing coastal population, invasive marine pests, lack of ecological knowledge and climate change all pose serious threats to the integrity of Marengo Reefs MS. Measures to address or minimise these threats form part of the management plan for Marengo Reefs MS (Parks Victoria 2007b).

3.1.1 PHYSICAL PARAMETERS & PROCESSES

Marengo Reefs MS is 12.5 hectares in size which makes it the smallest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 14, Figure 43, 45 and 46). Marengo Reefs MS lies within Mounts Bay, a small bay with a sandy beach facing east. The seafloor of MS is predominately < 15 metres deep (Ball and Blake 2007b). The reefs are the sandstone remnant of islands which have been planed off by marine erosion (Bird 1993). The Inner Reef is usually submerged at high tide but the Outer Reef is only occasionally inundated by high tides and large seas (Parks Victoria 2007b). It is a high wave energy location with large south-westerly swells crashing into the Outer Reef (Parks Victoria 2007b). Offshore currents predominantly carry water from the south-west towards the Outer Reef while the Inner Reef is also influenced by inshore processes within Mounts Bay (Parks Victoria 2007b). Tidal variation is 1.7 metres for spring tides and 0.9 metres for neap tides (Plummer *et al.* 2003). Currents, tides and wave energy produce complex local hydrodynamics, contributing to a high diversity of habitats within a small area (Parks Victoria 2007b). Surface water temperatures average 17° C in the summer and 13.5° C in the winter. The Barham River estuary discharges into Mounts Bay 2 km north-east of the sanctuary (Table 14). The Marengo STP outfall discharges waste water from Apollo Bay, Skenes Creek and Marengo immediately to the west of the sanctuary (Parks Victoria 2007b).

There are no declared sites of geological or geomorphological significance in the MS (Figure 47). The mouth of the Barham River to the east of the MS is of state geomorphological significance as the oldest outcrop unit of the Lower Cretaceous.

Table 14. Physical attributes of the Marengo Reefs Marine Sanctuary.

Park Name	Marengo Reefs
Conservation status	Marine Sanctuary
Biophysical Region	Central Victoria
Size	12.5 ha (ranked 24th of 24)
Length of coastline	0 km
Shoreline geology	sandstone
Area with depth:	
Intertidal	5.01 ha
Intertidal-2 m	1.83 ha
2-4 m	3.31 ha
4-6 m	1.79 ha
6-8 m	0.34 ha
8-10 m	0.20 ha
10-12 m	0.01 ha
Mean tidal variation - spring	1.7 m
Mean tidal variation - neap	0.9 m
Mean water temp - summer	17°C
Mean water temp - winter	13.5°C
Adjacent catchment	N/A
Discharges into MNP	Marengo STP west
Nearest major estuary (distance & direction)	Barham 2 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 target management activities, including emergency response, monitoring and research effectively. 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 Marengo Reefs MS include intertidal and subtidal reef, limited subtidal soft sediment, and the water column. The subtidal habitat of the Marengo Reefs MS (Figure 47) has been mapped from aerial photography and underwater video survey in 2004 (Ball and Blake 2007b).

Both the Inner and Outer Reef in Marengo Reefs MS are steep sided. The Inner Reef protrudes upward from the surrounding sand with a narrow band of reef around the base (Figure 47). A zonation pattern extends across from the edge and up the sides of the reef (Ball and Blake 2007b). The outer edge of the reef is low profile and dominated by mixed brown and green algae (Ball and Blake 2007b). It then becomes high profile and solid in texture and dominated by dense beds of crayweed *Phyllospora comosa*. Up towards the intertidal zone the *P. comosa* is replaced by extensive beds of bull kelp *Durvillea potatorum* (Ball and Blake 2007b).

The rocky reef at the base of the Outer Reef (Figure 47) is more extensive than the Inner Reef but has a similar zonation pattern to the Inner Reef along its south-eastern shore (Ball and Blake 2007b). Along its east shore the Outer Reef is high profile reef, becoming more broken in texture, with overhangs and ledges becoming more prominent (Figure 47). *P. comosa* and *D. potatorum* are the dominant canopy algae (Ball and Blake 2007b). Along the northern shore of the Outer Reef *P. comosa* was the dominant biota on predominantly low profile solid reef. Areas of higher profile broken reef were also present and dominated by *D. potatorum* (Ball and Blake 2007b).

Figure 43. Australian fur seals *Arctocephalus pusillus doriferus* over subtidal reef in Marengo Reefs Marine Sanctuary.

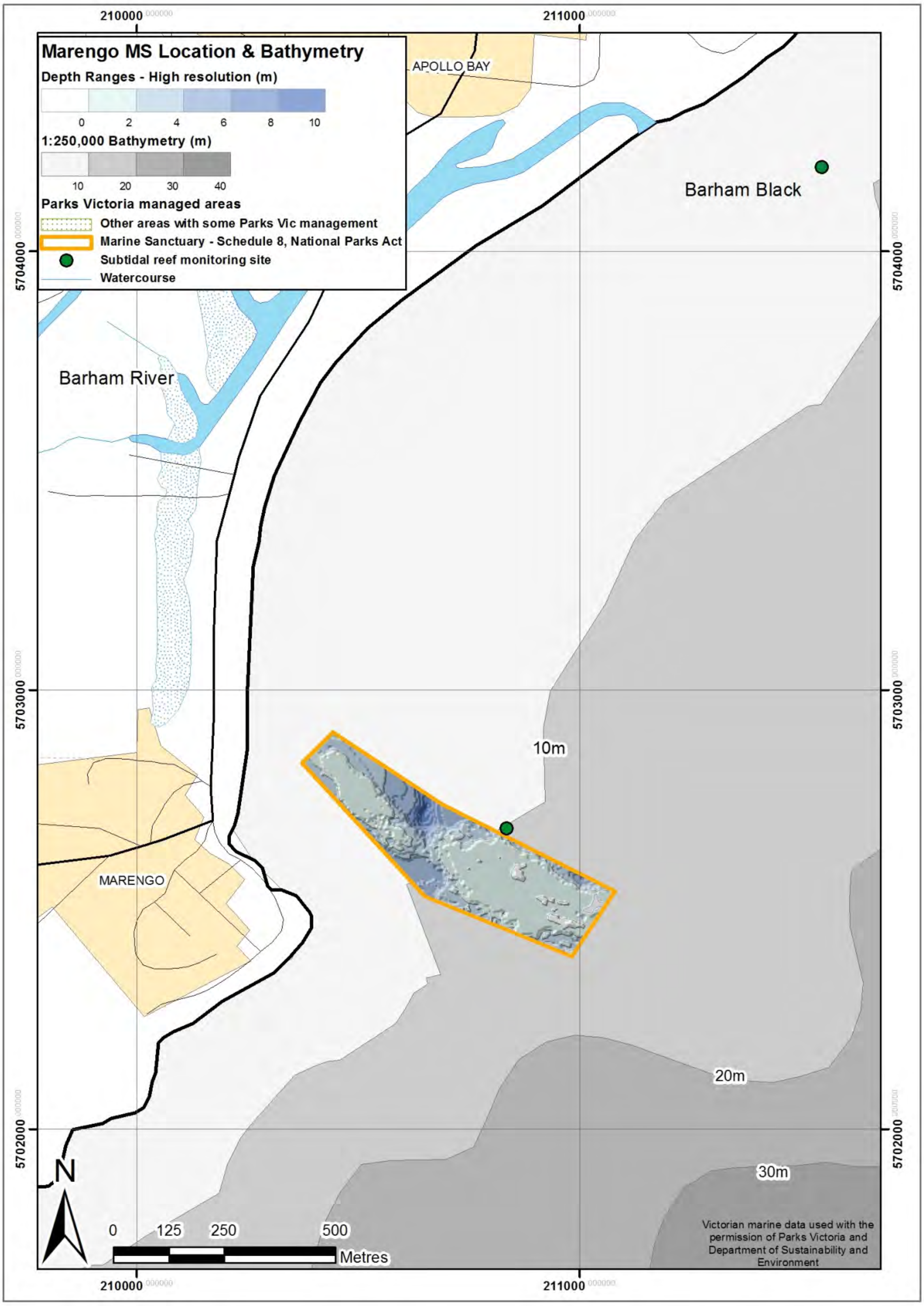


Figure 44. Location map of Marengo Reefs Marine Sanctuary with bathymetry. Subtidal reef monitoring sites inside and outside the MS are shown, there are no intertidal monitoring sites.

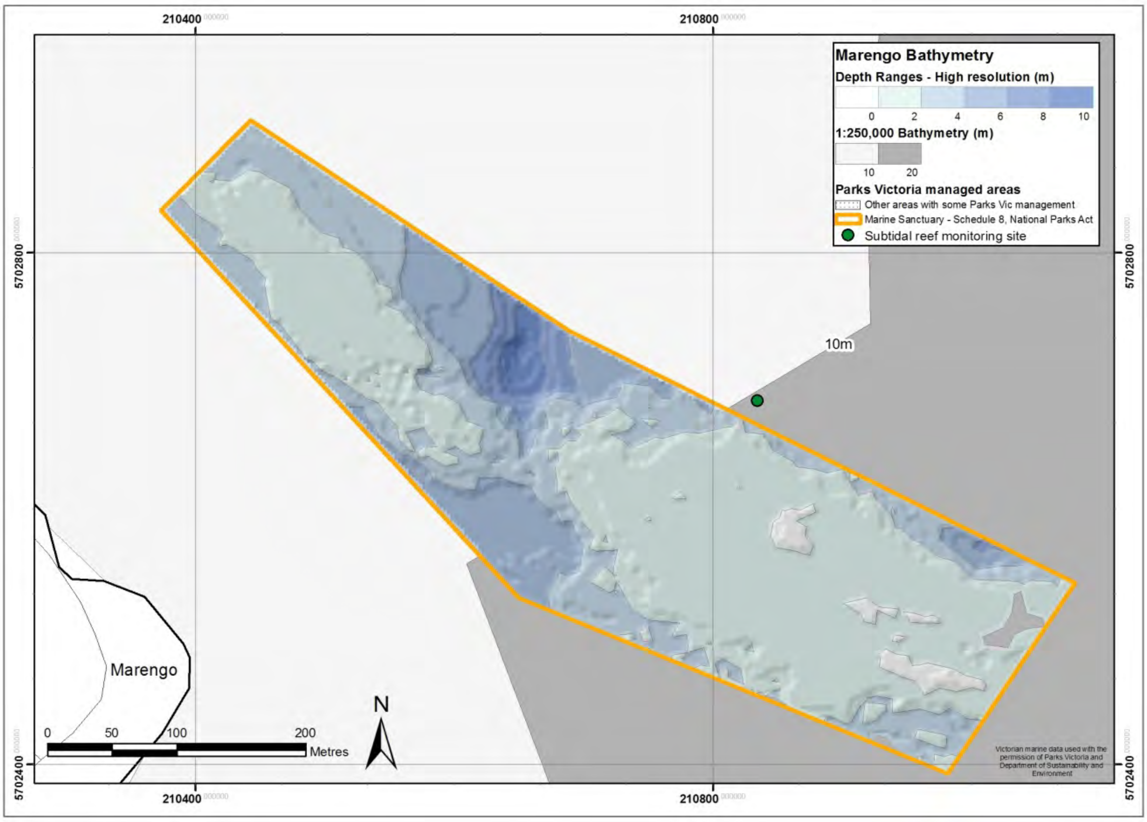


Figure 45. Detailed bathymetry of Marengo Reefs Marine Sanctuary. The subtidal reef monitoring site shown is actually inside the MS, there are no intertidal monitoring sites

Figure 46. Aerial view of Marengo Reefs Marine Sanctuary (Department of Sustainability and Environment, 1/11/04). From Ball and Blake (2007).

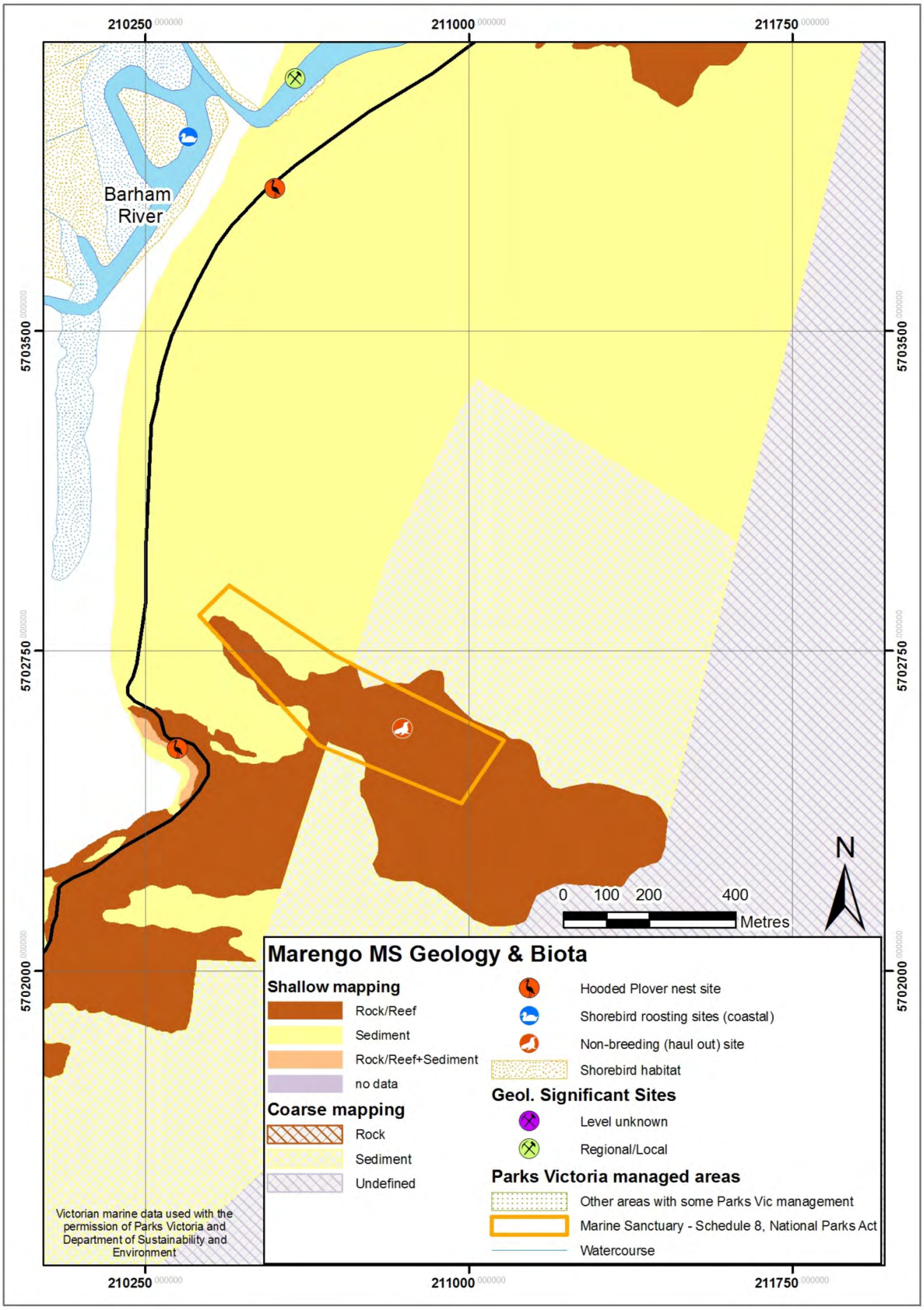


Figure 47. Coarse substrate mapping of Marengo Reefs Marine Sanctuary and surrounds, showing sites of geological and biotic significance.

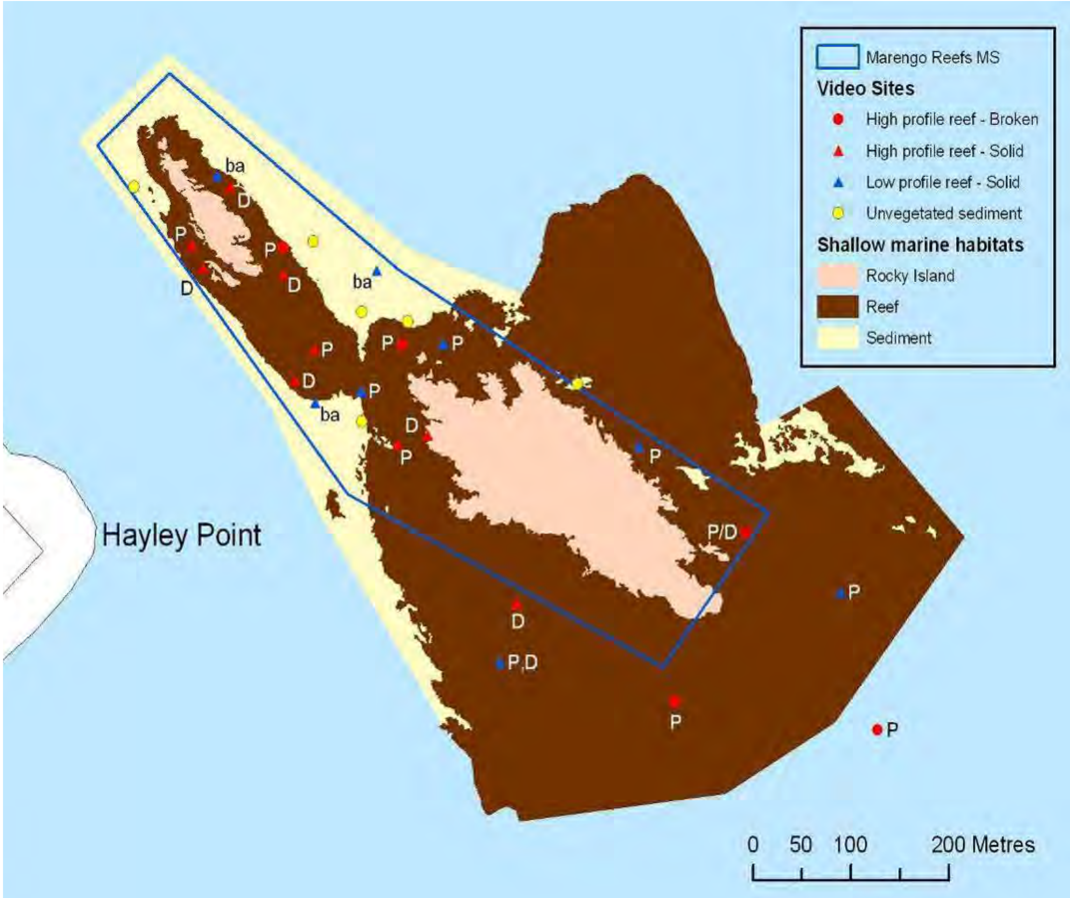


Figure 48. Detailed habitat mapping of Marengo Reefs Marine Sanctuary from Ball and Blake 2007. Dominant biota categories on the map ba = mixed brown algae, D = *Durvillea potatorum*, and P = *Phyllospora comosa*.

3.1.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring and mapping surveys in Marengo Reefs MS. This includes detailed mapping (Figure 44, Figure 48) of the MS (Ball and Blake 2007b). There have been five SRMP surveys of the shallow subtidal reef biota of Marengo Reefs MS (Hart *et al.* 2004; Hart *et al.* 2005b; Crozier *et al.* 2007). Brown algae dominate the diversity of macrophytes, birds and fish the vertebrates in species recorded in Marengo Reefs MS (Table 15, Appendix 1). There have been no further surveys of the biota of intertidal reef or the pelagic habitats. Important nearby locations for some birds are shown in Figure 47. The Outer Reef is a recognised state significant biota site for Australian fur seals *Arctocephalus pusillus doriferus*.

Table 15. Summary of the number of species in major biotic groups from surveys in Marengo Reefs Marine Sanctuary.

Biotic group	Number of species
Macrophytes	**42**
Green algae	4
Brown algae	23
Red algae	15
Invertebrates	**3**
Chitons	1
Gastropods	1
Echinoderms	1
Vertebrates	**48**
Fish	17
Birds	24
Mammals	7

Intertidal

Soft sediment

There is no intertidal soft sediment habitat in Marengo Reefs MS.

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 aggregating invertebrates

Bull kelp *Durvillaea potatorum* is the dominant algae around the edge of the intertidal reef with some *Phyllospora comosa* (Plummer *et al.* 2003; Ball and Blake 2007b).

Mobile invertebrates

Over 108 intertidal invertebrates, including nine seastar, five barnacles, seven crab and 52 mollusc species, have been recorded on Marengo Reefs MS (Plummer *et al.* 2003). No new surveys or research on intertidal invertebrates have been conducted other than that reported in Plummer *et al.* (2003).

Fish

No new surveys or research on intertidal fish have been conducted (Plummer *et al.* 2003).

Subtidal

Soft sediment

Subtidal soft sandy sediment surrounds the Inner Reef within the MS (Ball and Blake 2007b). No biological surveys have been undertaken of this community within the sanctuary to date (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 (Figure 54) 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.

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 major canopy species of the shallow reef at Marengo Reefs MS are bull kelp *D. potatorum* and crayweed *P. comosa* (Ball and Blake 2007b; Crozier *et al.* 2007). These species have large, stalk-like stipes and form a canopy 0.5-2 m above the rocky substratum. There is a relatively diverse assemblage of smaller brown algal species including *Cystophora retorta, C. moniliformis, Acrocarpia paniculata* (Crozier *et al.* 2007). Understorey communities have very few species and a very low cover of red and green algae (Crozier *et al.* 2007). Marengo Reefs MS have the lowest algal species richness of the monitored subtidal Central Victoria bioregion reefs (Crozier *et al.* 2007). The algal community on the subtidal reef in Marengo Reefs MS is similar to that of Eagle Rock MS with similar species present but in different abundances (Crozier *et al.* 2007). It is different from the monitored reference site at Barnham Black which is deeper (Crozier *et al.* 2007).

Figure 49. The cartrut welk *Dicathais orbita* on subtidal reef in Marengo Reefs Marine Sanctuary.

Invertebrate fauna

Common grazing subtidal invertebrates found in Marengo Reefs MS include the the blacklip abalone *Haliotis rubra* (Figure 50) and the warrener *Turbo undulatus.* The abundance of *H. rubra* is particularly high at the MS (Crozier *et al.* 2007). The predatory cartrut welk *Dicathais orbita* (Figure 49), tulip shell *Pleuroploca australasia,* triton *Cabestana spengleri,* red rock crab *Plagusia chabrus* and a variety of sea stars including *Tosia australis*, *Patiriella brevispina* are also found on the reef (Crozier *et al.* 2007). The purple urchin *Heliocidaris erythrogramma* also occurs in low abundance (Crozier *et al.* 2007). Like the algal community, the invertebrate community in the MS is similar to Eagle Rock MS and less diverse than that found at Point Addis (Crozier *et al.* 2007).

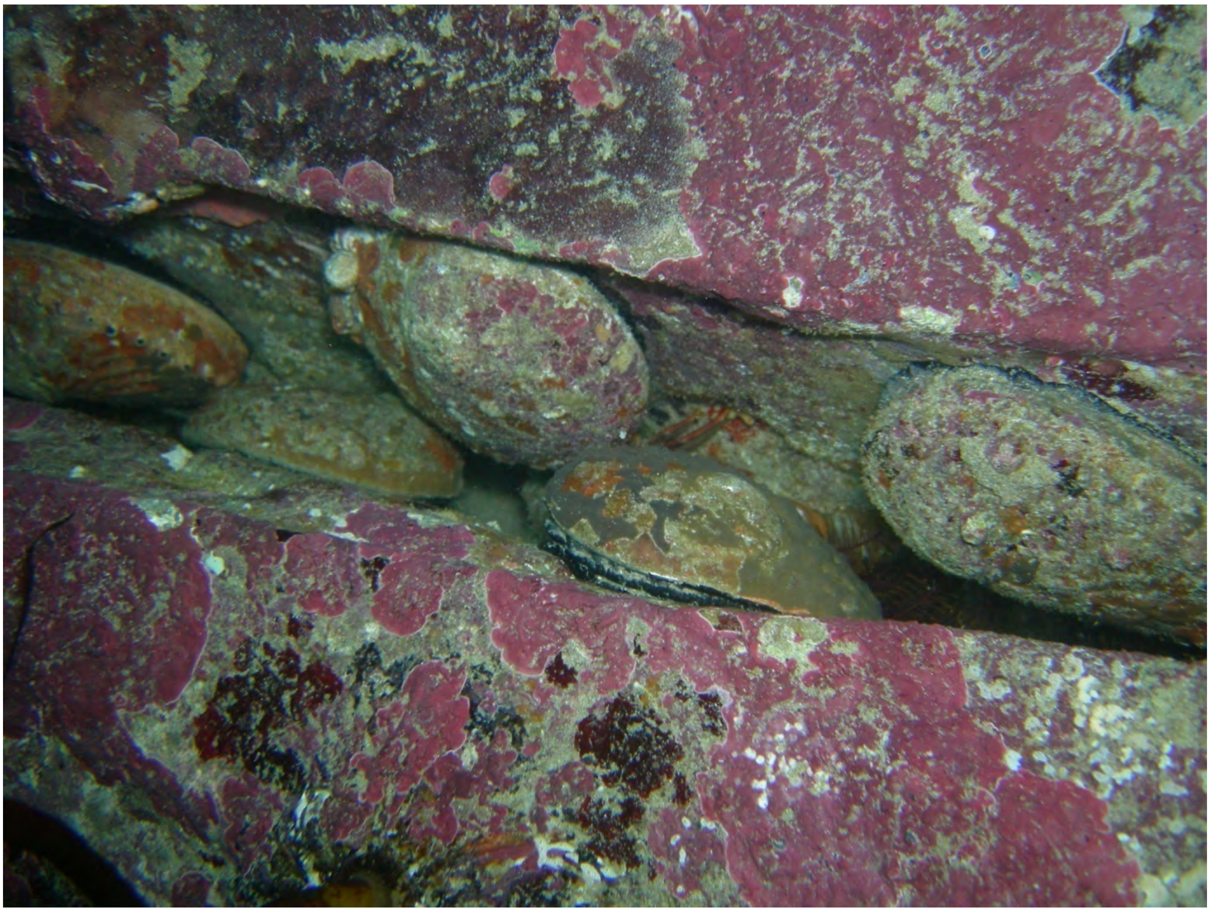


Figure 50. Blacklip abalone *Haliotis rubra* on subtidal reef in Marengo Reefs Marine Sanctuary.

Fish

Over 17 fish species have been recorded on the subtidal reefs of the MS (Hart *et al.* 2004; Hart *et al.* 2005a; Crozier *et al.* 2007; Figure 51). Fish species richness and diversity varies quite a lot over time (Hart *et al.* 2004; Crozier *et al.* 2007). Blue-throated wrasse *Notolabrus tetricus* (Figure 52), particularly the smaller females, are generally the most abundant species in the MS, similar to other reefs in the Central Victoria bioregion (Crozier *et al.* 2007). The purple wrasse *Notolabrus fucicola* occurs in higher desntieis at Marengo Reefs MS survey site than in other Central Victoria bioregion MPAs (Crozier *et al.* 2007; Keough and Carnell 2009). Other fish found on the subtidal reefs in the MS include herring cale *Odax cyanomelas,* magpie morwong *Cheliodactylus nigripes,* and in low abundance the horseshoe leatherjacket *Meuschenia hippocrepis* (Crozier *et al.* 2007). The Victorian scalyfin *Parma victoriae,* yellow striped leather jacket *Meuschenia flavolineata* and sea sweep *Scorpis aequipinnis* are found on other reefs in the Central Victoria bioregion but are absent from recent surveys at Marengo Reefs MS (Crozier *et al.* 2007; Keough and Carnell 2009).

Water column

The water column in the MS is an important habitat 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 shorebirds, seabirds, and mammals of conservation significance are found in the waters of Marengo Reefs MS.

Figure 51. Pike over subtidal reef kelp beds in Marengo Reefs Marine Sanctuary.

3.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is also 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 Marengo Reefs MS.

Fish

No conservation listed fish have been recorded in the Marengo Reefs MS.

Birds

Thirteen conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Marengo Reefs MS (Table 16). Four are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. One of these, the Australasian bittern *Botaurus poiciloptilus,* is listed as endangered and probably uses the wetlands of the Barham River rather than the MS itself. The Shy Albatross *Thallassarche cauta*, is listed as vulnerable nationally under the *EPBC Act (1999)*. It is more associated with the open ocean than the near shore. Six birds are recognized internationally under either CAMBA or JAMBA.

In the immediate surrounds of Marengo Reefs MS there are three state significant biotic sites (Figure 47). Hooded plovers *Thinornis rubricollis* nest on Haleys Point directly to the west of the MS and on the beach at Mounts Bay to the north of the MS. Barham River estuary and associated wetlands provide habitat for waders and waterfowl.

Table 16. Conservation listed shorebird and seabird records from Marengo Reefs 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
eastern great egret	*Ardea modesta*	L	VU		C	J
Australasian bittern	*Botaurus poiciloptilus*	L	EN			
hooded plover	*Thinornis rubricollis*	L	VU			
common sandpiper	*Actitis hypoleucos*		VU		C	J
ruddy turnstone	*Arenaria interpres*				C	J
pomarine jaeger	*Stercorarius pomarinus*				C	J
short-tailed shearwater	*Ardenna tenuirostris*					J
Pacific gull	*Larus pacificus*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
white-fronted tern	*Sterna striata*		NT			

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

Marine mammals and reptiles

The Australian fur seal *Arctocephalus pusillus doriferus* is a listed marine species under the *EPBC Act (1999)* and its haul out on Outer Reef is a declared a Special Protection Area (SPA) and state significant biotic site (Figure 47). Disturbance to the seals is minimized by restricting visitor access onto the Outer Reef and no anchoring, landing or launching of boats within 20 m of the Outer Reef (Parks Victoria 2007b). The SPA covers approximately 3 ha, or 25% of the MS (Parks Victoria 2007b). The Outer Reef supports a haul out area for approximately 200 fur seals which is relatively small in comparison to other Victorian colonies. Pupping has occurred here although it is not an established breeding site (Parks Victoria 2007b). The nationally vulnerable southern elephant seal *Mirounga leonina* has been recorded in or near the Marengo Reefs MS (Table 17).

Table 17. Conservation listed marine mammal records from Marengo Reefs Marine Sanctuary and surrounds.

Common name	Scientific name	FFG	EPBC
southern elephant seal	*Mirounga leonina*		VU
Australian fur seal	*Arctocephalus pusillus doriferus*		L

L = listed marine under EPBC, VU = Vulnerable

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 Marengo Reefs MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002a).

Nine biota (Table 18) have been recorded or presumed to be at their distributional limit in Marengo Reefs MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). Two red algae have been recorded and one gastropod is presumed to be at the easterly limit of their distribution in the MS (Table 18). One brown and one red algae are recorded as being at the western limit of their distribution with a further two algae, a chiton and one sea cucumber are presumed to be at the western limit of their distribution (O'Hara and Barmby 2000; O'Hara and Poore 2000). The distributional limits of the biota listed in Table 18 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 18. Marine species at their distribution limits in Marengo Reefs Marine Sanctuary (O'Hara and Barmby 2000; O'Hara 2002a).

Order	Family	Species	Common name	Category
Chordiales	Scytothamnaceae	*Scytothamnus australis*	brown algae	RW
Fucales	Cystoseiraceae	*Cystophora torulosa*	brown algae	PW
Ceramiales	Ceramiaceae	*Ceramium lenticulare*	red algae	RE
Ceramiales	Ceramiaceae	*Trithamnion aculeatum*	red algae	RE
Corallinales	Corallinaceae	*Spongites tunicatus*	red algae	PW
Hildenbrandiales	Hildenbrandiaceae	*Hildenbrandia expansa*	red algae	RW
Polyplacophora	Acanthochitonidae	*Acanthochitona retrojectus*	chiton	PW
Holothuroidea	Cucumariidae	*Apsolidium densum*	sea cucumber	PW
Gastropoda	Volutidae	*Notovoluta kreuslerae*	marine snail	PE

PE = presumed eastern limit, PW = presumed western limit, RE = recorded eastern limit, RW = recorded western limit.

In a study assessing the conservation of reef fishes in Victoria, Colton and Swearer (2009; 2010) observed 56 species of fish found around Marengo Reefs MS and Apollo Bay. They regard six as species of concern as they were numerically and spatially rare at the state level (Table 19). Barracuda *Sphyraena novaehollandiae*, common gurnard perch *Neosebastes scorpaenoides* and dusky morwong *Dactylophora nigricans* are targeted by fishermen outside the MPAs (Colton and Swearer 2010).

Table 19. Reef fishes of conservation concern recorded in Marengo Reefs Marine Sanctuary and Apollo Bay (Colton and Swearer, 2009; 2010). Species in bold are targeted through fishing outside MPAs.

Family	Species at risk	common name
Cheilodactylidae	*Dactylophora nigricans*	dusky morwong
Monacanthidae	*Thamnoconus degeni*	Degens leatherjacket
Moridae	*Eeyorius hutchinsi*	Tasmanian codling
Neosebastidae	*Neosebastes scorpaenoides*	common gurnard perch
Odacidae	*Haletta semifasciata*	blue weed whiting
Sphyraenidae	*Sphyraena novaehollandiae*	barracuda

Figure 52. Wrasse over subtidal reef kelp beds in Marengo Reefs Marine Sanctuary.

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 MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 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. Divers or snorkelers illegally taking edible species such as abalone, crayfish (Figure 53) and resident fish and thereby affecting the size distribution of these species within the sanctuary (subtidal reef).
2. Commercial tour groups or other organised groups of human visitors on or around the reef disturbing seals (intertidal reef).
3. Coastal infrastructure development causing increased sedimentation or turbidity in the sanctuary and thus affecting benthos, filter feeders or algae in the sanctuary (all habitats in MS).
4. Nutrient increase in the sanctuary as a result of increased human population causing changes in community composition in the sanctuary (intertidal and subtidal reef).
5. Fishing in areas surrounding the sanctuary resulting in reduced populations of fin fish in the sanctuary (subtidal reef).
6. Lack of clear boundary marks resulting in damage to or disturbance of sanctuary flora and fauna (all habitats in MS).
7. Increased quantity of sediment resulting from land practices around the estuary and discharged via the river affecting algae and filter feeders in the sanctuary (all habitats in MS).
8. Small size of the sanctuary affecting management decisions and resourcing, with flow on effects to habitats and communities in the sanctuary (all habitats in MS).
9. Lack of ecological knowledge leading to inappropriate/ineffective management and consequently affecting sanctuary species and communities (all habitats in MS).
10. Establishment of marine pests disrupting (*e.g.* by competition, predation) ecological processes in the sanctuary (intertidal and subtidal reef, subtidal soft sediment).
11. Lack of public awareness of the existence of a marine sanctuary leading to damage to or disturbance of sanctuary flora and fauna (intertidal and subtidal reef, subtidal soft sediment).
12. Small boat operation in the Gap (between the high points of Little Henty Reef) or personal water craft disturbing or damaging birds, seals, fish, intertidal algae and invertebrates (intertidal and subtidal reef).

Barwon Water's Marengo STP outfall discharges waste water from Apollo Bay, Skenes Creek and Marengo immediately to the west of the sanctuary. Barwon Water is required to comply with Environment Protection Authority license requirements and to undertake a monitoring program to assess the impact of the outfall on marine values. The close proximity of this outfall is cause for concern (Parks Victoria 2007b).

The introduction of invasive marine species threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most invasive marine species known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). No invasive species have been recorded from Marengo Reefs MS (Parks Victoria 2007b). It is thought that the introduced green shore crab *Carcinus maenas* is found within the MS. To the east in the 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). 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). *Grateloupia turuturu, Caulerpa racemosa* var. *cylindracea* and *Codium fragile* ssp. *fragile* were also recorded in Portland harbor in 2010 (John Lewis pers. comm.). Another species of particular concern is the marine fanworm *Sabella spallanzanii* (Parks Victoria 2003). Japanese kelp *Undaria pinnatifida* has recently been found in Apollo Bay harbour, which is 2.5 km to the north of Marengo Reefs MS, and there are grave concerns about its spread to the sanctuary. The harbour is used by a finfish, crayfish and abalone fishing fleet as well as charter boats and recreational craft (Parks Victoria 2007b). Both commercial and recreational boats can be vectors for invasive marine species. Prevention of the introduction of invasive marine species is the most effective management option (Parks Victoria 2007b). State guidelines for boat hull cleaning and maintenance have been developed (Parks Victoria 2007b).

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 is not currently in the Marengo Reefs MS but its spread into the park could have serious long term ecological consequences for rocky reef communities (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). A number of species are at the eastern or western limit of their distributional range at Marengo Reefs 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 Marengo Reefs MS (Parks Victoria 2007b). For example research is being conducted into marine pest species and several Japanese kelp surveys have been conducted in and around Apollo Bay harbour, Marengo Reefs MS and the Otway coast. There has also been some research investigating water quality issues which may impact on park natural values. Management actions have been implemented to try to minimise these threats (Parks Victoria 2007b). Ongoing subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Marengo Reefs MS.

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 Marengo Reefs 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).

Marengo Reefs MS does not have an ongoing intertidal reef monitoring program. The shallow subtidal reef monitoring program (SRMP; Edmunds and Hart 2003) in and around the Marengo Reefs MS began in January 2004. Since that time a monitoring and reference site at nearby Barham reef off Bunbury Point outside of the MNP (Figure 43) have been surveyed over five census events (Hart *et al.* 2004; Hart *et al.* 2005a; Crozier *et al.* 2007). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than 10 metres (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water.

Figure 53. Southern rocklobster *Janus edwardsii* under a ledge in Marengo Reefs Marine Sanctuary.

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 Marengo Reefs Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising 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 Japanese Kelp (*Undaria*) surveys

*The project is being led by DSE and includes sections of Marine National Parks and Sanctuaries.

Keough and Carnell's (2009) preliminary analysis of the SRMP data from the two census events up to 2006 was done at the Central Victoria bioregion level, including Point Addis MNP, Eagle Rock and Marengo Reefs MS. The analysis compared sites within MPAs to reference sites outside the MPAs. They found there was no significant difference in species richness and number of species between MPA and reference sites for the Central Victoria bioregion (Keough and Carnell 2009). The abundances of algae inside and outside the various MPAs showed a complex set of results. *Haliptilon roseum* displayed greater percentage cover overall at the MPA sites, which seemed primarily driven by greater abundances at Eagle Rock and Marengo Reefs MS. *Halopteris* spp. displayed a greater percentage cover in MPA sites at both Eagle Rock and Point Addis, but the opposite pattern at Marengo Reefs. Algal species *Acrocarpia paniculata*, *Ballia callitricha*, *Ecklonia radiata*, *Gelidium asperum*, *Phacelocarpus peperocarpus*, *Plocamium angustum Plocamium dilatatum* and *Rhodymenia australis* all tended to show a pattern of significantly greater abundance at the reference sites compared to the Eagle Rock and Marengo Reefs MS sites but not for Point Addis MNP. A similar pattern occurs for herring cale *Odax cyanomelas* and the predatory dogwelk *Dicathais orbita.* Blacklip abalone *Haliotis rubra* and warrener *Turbo undulatus* showed no statistical effect of the MPAs, but displayed greater mean abundances at Eagle Rock MS and Point Addis MNP (Keough and Carnell 2009).

Limitations to this work include the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). 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 targeted analysis of monitoring data in relation to conservation outcomes for the park will be done by 2013. Marengo Reefs is now be surveyed every second year as part of the SRMP.

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.

3.1.7 KNOWLEDGE GAPS

No new surveys exist for the ecological communities of intertidal reef habitat or subtidal soft sediments. There is little new data on fish abundances, distributions or interactions except in the shallow subtidal reef habitat. No information exists at present for the subtidal soft sediment or water column assemblages. Major threats have been identified for Marengo Reefs MS but we have limited knowledge of the affect on the natural values, particularly ecological communities.

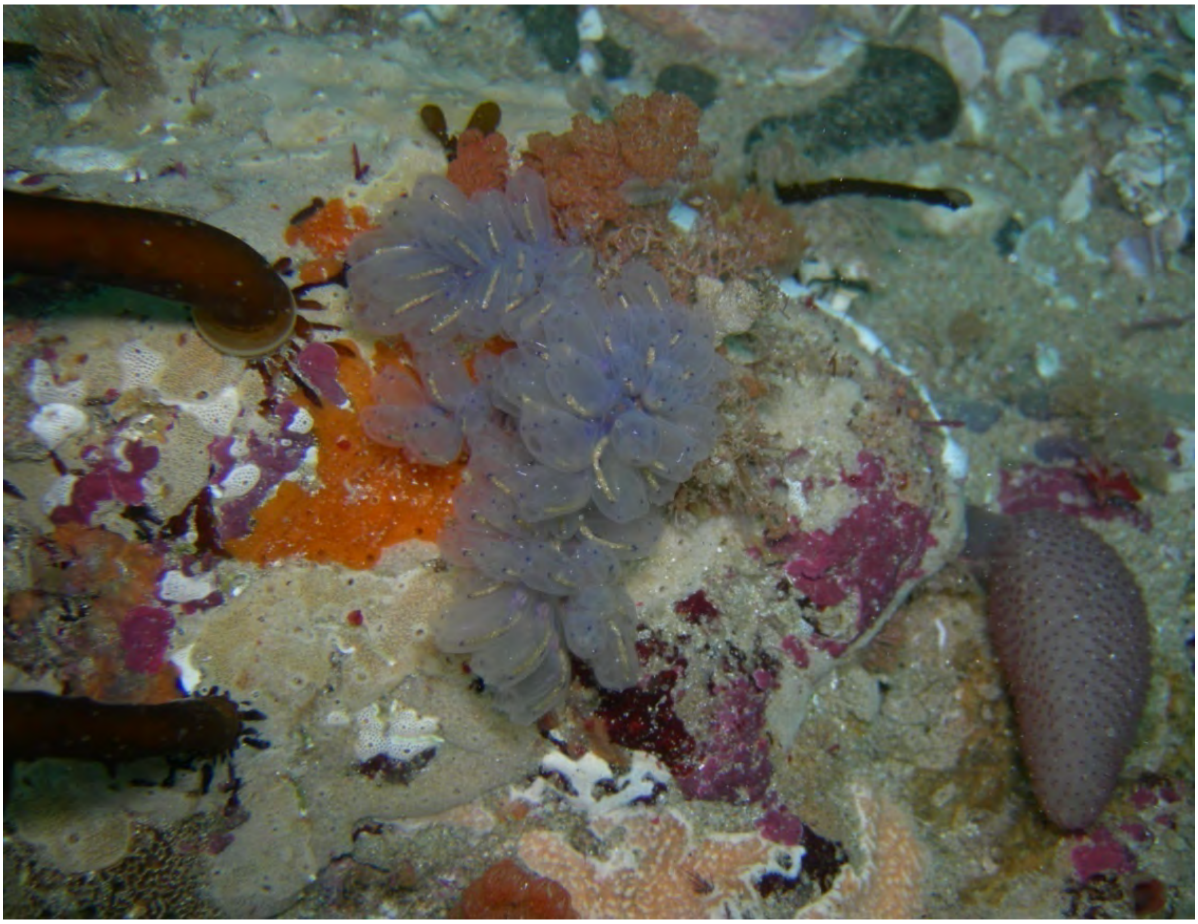


Figure 54. Colonial clavelinid ascidians on subtidal reef in Marengo Reefs Marine Sanctuary.

3.2 Eagle Rock Marine Sanctuary

Eagle Rock MS (Figure 55) is the one of five Marine Sanctuaries in the Central Victoria Bioregion, which also contains Point Addis, and Bunurong Marine National Parks. Eagle Rock MS is approximately 125 km west of Melbourne and 48 km south-west of Geelong in the township of Aireys Inlet. The MS covers 17.9 hectares. It extends from high water mark around the base of Split Point between Castle Rock and Sentinel Rock. It extends offshore for about 300 metres and includes the 20 m high Eagle Rock and Table Rock (Figure 57 and 58). Eagle Rock MS is accessible down stairs from Split Point lighthouse visitors' car park onto Step Beach, or from the Painkalac Creek car park by walking past the creek mouth.

Aboriginal tradition indicates that the Eagle Rock MS is part of the *Country* of the Wathaurung people (Parks Victoria 2005). Other Aboriginal communities, including Wathaurong Aboriginal Cooperative and the Southern Otways Indigenous Group have an association with the coastal region of this area (Parks Victoria 2005).

Important natural values of Eagle Rock MS are its intertidal (Figure 56) and subtidal sandstone and basalt reef (Figure 57), subtidal soft sediment, and open water that provide habitat for a diversity of marine flora and fauna species (ECC 2000; Carey *et al.* 2007b). The shoreline has a mixture of sandy beach and rocky reef. Its varied sandstone and basalt geology forms platforms, pools, fissures and boulder fields (Carey *et al.* 2007b).

Adjacent to Eagle Rock MS, the cliffs of Split Point are of state geological significance as a formation of Oligocene basalt together with pyroclastic and associated terriginous sediments. Aireys Inlet estuary to the west of the MS is regarded as geomorphically significant.

The brown algae Neptune's necklace *Hormosira banksii* is a key habitat forming plant on intertidal sandstone rocky reef (Ball and Blake 2007b; Porter and Wescott 2010). Twenty-five species of intertidal algae occur in the MS, of which fifteen are brown algae species (Porter and Wescott 2010). Over 48 species of intertidal invertebrates have been recorded including 36 species of mollusc (Costa *et al.* 2010; O'Hara *et al.* 2010). Grazers and deposit feeders are dominant on the basalt boulders (Porter and Wescott 2010). The variegated limpet *Cellana tramoserica,* siphon limpet *Siphonaria diemenensis* and the predatory cartrut whelk *Dicathais orbita* are abundant in the MS (Bathgate 2010; Porter and Wescott 2010). Stands of bull kelp *Durvillaea potatorum* grow on the intertidal reef edge (Ball and Blake 2007b; Porter and Wescott 2010).

Over 45 species of algae have been recorded on the subtidal reefs in Eagle Rock MS (Hart *et al.* 2004; Hart *et al.* 2005a; Crozier *et al.* 2007). Canopy forming algae is the large brown crayweed *Phyllospora comosa* (Ball and Blake 2007b; Crozier *et al.* 2007). The assemblage of smaller brown algae is relatively diverse, including *Cystophora retroflexa* and *Acrocarpia paniculata* (Crozier *et al.* 2007). Red and green understorey algae is not abundant or diverse in the MS (Crozier *et al.* 2007). The subtidal invertebrate community at Eagle Rock MS is dominated by the high abundance of the warrener *Turbo undulatus,* with low numbers of other invertebrates (Crozier *et al.* 2007). Twenty-five species of fish have been recorded in the subtidal reef region of the MS (Crozier *et al.* 2007). The most abundant species are the blue-throated wrasse *Notolabrus tetricus*, herring cale *Odax cyanomelas*, Scalyfin *Parma victoriae* and the yellow-striped leatherjacket *Meuschenia flavolineata* (Crozier *et al.* 2007).

Eagle Rock MS provides important feeding and roosting habitat for several threatened bird species such as the white-bellied sea-eagle, *Haliaeetus leucogaster*, which is listed under the *Flora and Fauna Guarantee* (*FFG*) *Act* (1998) and regarded as vulnerable in Victoria. The MS protects feeding areas for four internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). The intertidal reef of Table and Eagle rock provides an occasional haul-out area for

Australian fur seals *Arctocephalus pusillus doriferus*. Seven species of marine flora and fauna are believed to be at their eastern or western distributional limits within the MS.

Serious threats to the MS include limited ecological knowledge of important processes. Invasive marine pests, illegal fishing, increased nutrients from the land, trampling of the intertidal areas, disturbance of birds and seals, possible oil spills and climate change all pose serious threats to the integrity of Eagle Rock MS. Measures to address or minimise these threats form part of the management plan for Eagle Rock MS (Parks Victoria 2005). Ongoing subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Eagle Rock MS.

Figure 55. Eagle Rock Marine Sanctuary with Eagle Rock with Table Rock on the far right. Photo by Jan Barton, Deakin University.

3.2.1 PHYSICAL PARAMETERS & PROCESSES

Eagle Rock MS is 17.9 hectares in size which makes it the third smallest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 21, Figure 57). The reef is either sandstone or a mix of basalt and sandstone rising from a gently sloping sandy sea floor (Ball and Blake 2007b; Porter and Wescott 2010). The MS is predominately > 10 metres deep (Ball and Blake 2007b). Prevailing winds and swells are generally from the south-west in winter and south-east in spring/summer (Parks Victoria 2005). The sanctuary is influenced by high-energy waves and the associated movement of sand (Parks Victoria 2005). Tidal variation is 1.7 metres for spring tides and 0.9 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. Painkalac Creek discharges adjacent to Eagle Rock MS and Sandy Gully Creek discharges 0.8 km east of the MS (Table 21).

There are no declared sites of biotic significance in the MS (Figure 59). Spilt Point is geologically significant because of its Oligocene basalt together with pyroclastic and associated terriginous sediments of the Angahook Member. To the west of the MS Aireys Inlet at the mouth of Painkalac Creek is also regarded as a significant geological feature.

Table 21. Physical attributes of the Eagle Rock Marine Sanctuary.

Park Name	Eagle Rock
Conservation status	Marine Sanctuary
Biophysical Region	Central Victoria
Size	17.9 ha (ranked 22th of 24)
Length of coastline	~709 m
Shoreline geology	Sandstone and basalt
Area with depth:	
0-10 m (low res)*	0.34 ha
Intertidal	2.90 ha
Intertidal-2 m	3.69 ha
2-4 m	5.25 ha
4-6 m	4.72 ha
6-8 m	0.96 ha
8-10 m	0.01 ha
Mean tidal variation - spring	1.7 m
Mean tidal variation - neap	0.9 m
Mean water temp - summer	17.5°C
Mean water temp - winter	13°C
Adjacent catchment	Urban, Agricultural
Discharges into MNP	None
Nearest major estuary (distance & direction)	Painkalac Creek discharges immediately west Sandy Gully Creek discharges 0.8 km east

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

3.2.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats (Figure 59) 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, including emergency response, monitoring and research effectively. 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 Eagle Rock MS include intertidal and subtidal reef, soft sediment, and the water column. Eagle Rock MS has detailed bathymetry (Figure 57) and its habitat has been mapped with aerial survey, underwater video and ground truthing (Figure 58, Figure 59 & Figure 61) in 2004 (Ball and Blake 2007b).

The intertidal reef (Figure 60) in the west of the MS is a 60 to 90 m wide high-profile sandstone and basalt rock platform dominated by basalt boulders, with grazer or deposit feeding invertebrates. In the east of the MS a narrower, low profile sandstone platform dominated by the brown algae Neptune's necklace *Hormosira banksii* extends from the base of Eagle Rock (Ball and Blake 2007b; Porter and Wescott 2010). A small dynamic sand beach separates the two intertidal rock platforms (Ball and Blake 2007b).

Figure 56. Basalt boulders on the intertidal reef below the Split Point lighthouse cliffs in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

The inshore subtidal environment is a mix of bare sandy sediment, high and low profile patchy broken basalt and sandstone reef with a canopy of bull kelp *Durvillea potatorum* (Ball and Blake 2007b; Crozier *et al.* 2007). Further offshore the reef becomes low profile, less patchy and more solid, particularly in the north of the MS (Ball and Blake 2007b). The inshore beds of *D. potatorum* give way to a band of mixed brown algae, then extensive beds of *Phyllospora comosa* extending out to the seaward boundary (Ball and Blake 2007b). High profile broken reef is also present offshore (Ball and Blake 2007b). The MS has extensive areas of bare sand along its western edge and at its centre between Table and Eagle Rocks. The MS has a maximum depth of approximately 10 m (Ball and Blake 2007b).

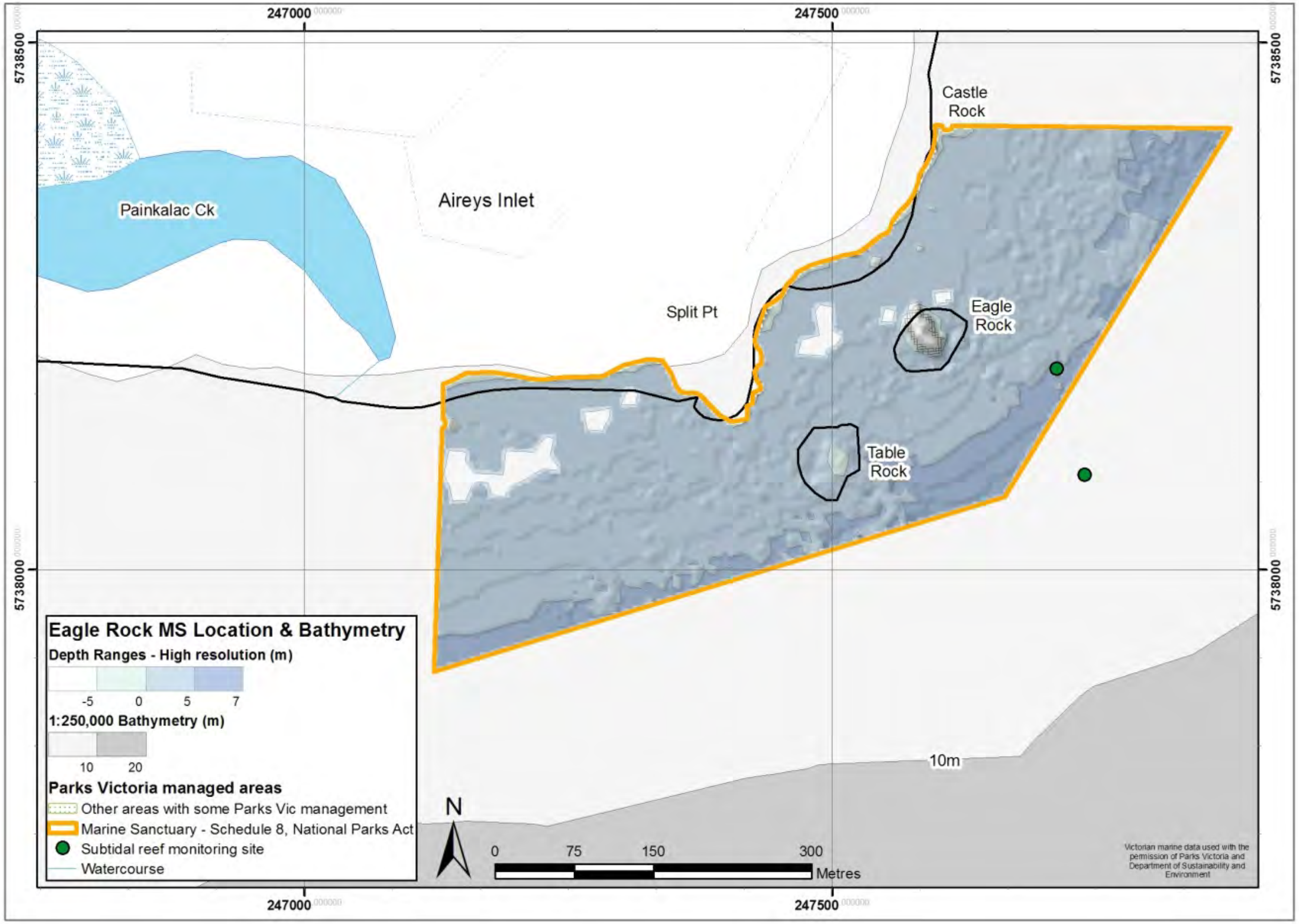


Figure 57. Location map of Eagle Rock Marine Sanctuary with bathymetry. Subtidal reef monitoring sites inside and outside the MS are shown, there are no intertidal reef monitoring sites.

Figure 58. Aerial photograph of Eagle Rock Marine Sanctuary (Geomatic Technology 13/12/2003). From Ball and Blake 2007.

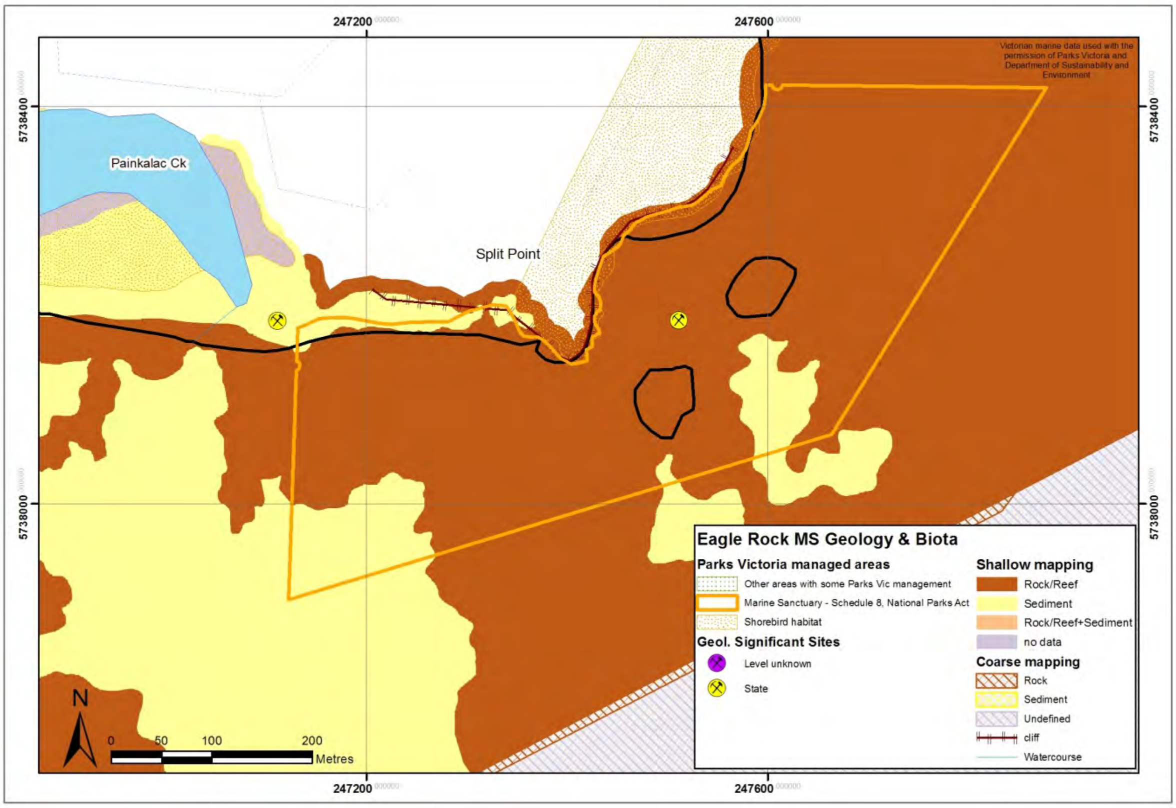


Figure 59. Coarse substrate mapping of Eagle Rock Marine Sanctuary and surrounds, showing sites of geological and biotic significance.

Figure 60. Intertidal soft sediment and reef in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

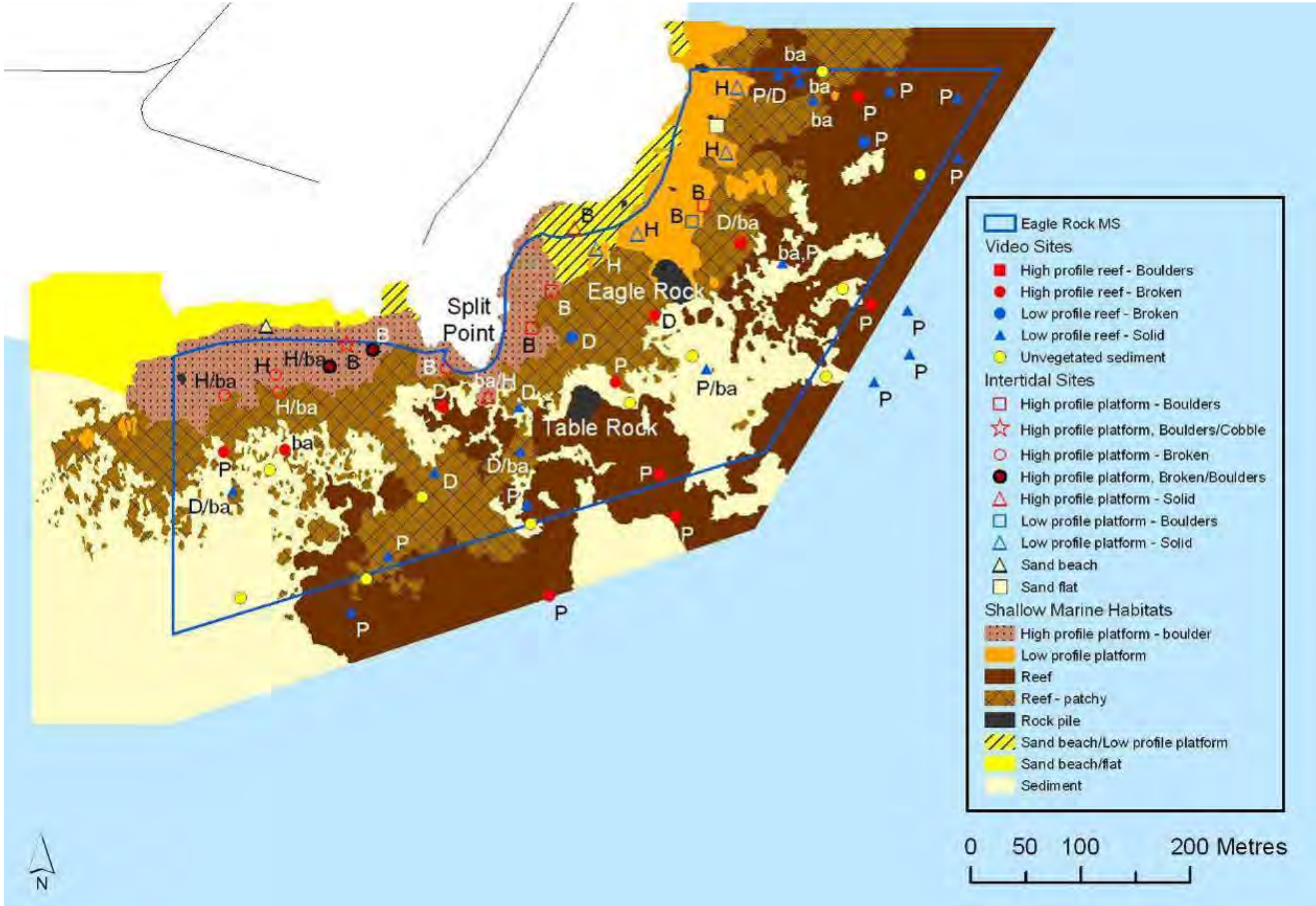


Figure 61. Detailed substrate mapping of Eagle Rock Marine Sanctuary from Ball and Blake 2007. Dominant biota categories on the map B = bare reef or sediment, ba = mixed brown algae, D = *Durvillea potatorum*, H = *Hormosira banksii* and P = *Phyllospora comosa*

3.2.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring and mapping surveys in Eagle Rock MS. This includes detailed bathymetric and habitat mapping of the MS (Ball and Blake 2007b). The intertidal biota has been surveyed as part of studies on human impacts on intertidal reefs (Costa *et al.* 2010; O'Hara *et al.* 2010; Porter and Wescott 2010) and gastropod recruitment (Bathgate 2010). There have been 5 SRMP surveys of the subtidal reef biota of Eagle Rock MS (Hart *et al.* 2004; Hart *et al.* 2005a; Crozier *et al.* 2007). Surveys conducted in the MS found that brown algae and red algae dominate the diversity of macrophytes, gastropods the invertebrates and birds and fish the vertebrates in Eagle Rock MS (Table 22, Appendix 1). There have been no surveys of the biota of the intertidal soft sediment nor pelagic habitats. There are no state significant biotic sites in the MS (Figure 59).

Table 22. Summary of the number of species in major biotic groups from surveys in Eagle Rock Marine Sanctuary.

Biotic group	Number of species
Macrophytes	**62**
Green algae	8
Brown algae	30
Red algae	24
Invertebrates	**46**
Cnidaria	3
Polychaetes	1
Barnacles	4
Decapod crustaceans	1
Chitons	3
Gastropods	32
Bivalves	2
Vertebrates	**52**
Ascidian	1
Fish	25
Birds	22
Mammals	4

Intertidal

Soft sediment

Flora is restricted to macroalgae drift and macroalgal epiphytes. The fauna of the intertidal soft sediment habitat in Eagle Rock MS has 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.

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; Figure 67). 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).

Figure 62. Intertidal reef dominated by the brown algae Neptune's necklace *Hormosira banksii* in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

Macroalgae and aggregating invertebrates

Twenty-five species of algae have been recorded in the MS, including fifteen brown algae species (Porter and Wescott 2010; Figure 68). The brown algae Neptune's necklace *Hormosira banksii* is a key habitat forming plant on the intertidal sandstone rocky reef (Ball and Blake 2007b; Porter and Wescott 2010; Figure 62). *Hormosira* mats provide shelter for a range of organisms, including gastropods, small crustaceans, polychaete worms, small foliose algae and articulating coralline algae. Mussel beds (Figure 64), coralline algae mats and barnacles (Figure 63) are generally sparse (Porter and Wescott 2010). Mixed brown and red algae, and the green algae *Caulerpa* grow in the intertidal rock pools (Porter and Wescott 2010). Articulating corallines form a dense cover at the extreme low tide mark and in rock pools (Porter and Wescott 2010).

Figure 63. Barnacles *Tetraclitella purpurescens* growing on the intertidal reef in Eagle Rock Marine Sanctuary. Photo Jan Barton, Deakin University.

Figure 64. Mussels *Austromytilus rostratus* growing on the intertidal reef in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

Mobile invertebrates

Over 48 species of intertidal invertebrates have been recorded in the MS including 36 species of mollusc (Costa *et al.* 2010; O'Hara *et al.* 2010; Figures 65 and 66). Grazers and deposit feeders, such as the black nerite *Nerita atramentosa,* are dominant in the basalt boulders (Porter and Wescott 2010). The scavenger chequerboard snail *Cominella lineolata* is more abundant in the rock rubble habitat (Porter and Wescott 2010). Eagle Rock MS, like Point Addis MNP and Point Danger MS, has a higher intertidal invertebrate species richness than other nearby intertidal reefs (Porter and Wescott 2010). Abundances of gastropods including the warrener *Turbo undulatus*, siphon limpet *Siphonaria diemenensis,* striped-mouth conniwink *Bembicium nanum,* variegated limpet *Cellana tramoserica* and ribbed top shell *Austrocochlea constricta* are significantly higher in the MPAs compared to other reefs (Porter and Wescott 2010). In Eagle Rock MS the micrograzers, the variegated limpet *C. tramoserica and* siphon limpet *S. diemenensis,* and the predatory cartrut whelk *Dicathais orbita* are more abundant compared to other Central Victoria MPAs (Bathgate 2010). Five regionally uncommon intertidal invertebrates were found in Eagle Rock MS (Porter and Wescott 2010). They included three crabs, the shore *Cyclograpsis granulosis*, spider *Notomitrax sp* and red swimmer *Nectocarcinus turberculosus*; the flame limpet *Notoacmea flammea* and green algae *Codium pomoides* (Porter and Wescott 2010).

Fish

No specific information on the fish species on intertidal reefs has been found for Eagle Rock MS (Plummer *et al.* 2003).

Figure 65. Sessile tube worm *Galeolaria caespitosa*, barnacles and mobile gastropods black nerite *Nerita atramentosa* and limpet *Cellana tramoserica* on an intertidal boulder in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

Figure 66. The pulmonate gastropod *Onchidella patelloides* on the intertidal reef in Eagle Rock Marine Sanctuary.

Subtidal

Soft sediment

No biological surveys have been undertaken of this community (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 (< 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.

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. Canopy forming algae in Eagle Rock MS is the large brown crayweed *Phyllospora comosa* (Crozier *et al.* 2007). The assemblage of smaller brown algae is relatively diverse, including *Seirococcus axillaris, Cystophora retroflexa* and *Acrocarpia paniculata* (Crozier *et al.* 2007). There are very few species and a very low cover of red and green understorey algae in the MS especially compared to Point Addis MNP (Crozier *et al.* 2007). Encrusting coralline algae has a low cover (Crozier *et al.* 2007). Over 45 species of algae have been recorded on the subtidal reefs in Eagle Rock MS. Similar algal species are present in Marengo Reefs MS, but occur in different abundances to produce different community structures (Crozier *et al.* 2007). Sand coverage of the reef is high in Eagle Rock MS and influences the algal species composition (Crozier *et al.* 2007).

Invertebrate fauna

The subtidal invertebrate community at Eagle Rock MS is dominated by the high abundance of the warrener *Turbo undulatus,* with low numbers of other invertebrates (Crozier *et al.* 2007). This includes the blacklip abalone *Haliotis rubra* and a variety of sea stars, including biscuit *Tosia australis* and *Pentagonaster dubeni*, eleven armed *Coscinasterias muricata* and the many-pored *Fromia polypore* seastars (Crozier *et al.* 2007). Like the algal community the invertebrate community does not have as many species as Point Addis MNP and is more similar to Marengo Reefs MS (Crozier *et al.* 2007).

Fish

Twenty-five species of fish have been recorded on the subtidal reef in the MS (Crozier *et al.* 2007). The most abundant species are the blue-throated wrasse *Notolabrus tetricus*, herring cale *Odax cyanomelas*, scalyfin *Parma victoriae* and the yellow-striped leatherjacket *Meuschenia flavolineata* (Crozier *et al.* 2007). Other fish species include the horseshoe leatherjacket *Meuschenia hippocrepis,* sea sweep *Scorpis aequipinnis* and low abundances of magpie morwong *Cheliodactylus nigripes.* Sharks and rays such as the Port Jackson shark *Heterodontus portusjacksoni*, necklace carpetshark *Parascyllium variolatum* and sparsely-spotted stingaree *Urolophus paucimaculatus* have also been recorded on the subtidal reef.

Figure 67. The seagrass *Amphibolis antarctica* growing in a rockpool in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

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 shorebirds, seabirds and mammals of conservation significance are found in the relatively shallow waters of Eagle Rock MS.

Figure 68. The subtidal brown algae bull kelp *Durvillaea potatorum* in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

3.2.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is also 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 Eagle Rock MS.

Fish

There a no recorded conservation listed fish in Eagle Rock MS.

Birds

Seven conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Eagle Rock MS (Table 16). Five are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. The white-bellied sea-eagle, *Haliaeetus leucogaster* is regarded as vulnerable, and the others as near threatened. No birds listed as threatened at the national level have been recorded in the MS. Four birds are recognized internationally under either CAMBA or JAMBA.

Table 23. Conservation listed shorebird and seabird records from Eagle Rock Marine Sanctuary and surrounds.

		Victorian listing		International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**CAMBA**	**JAMBA**
Caspian tern	*Hydroprogne caspia*	L	NT	C	J
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU	C	
sooty shearwater	*Ardenna grisea*			C	J
short-tailed shearwater	*Ardenna tenuirostris*				J
Pacific gull	*Larus pacificus*		NT		
black-faced cormorant	*Phalacrocorax fuscescens*		NT		
common diving-petrel	*Pelecanoides urinatrix*		NT		

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

Marine mammals and reptiles

The intertidal reef of Table and Eagle rocks provides an occasional haul-out area for *EPBC Act (1999)* listed Australian fur seals *Arctocephalus pusillus doriferus*.

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 Eagle Rock MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002a).

Seven biota (Table 24) are presumed to be at their distributional limit in Eagle Rock MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). Five red algae are presumed to be at the easterly limit of their distribution (Table 24). One crab and one marine snail are presumed to be at their western limit of distribution (O'Hara and Barmby 2000; O'Hara and Poore 2000). The distributional limits of the biota listed in Table 24 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 24. Marine species at their distribution limits in Eagle Rock Marine Sanctuary (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002a).

Order	Family	Species	Common name	Category
Ceramiales	Ceramiaceae	*Muellerana wattsii*	red algae	PE
Ceramiales	Ceramiaceae	*Psilothallia siliculosa*	red algae	PE
Corallinales	Corallinaceae	*Lesueuria mindeniana*	red algae	PE
Gigartinales	Phyllophoraceae	*Ahnfeltiopsis humilis*	red algae	PE
Gigartinales	Polyidaceae	*Rhodopeltis australis*	red algae	PE
Brachyura	Hymenosomatidae	*Amarinus paralacustris*	crab	PW
Gastropoda	Olividae	*Belloliva leucozona*	marine snail	PW

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

Figure 69. Beach washed plastic, macroalgae and leatherjacket in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

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 MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 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). 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. Lack of ecological knowledge about hydrology, habitats, population dynamics including recruitment, geomorphology and sand movement, and fisheries management leading to less effective management of communities and habitats (all habitats in MS);
2. New and emerging marine pests, including pathogens, displacing local species and causing ecological change (intertidal and subtidal reef and soft sediment);
3. Illegal harvesting (organised poaching) of abalone leading to decreased population viability and flow-on effects to other organisms (subtidal reef);
4. Increased nutrients and heavy metals from sewage outfall causing any loss of seagrass or reef biota (intertidal and subtidal reef and soft sediment);
5. Trampling and disturbance to intertidal platforms causing greater than natural variability in communities (intertidal reef);
6. Increased shore-based development leading to increases in small boating activity which may cause physical damage to habitats and communities greater than that caused naturally (intertidal and subtidal reef and soft sediment);
7. Man-made discharges of freshwater/stormwater from outfalls and estuaries (the latter due to increased mechanical opening) leading to changes in subtidal communities greater than natural variation (intertidal and subtidal reef and soft sediment);
8. Increased shore-based development leading to increased cost of management and consequent effects on park communities and habitats (intertidal and subtidal reef and soft sediment);
9. Plastic and other litter from sea or land leading to injury or death of resident or transient organisms and thus reduced community viability (all habitats in MS; Figure 69);
10. Moderate (*i.e.* not major spill from shipwreck) oil pollution from sea, either deliberate or accidental, having sublethal effects on biota in more than 5% of a park (all habitats in MS);
11. Dogs, horses and vehicles reducing viability of populations of birds and seals; and
12. Physical damage, pollution or cleanup impacts of a shipwreck sufficient to invoke an AMSA response, and resulting in any impacts on the parks (all habitats in MS).

Human visitation to Central Victoria bioregion intertidal reefs is highest during summer, coinciding with very low tides in the middle of the day potentially creating greatest impact at this time (Porter and Wescott 2010). Harvesting is prohibited in MPAs but trampling can reduce the cover of algae, particularly Neptune's necklace *Hormosira banksii* and impact the intertidal community (Porter and Wescott 2010). Smaller *Turbo undulatus*, *Austrocochlea constricta*, and *Dicathais orbita* are found on high use shores outside the MPAs (Porter and Wescott 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). No introduced species or marine pest has been recorded from Eagle Rock MS. It is thought that the introduced green shore crab *Carcinus maenas* is found within the MS. Species of particular concern from Port Phillip Bay include the marine fanworm

Sabella spallanzanii, Japanese kelp *Undaria pinnatifida,* Northern Pacific Seastar *Asterias amurensis* and broccoli weed *Codium fragile (subsp. fragile)* (Parks Victoria 2003). *Undaria pinnatifida* has also recently been found in Apollo Bay harbour.

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 is not in the Eagle Rock MS but its spread into the park could have serious long term ecological consequences for rocky reef communities (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). Some species are at the eastern or western limit of their distributional range in Eagle Rock MS and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in Flinders and Twofold Shelf bioregions, has increased its range down the east coast of Australia to Tasmania and that increase is thought to be linked to climate change with the EAC extending further south (Banks *et al.* 2010).

Measures to address or minimise these threats form part of the management plan for Eagle Rock MS (Parks Victoria 2005). For example research is being conducted into marine pest species, and investigations into water quality issues which may impact on park natural values have also been undertaken. 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 Eagle Rock 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 25 and Appendix 2).

Table 25. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Eagle Rock Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising 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 project is being led by DSE and includes sections of Marine National Parks and Sanctuaries.

Eagle Rock MS does not have an ongoing intertidal reef monitoring program. The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003) in and around the Eagle Rock MS began in December 2003. Since that time an MPA site and reference site outside of the MS (Figure 57) have been surveyed over five census events (Hart *et al.* 2004; Hart *et al.* 2005a; Crozier *et al.* 2007). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than 10 metres (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water.

Keough and Carnell's (2009) preliminary analysis of the SRMP data from the two census events up to 2006 was done at the Central Victoria bioregion level, including Point Addis MNP, Eagle Rock and Marengo Reefs MS. The analysis compared sites within MPAs to reference sites outside the MPAs. They found there was no significant difference in species richness and number of species between MPA and reference sites for the Central Victoria bioregion (Keough and Carnell 2009). The abundances of algae inside and outside the various MPAs showed a complex set of results. *Haliptilon roseum* displayed greater percentage cover overall at the MPA sites, which seemed primarily driven by greater abundances at Eagle Rock and Marengo Reefs MS. *Halopteris* spp. displayed a greater percentage cover in MPA sites at both Eagle Rock and Point Addis, but the opposite pattern at Marengo Reefs. Algal species *Acrocarpia paniculata*, *Ballia callitricha*, *Ecklonia radiate*, *Gelidium asperum*, *Phacelocarpus peperocarpus*, *Plocamium angustum, Plocamium dilatatum* and *Rhodymenia australis* all tended to show a pattern of significantly greater abundance at the reference sites compared to the Eagle Rock and Marengo Reefs MS sites but not for Point Addis MNP. A similar pattern occurs for herring cale *Odax cyanomelas* and the predatory dogwelk *Dicathais orbita.* Blacklip abalone *Haliotis rubra* and warrener *Turbo undulatus* showed no statistical effect of the MPAs, but displayed greater mean abundances at Eagle Rock MS and Point Addis MNP (Keough and Carnell 2009).

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 targeted analysis of monitoring data 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). Eagle Rock is now surveyed every two years.

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.

Figure 70. Intertidal reef in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

3.2.7 KNOWLEDGE GAPS

No new surveys exist for the ecological communities of intertidal soft sediments. There is data on fish abundances, distributions or interactions in the shallow subtidal reef habitat, but little new data for other habitats in the sanctuary. No information exists at present for subtidal soft sediment or water column assemblages. Major threats have been identified for Eagle Rock MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.

Figure 71. Table Rock in Eagle Rock Marine Sanctuary. Photo by Jan Barton, Deakin University.

3.3 Point Danger Marine Sanctuary

Point Danger MS is the one of five Marine Sanctuaries in the Central Victoria Bioregion, which also contains Point Addis, and Bunurong Marine National Parks. Point Danger MS is approximately 100 km west of Melbourne, 20 km south-west of Geelong close to the township of Torquay and nearby Jan Juc. The MS covers 21.7 hectares. It extends from the high water mark of the prominent limestone headland of Point Danger offshore for approximately 600 metres east and 400 metres south, encompassing an offshore limestone rock platform (Figure 73 & Figure 74). Point Danger MS is accessible from the Point Danger car park and viewing area or from adjacent beaches.

Aboriginal tradition indicates that Barwon Bluff Marine Sanctuary is part of *Country* of the Wathaurung people, who continue to have a close relationship with the sanctuary (Parks Victoria 2005).

Important natural values of Point Danger MS are its limestone intertidal (Figure 73 and 75) and subtidal reef, subtidal soft sand sediment and water column. It has a high invertebrate diversity, and is particularly recognised for its diverse opisthobranch (sea slug) fauna (ECC 2000; Carey *et al.* 2007b). Ninety-six species are found in the MS and many are endemic.

An extensive low profile limestone platform extends eastward from Point Danger into low profile subtidal reef (Ball and Blake 2007b). The reef platform has a high proportion of broken reef, rubble and cobbles interspersed with sand (Edmunds *et al.* 2004; Porter and Wescott 2010). The intertidal and subtidal reef is buried or exposed by mobile sand under the influence of strong wave energy (Ball and Blake 2007b; Edmunds *et al.* 2010). The algae on the platform is dominated by Neptune's necklace *Hormosira banksii* and mixed brown algae subtidally (Ball and Blake 2007b). Extensive areas of the seagrass *Amphibolis antarctica* mixed with algae grow over reef and sediment in the more sheltered north-eastern region of the MS (Ball and Blake 2007b). Patches of small coralline and filamentous turfing species, sea lettuce *Ulva* sp. and the mat-forming mussel *Limnoperna pulex,* are common on the intertidal platform (Ball and Blake 2007b; Edmunds *et al.* 2010). The mobile invertebrate fauna is dominated by molluscs (Edmunds *et al.* 2010; Porter and Wescott 2010). The pulmonate limpet *Siphonaria* spp., striped conniwink *Bembicium nanum* and rugose slit limpet *Clypidina rugosa* are the most abundant (Bathgate 2010; Edmunds *et al.* 2010). The snails *Dicathais orbita*, *Lepsiella vinosa*, *Turbo undulates* and limpet *Patelloida alticostata* occur at lower densities (Edmunds *et al.* 2010). The subtidal reef and soft sediment invertebrate and fish fauna have not been surveyed for Point Danger MS.

Point Danger MS provides important feeding and roosting habitat for several 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 12 internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Two species of marine flora and fauna are believed to be at their western distributional limits within the MS.

The MS is popular for kite surfing, sailboarding, surfing and sea kayaking (Parks Victoria 2005). This is recognised in a 10 ha special management overlay the Point Danger Marine Sanctuary Sail-powered Only Area, for sailboards and kite boarding. There is one known shipwreck in Point Danger MS, the 1891 North American wooden cargo sailing ship *Joseph H. Scammell* (Parks Victoria 2005).

Serious threats to the MS include limited ecological knowledge of important processes. Additionally, invasive marine pests, illegal fising, trampling and disturbance from rambling and boating, discharge from the land, possible oil spills and climate change all pose serious threats to the integrity of Point Danger MS (Carey *et al.* 2007b). Measures to address or minimise these threats form part of the management plan for Point Danger MS (Parks

Victoria 2005). Ongoing intertidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to, Point Danger MS.

3.3.1 PHYSICAL PARAMETERS & PROCESSES

Point Danger MS is 21.7 hectares in size which makes it the 4th smallest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 26, Figure 73). It consists mainly of a large, flat limestone reef that is only exposed at low tides less than 0.5 m (Bird 1993; Porter and Wescott 2010). The MS is predominately < 7 m deep (Ball and Blake 2007b). Point Danger MS is exposed to strong winds, large swell and currents that are typical of open coastal locations (Edmunds *et al.* 2004; Ball and Blake 2007b). Prevailing winds and swells are generally from the south and south-west (Edmunds *et al.* 2004). Its intertidal platform is influenced by easterly sand movement along the open coastline (Edmunds *et al.* 2004). The tidal variation is 2.1 metres for spring tides and 0.7 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. Spring Creek discharges 1 km to the west of Point Danger MS and Barwon River 20 km to the east (Table 26).

There are no declared sites of geological or geomorphological or biotic significance in the MS (Figure 75). To the west near the mouth of Spring Creek there is the geologically significant Jan Juc (Rocky) Point. Significant because of its Zeally limestone, a member of the Puebla formation containing fossils, bryozoal calcarenite with thin beds of calcirodite.

Table 26. Physical attributes of the Point Danger Marine Sanctuary.

Park Name	Point Danger
Conservation status	Marine Sanctuary
Biophysical Region	Central Victoria
Size	21.7 ha (ranked 21st of 24)
Length of coastline	~139 m
Shoreline geology	limestone
Area with depth:	
Intertidal	9.19 ha
Intertidal-2 m	3.57 ha
2-4 m	4.50 ha
4-6 m	2.63 ha
6-8 m	1.82 ha
Mean tidal variation - spring	2.1 m
Mean tidal variation - neap	0.7 m
Mean water temp - summer	17.5°C
Mean water temp - winter	13.5°C
Adjacent catchment	Urban, Agricultural
Discharges into MNP	None
Nearest major estuary (distance & direction)	Spring Creek 1 km west Barwon River 30 km east

3.3.2 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 target management activities, including emergency response, monitoring and research effectively. 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.

Shallow habitats up to depths of about 7 m were mapped in Point Danger (Figure 77) from 1999 and 2004 aerial photography (Ball and Blake 2007b). Site visits and underwater video ground-truthed habitat types and identified dominant macroalgae and seagrasses. The main habitats present in Point Danger MS are intertidal and subtidal limestone reef with extensive low profile rock platform extending eastward from Point Danger into low profile subtidal reef (Ball and Blake 2007b). The reef platform has a high proportion of broken reef, rubble and cobbles interspersed with sand (Edmunds *et al.* 2004; Porter and Wescott 2010). Its surface has been eroded to make it rugose, with a relief of 10-15 cm and it quickly drains or floods with the tide (Edmunds *et al.* 2004).

The biota on the platform is dominated by Neptune's necklace *Hormosira banksii* changing to mixed brown algae on the edge of the platform and subtidally (Ball and Blake 2007b). Rockpools have a sand seabed with brown algae and seagrass *Amphibolis antarctica.* Extensive areas of the *A.antarctica* mixed with algae grows amongst patchy and broken low profile reef in the north-eastern region of the MS (Ball and Blake 2007b). Only small patches of seagrass grow in the more exposed south (Ball and Blake 2007b). Intertidal soft sediment consists of a sandy beach around Point Danger and a low profile sandy platform in the north of the MS. The rocky intertidal platform is continually buried or exposed by mobile sand under the influence of strong wave energy, sand cover varies from 2 – 30 % (Ball and Blake 2007b; Edmunds *et al.* 2010).

Figure 72. Intertidal reef in Point Danger Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

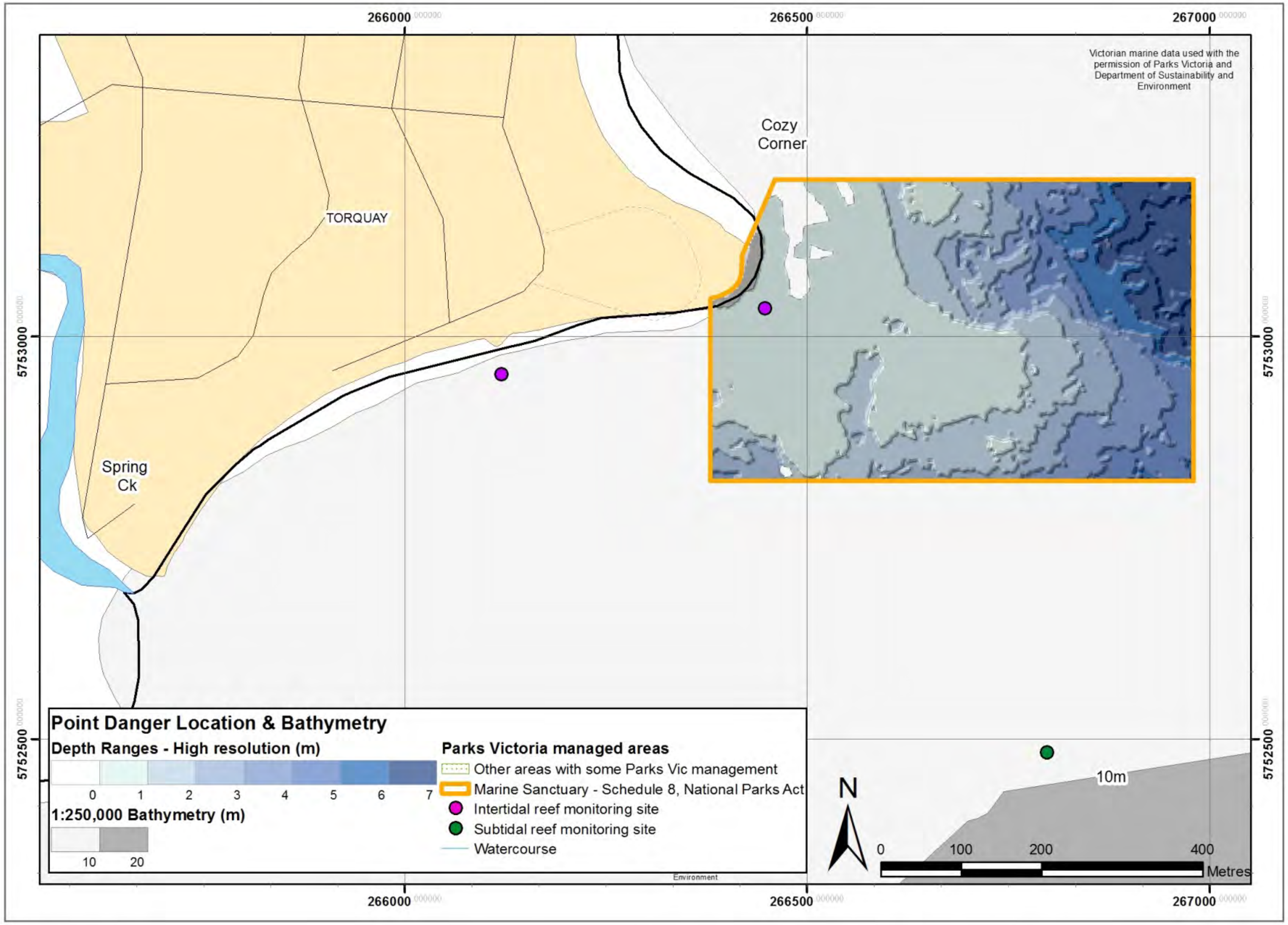


Figure 73. Location map of Point Danger Marine Sanctuary with bathymetry. Intertidal reef monitoring sites inside and outside the MS are shown, there are no subtidal monitoring sites.

Figure 74. Aerial view of Point Danger Marine Sanctuary (Geomatic Technology, 13/12/03). From Ball and Blake (2007).

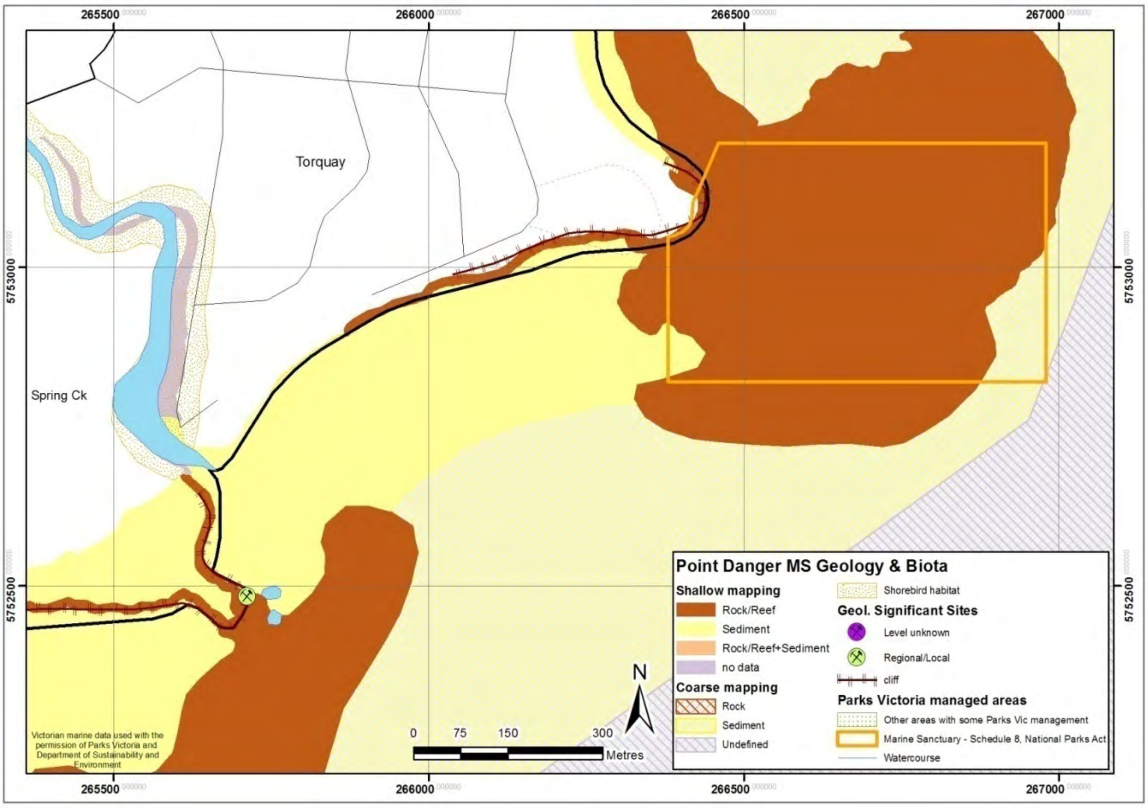


Figure 75. Coarse substrate mapping of Point Danger Marine Sanctuary and surrounds, showing sites of geological and biotic significance.

Figure 76. Intertidal reef platform Point Danger Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

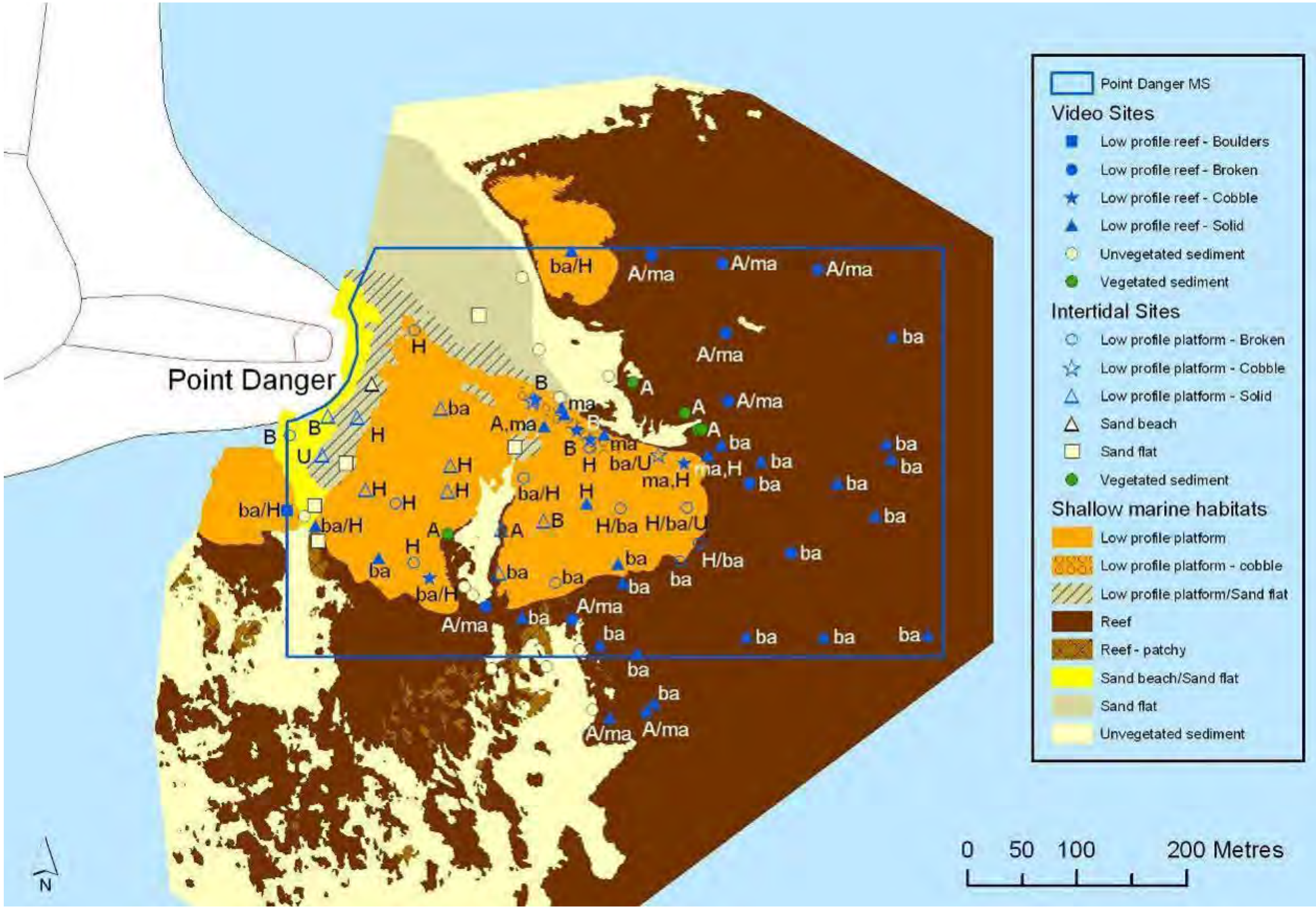


Figure 77. Detailed substrate mapping of Point Danger Marine Sanctuary from Ball and Blake 2007. Dominant biota categories on the map A = *Amphibolis antarctica* B = bare reef or sediment, ba = mixed brown algae, H = *Hormosira banksii*, ma = mixed algae and U = Ulva

3.3.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring and mapping surveys in Point Danger MS. This includes detailed habitat mapping of the MS (Ball and Blake 2007b). The intertidal biota has been surveyed as part of a study on human impacts on intertidal reefs (Porter and Wescott 2010) and gastropod recruitment (Bathgate 2010). There have been six intertidal reef monitoring program (IRMP) surveys of the intertidal reef biota of Point Danger MS (Edmunds *et al.* 2004; Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010). Surveys in the MS have found that gastropods dominate the diversity invertebrates and birds the vertebrates in Point Danger MS (Table 27, Appendix 1).There have still been no surveys of the biota of soft sediments, subtidal reef or the pelagic habitats. There are no recognised state significant biota sites in the MS (Figure 75).

Table 27. Summary of the number of species in major biotic groups from surveys in Point Danger Marine Sanctuary.

Biotic group	Number of species
Macrophytes	**9**
Blue-green algae	1
Green algae	3
Brown algae	2
Red algae	3
Invertebrates	**25**
Cnidaria	3
Polychaetes	1
Barnacles	1
Decapod crustaceans	1
Chitons	1
Gastropods	16
Bivalves	2
Vertebrates	**43**
Birds	38
Mammals	5

Intertidal

Soft sediment

Flora is restricted to macroalgae drift and macroalgal epiphytes. 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. No surveys are known of the biota of the intertidal soft sediment habitat in Point Danger MS.

Reef

Rocky intertidal reefs (Figure 81), 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, including 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).

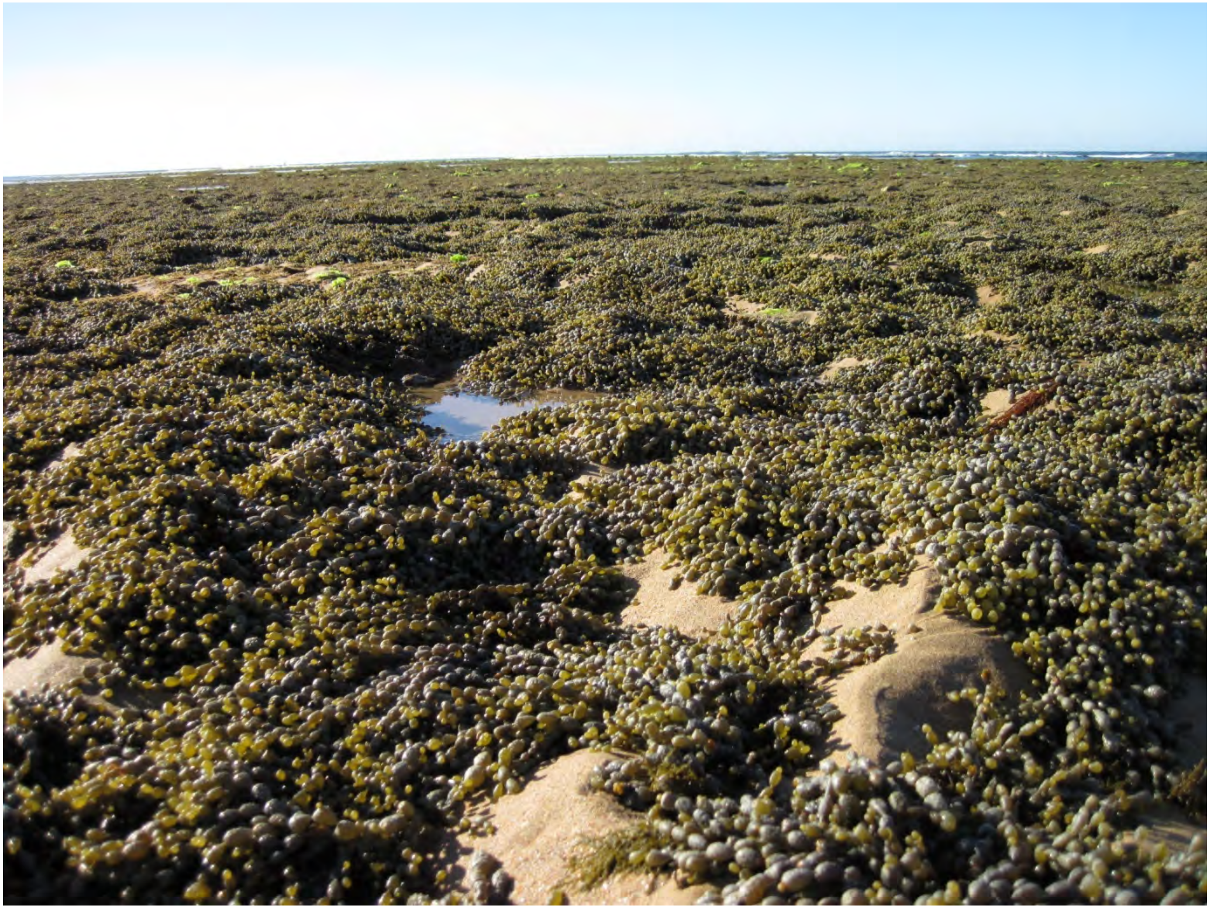


Figure 78. The brown algae Neptune's necklace *Hormosira banksii* on the intertidal reef in Point Danger. Photo by Mark Rodrigue, Parks Victoria.

Macroalgae and aggregating invertebrates

Twenty-six species of plants have been recorded intertidally in the MS, including fifteen brown algae species (Porter and Wescott 2010). The brown algae Neptune's necklace *Hormosira banksii* (Figure 78) is a key habitat forming plant on the intertidal limestone rocky reef (Ball and Blake 2007b; Edmunds *et al.* 2010; Porter and Wescott 2010). Assemblages of mixed brown algae include *Cystophora moniliformis, C. Retorata, C. Subfarcinata, Notheia anomala* and *Sargassum* spp. (Porter and Wescott 2010). Patches of small coralline and filamentous turfing species, sea lettuce *Ulva* sp (Figure 82) and the mat-forming mussel *Limnoperna pulex* are also common (Ball and Blake 2007b; Edmunds *et al.* 2010).

Mobile invertebrates

Over 44 species of intertidal invertebrates (Figures 79, 80 and 83) have been recorded in Point Danger MS including 25 species of mollusc (Edmunds *et al.* 2010; Porter and Wescott 2010). Animals are usually found under rather than on top of the rocks (Porter and Wescott 2010). The pulmonate limpet *Siphonaria* spp., striped conniwink *Bembicium nanum* and rugose slit limpet *Clypidina rugosa* are the most abundant mobile intertidal invertebrates in Point Danger MS (Bathgate 2010; Edmunds *et al.* 2010). The snails *Dicathais orbita*, *Lepsiella vinosa*, *Turbo undulates* and limpet *Patelloida alticostata* occur at lower densities (Edmunds *et al.* 2010). The predatory gastropods *Lepsiella vinosa* and *Dicathais orbita* are often associated with *Limnoperna pulex* mussel beds (Edmunds *et al.* 2010; Porter and Wescott 2010). The top shell *Chlorodiloma adelaidae* can be abundant at Point Danger MS, hidden amongst rubble and under stones (Porter and Wescott 2010). Point Danger MS is particularly recognised for its diverse opisthobranch (sea slug) fauna found on both intertidal and subtidal reefs (ECC 2000; Carey *et al.* 2007b). Ninety-six species are found in the MS and many are endemic.

Fish

No specific information on the fish species on intertidal reefs has been found for Point Danger MS (Plummer *et al.* 2003).

Figure 79. Flat backed crab (Family Hymenosomatidae) on the intertidal reef of Point Danger. Photo by Mark Rodrigue, Parks Victoria.

Subtidal

Soft sediment

Subtidal soft sandy sediment occurs near the north and south shores within the MS (Figure 77). No comprehensive biological surveys have been undertaken of this community within the MS. The seagrass *Amphibolis antarctica* grows over reef and sediment at the more sheltered areas of Point Danger MS (Ball and Blake 2007b).

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.

Flora

Seaweeds provide important habitat structure for other organisms on the subtidal reef. There is no single dominant subtidal canopy species in Point Danger MS, with the shallow subtidal reefs having a mix of brown algae (Ball and Blake 2007b). Extensive areas of the seagrass *Amphibolis antarctica* mixed with algae grows amongst patchy and broken low profile subtidal reef in the north-eastern region of the Point Danger MS, small seagrass patches also grow in the south (Ball and Blake 2007b). Crayweed *Phyllospora comosa* does not grow in the MS (Ball and Blake 2007b).

Invertebrate fauna

The invertebrate fauna on subtidal reefs has not been surveyed for Point Danger MS. Ninety-six species of opisthobranch (sea slug) are found on the intertidal and subtidal reef the MS and many are endemic (ECC 2000; Carey *et al.* 2007b).

Fish

The fish assemblages on subtidal reefs has not been surveyed for Point Danger MS.

Figure 80. Egg urchin *Holopneuste*s sp. in an intertidal pool in Point Danger Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

Water column

The water column as a whole is the largest habitat in the MNP and 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 variety of shorebirds and seabirds of conservation significance are found in the relatively shallow waters of Point Danger MS.

3.3.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is also 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 Point Danger MS.

Fish

No conservation listed fish have been recorded in Point Danger MS.

Birds

Eighteen conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Point Danger MS (Table 28). Twelve are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Two, the fairy tern *Sternula nereis* and wandering albatross *Diomedea exulans* are regarded as endangered. Three birds are listed as vulnerable at both the state and national level, including *D. exulans,* the shy *Thalassarche cauta* and black-browed albatross *Thalassarche melanophris*, however albatross are open ocean birds and would not be closely associated with Point Danger MS. Twelve birds are recognized internationally under CAMBA or JAMBA.

Marine mammals and reptiles

No conservation listed mammals or reptiles have been recorded in Point Danger MS.

Table 28. Conservation listed shorebird and seabird records from Point Danger Marine Sanctuary 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
eastern great egret	*Ardea modesta*	L	VU		C	J
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
fairy tern	*Sternula nereis*	L	EN			
hooded plover	*Thinornis rubricollis*	L	VU			
Latham's snipe	*Gallinago hardwickii*		NT		C	J
red-necked stint	*Calidris ruficollis*				C	J
cattle egret	*Ardea ibis*				C	J
sharp-tailed sandpiper	*Calidris acuminata*				C	J
sooty shearwater	*Ardenna grisea*				C	J
short-tailed shearwater	*Ardenna tenuirostris*					J
Arctic jaeger	*Stercorarius parasiticus*					J
royal spoonbill	*Platalea regia*		VU			
Pacific gull	*Larus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
common diving-petrel	*Pelecanoides urinatrix*		NT			

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

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 Point Danger MS (O'Hara and Barmby 2000; O’Hara and Poore 2000; O'Hara 2002a).

Two biota, a crab and a marine snail (Table 29) are presumed to be at their western distributional limit in Point Danger MS (O'Hara and Barmby 2000; O’Hara and Poore 2000; O'Hara 2002a). The distributional limits of the biota listed in Table 18 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 29. Marine species at their distribution limits in Point Danger MS (O'Hara and Barmby 2000; O’Hara and Poore 2000; O'Hara 2002a).

Order	Family	Species	Common name	Category
Brachyura	Goneplacidae	*Hexapus granuliferus*	Crab	PW
Gastropoda	Cerithiopsidae	*Tubercliopsis septapila*	Marine snail	PW

PW = presumed western limit

3.3.5 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 MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 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). Ten 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. Lack of ecological knowledge about hydrology, habitats, population dynamics including recruitment, geomorphology and sand movement, and fisheries management leading to less effective management of communities and habitats (all habitats in MS);
2. New and emerging marine pests, including pathogens, displacing local species and causing ecological change (intertidal and subtidal soft sediment and reef);
3. Illegal harvesting (organised poaching) of abalone leading to decreased population viability and flow-on effects to other organisms (subtidal reef);
4. Trampling and disturbance to intertidal platforms causing greater than natural variability in communities (intertidal reef);
5. Increased shore-based development leading to increases in small boating activity which may cause physical damage to habitats and communities greater than that caused naturally (intertidal and subtidal soft sediments and reef);
6. Man-made discharges of freshwater/stormwater from outfalls and estuaries (the latter due to increased mechanical opening) leading to changes in subtidal communities greater than natural variation (intertidal and subtidal soft sediments and reef);
7. Increased shore-based development leading to increased cost of management and consequent effects on park communities and habitats (all habitats in MS);
8. Plastic and other litter from sea or land leading to injury or death of resident or transient organisms and thus reduced community viability (all habitats in MS);
9. Moderate (*i.e.* not major spill from shipwreck) oil pollution from sea, either deliberate or accidental, having sublethal effects on biota in more than 5% of a park (all habitats in MS); and
10. Physical damage, pollution or cleanup impacts of a shipwreck sufficient to invoke an AMSA response, and resulting in any impacts on the parks (all habitats in 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). No introduced species or marine pest has been recorded from Point Danger MS, althoughit is thought that the introduced green shore crab *Carcinus maenas* is found within the MS. Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003) which have the potential to spread to Point Danger Marine Sanctuary. Some of the most invasive marine pests in PPB include the Japanese kelp *Undaria pinnatifida*, Northern Pacific Seastar *Asterias amurensis* and European fanworm *Sabella spallanzanii* Another species of concern in PPB is the broccoli weed *Codium fragile (subsp. fragile)* (Parks Victoria 2003). Japanese kelp *Undaria pinnatifida* has been recently found in Apollo Bay and there are grave concerns about its spread. Prevention of marine pest invasions is the most effective management option (Parks Victoria 2005). Both commercial and recreational boats can be vectors for introducing marine pests. State guidelines for boat hull cleaning and maintenance have been developed (Parks Victoria 2005).

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 is not in the

Point Danger MS but its spread into the park could have serious long term ecological consequences for rocky reef communities (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 Point Danger MS (Parks Victoria 2005). For example research is being conducted into marine pest species, and research investigating water quality issues which may impact on park natural values has also been completed. 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 81. Intertidal reef and rock pool in Point Danger Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

3.3.6 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 Point Danger 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 30 and Appendix 2).

Table 30. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Point Danger Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising 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 Intertidal Reef Monitoring Program

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

Point Danger MS has an ongoing intertidal reef monitoring program (IRMP) but it does not have a shallow subtidal reef monitoring program (SRMP). The IRMP in and around the Point Danger MS began in 2003 with the explicit aim to track changes in invertebrates and macro-algae abundances due to human use, trampling and fossicking, of the platforms (Power and Boxshall 2007). A site in the MS and reference site outside of the MS (Figure 73) have been surveyed over five census events (Edmunds *et al.* 2004; Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010). The monitoring involves surveying a single reef during a single low tide, targeting the predominant substratum type at each intertidal reef (Hart and Edmunds 2005). The survey is conducted along transects running from the high to the low shore. The density of non-sessile invertebrates and the percentage cover of macroalgae and aggregated sessile invertebrates are surveyed within quadrats along the transects (Hart and Edmunds 2005).

Keough and Carnell's (2009) preliminary analysis of the IRMP data from two census events up to 2006 was done at the Central Victoria bioregion level, including Mushroom Reef, Point Danger and Barwon Bluff MSs and, Point Addis MNP. The analysis compared sites within MPAs to reference sites outside the MPAs post declaration. They found there was no significant difference in species richness and number of species between MPA and reference sites (Keough and Carnell 2009). *Austrocochlea constricta*, had greater abundances in MPAs and compared to reference sites, with this pattern consistent between the three MSs, Point Danger, Marengo Reefs and Barwon Bluff, for which it could be analysed (Keough and Carnell 2009). This result needs to be interpreted cautiously as the difference may have been present before declaration of the MPAs (Keough and Carnell 2009).

Limitations of Keough and Carnell's (2009) analysis include no pre-declaration sampling, the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). A clear MPA effect is also 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 targeted analysis of IRMP monitoring data in relation to conservation outcomes for the park and review of the monitoring design will be done by 2013.

Statewide, the Museum of Victoria is collecting additional data on the marine natural values of Victoria's MPAs (Table 30). 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..

Figure 82. Green algae *Ulva* sp. dominated intertidal reef in Point Danger Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

3.3.7 KNOWLEDGE GAPS

No new surveys exist for the ecological communities of intertidal or subtidal soft sediments. Limited information exists for the shallow subtidal reef habitat. No information exists at present for water column assemblages. Major threats have been identified for Point Danger MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.

Figure 83. Intertidal rock pool with a spotted seastar *Nectria ocellata* in Point Danger Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

3.4 Barwon Bluff Marine Sanctuary

Barwon Bluff MS is the one of five Marine Sanctuaries in the Central Victoria Bioregion, which also contains Point Addis, and Bunurong Marine National Parks. Barwon Bluff MS is approximately 100 km west of Melbourne, and 25 km west of Geelong. It is offshore from the Crown land of Barwon Heads Park in the township of Barwon Heads. The MS covers 15.7 hectares of the shallow near shore (< 7 m, Figure 86 & Figure 87). It incorporates 610 metres of the coastline surrounding the base of ‘The Bluff’, the headland at Point Flinders at the mouth of the Barwon River. It includes basalt and sandstone (calcarenite) reefs, riverbank and ocean beaches, and the waters extending 400 metres to the east and south of the headland (Parks Victoria 2007a). Barwon Bluff MS is accessible from the shore through the Barwon Heads township or from The Bluff via stairways (Parks Victoria 2007a).

Aboriginal tradition indicates that Barwon Bluff Marine Sanctuary is part of *Country* of the Wathaurung people, who continue to have a close relationship with the sanctuary (Parks Victoria 2007a).

Important natural values of Barwon Bluff MS are its intertidal (Figure 84) and subtidal (Figure 86) sandstone and basalt reefs with thick patches of giant *Macrocystis pyrifera* and bull kelp *Durvillaea potatorum* (Carey *et al.* 2007b). It has spectacular subtidal sandstone arches and gutters (Carey *et al.* 2007b; Parks Victoria 2007a). There are also extensive sandflats between basalt boulders in the east (Parks Victoria 2007a). Its intertidal sandy beaches are important foraging and roosting sites for shore birds, including the endangered hooded plover *Thinornis rubricollis* (Carey *et al.* 2007b). Its intertidal shore platforms with a diversity of marine life are used extensively for marine education (ECC 2000; Carey *et al.* 2007b). The 1853 wreck of the *Earl of Charlemont* is located around the eastern boundary of the sanctuary (Parks Victoria 2007a).

The brown algae Neptune’s necklace *Hormosira banksii* is a key habitat forming plant on the western intertidal sandstone rocky reef (Ball and Blake 2007b; Edmunds *et al.* 2010). Patches of small coralline and filamentous turfing species, and mat forming mussel *Limnoperna pulex* occur in low abundance (Ball and Blake 2007b; Edmunds *et al.* 2010). The mobile invertebrate assemblages in Barwon Bluff MS are dominated by the gastropod snails *Bembicium nanum*, *Nodilittorina acutispira* and *N. unifasciata* and the limpets *Clypidina rugosa*, *Notoacmea mayi*, *Cellana tramoserica* and *Siphonaria* spp (Koss *et al.* 2005a; Bathgate 2010; Edmunds *et al.* 2010; Figure 89). Plants growing in the rock pools include *H. banksii*, mixed brown algae and seagrass *Amphibolis antarctica* (Ball and Blake 2007b). On the seaward edge of the intertidal platform bull kelp *D. potatorum* forms a narrow band approximately 10–15 m wide (Ball and Blake 2007b).

On low profile reef that gets inundated with sand, the canopy is formed by a mix of brown algae species; whereas on higher profile reef it is formed by the crayweed *Phyllospora comosa* (Ball and Blake 2007b). Beds of *M. pyrifera* are found in the deeper southern corner of the MS (Ball and Blake 2007b). Common molluscan species include the black lip abalone *Haliotis rubra*, warrener *Turbo undulatus*, elephant snail *Scutus antipodes* and cartrut whelk *Dicathais orbita* (Plummer *et al.* 2003). The subtidal reef fish includes species common in the Central Victoria bioregion such as blue-throated wrasse *Notolabrus tetricus*, herring cale *Odax cyanomelas*, scalyfin *Parma victoriae,* sea sweep *Scorpis aequipinnis,* magpie morwong *Cheliodactylus nigripes* and various leatherjackets (Colton and Swearer 2009; Colton and Swearer 2010).

Barwon Bluff MS provides important feeding and roosting habitat for several 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 18 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 Barwon Bluff MS include limited ecological knowledge of important processes. Illegal fishing, trampling and disturbance, lack of baseline information and inadequate monitoring, invasive marine pests, increased nutrients from shore, marine pollution 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 Barwon Bluff MS (Parks Victoria 2007a). Ongoing subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Barwon Bluff MS.

Figure 84. Intertidal reef in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

3.4.1 PHYSICAL PARAMETERS & PROCESSES

Barwon Bluff MS is 15.7 hectares in size which makes it the 2nd smallest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 31, Figure 86). Geological and geomorphological processes, including tectonic movement, lava flows, dune accretion and erosion and deposition from the Barwon River, have shaped the MS's environment (Bird 1993). It includes basalt and sandstone (calcarenite) reefs rising from a shallow (< 7m) sandy sea floor (Ball and Blake 2007b). East of Point Flinders, the MS shores within the Barwon River are relatively calm, influenced predominantly by tidal currents and the flow of water from Barwon River (Parks Victoria 2007a). West of Point Flinders the intertidal platforms and beach are exposed to persistent high-energy south-westerly swells in Bass Strait (Parks Victoria 2007a). Wind and wave action influence the beaches, affecting grain size, deposition and erosion. Natural hydrodynamic events such as storm surges displace seaweed and kelp communities, erode beaches and deposit sand over the reefs (Parks Victoria 2007a). Tides in the area are strongly diurnal with two high and two low tides each day, the heights of the subsequent high or low tides are usually different. Tidal variation is 2.1 metres for spring tides and 0.7 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. The Barwon River estuary runs into Bass Strait 600 m north of the MS (Table 31, Figure 86).

Barwon Heads is geologically significant as it is a coastal bluff in Pleistocene dune calcarenite with interbedded palaeosoils, resting upon basalt.

Table 31. Physical attributes of the Barwon Bluff Marine Sanctuary.

Park Name	Barwon Bluff
Conservation status	Marine Sanctuary
Biophysical Region	Central Victoria
Size	15.7 ha (ranked 23rd of 24)
Length of coastline	~614 m
Shoreline geology	Basalt and sandstone
Area with depth:	
0-10 m (low res)*	2.12 ha
Terrestrial	0.20 ha
Intertidal	3.89 ha
Intertidal-2 m	1.71 ha
2-4 m	4.66 ha
4-6 m	2.98 ha
6-8 m	0.13 ha
Mean tidal variation - spring	2.1 m
Mean tidal variation - neap	0.7 m
Mean water temp - summer	17.5°C
Mean water temp - winter	13.5°C
Adjacent catchment	Agricultural, Urban
Discharges into MNP	Barwon River
Nearest major estuary (distance & direction)	Barwon River 0.6 km to east

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

3.4.2 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.

Bluff MS (Figure 88 & Figure 90) is a mixed rocky platform/boulder shoreline extending into high and low profile shallow reef (Ball and Blake 2007b). The intertidal zone is a rock platform extending from the base of The Bluff. The rock platform can be divided into two distinct habitats. The platform to the east is characterised by black basalt with overlying boulders in places (Ball and Blake 2007b; Edmunds *et al.* 2010). A small sand beach separates the platform to the west, which is a low profile sandstone platform covered with dense beds of the brown algae Neptune's necklace *Hormosira banksii*, becoming bare near the western MS boundary (Ball and Blake 2007b). This rock platform is more exposed to large swells and sand inundation (Edmunds *et al.* 2010). Rock pools have *H. banksii*, mixed brown algae and the seagrass *Amphibolis antarctica* (Ball and Blake 2007b).

The majority of the subtidal region at the Barwon Bluff MS (Figure 88) is reef at depths <5 m (Ball and Blake 2007b). In the east of the MS the subtidal reefs are low profile with some sand cover at depths of approximately 4 – 6 m (Ball and Blake 2007b). This part of the MS can have poor visibility due to influence of freshwater output from the Barwon River (Ball and Blake 2007b). Areas of low profile reef that were close to sand patches are generally dominated by mixed brown algae (Ball and Blake 2007b). In the west and away from the sand patches, the reef becomes a little heavier and shallower (1 – 4 m), and dominated by the brown algae crayweed *Phyllospora comosa* (Ball and Blake 2007b). On the seaward edge of the intertidal platform bull kelp *Durvillaea potatorum* forms a narrow band approximately 10–15 m wide (Ball and Blake 2007b). Beds of giant kelp *Macrocystis pyrifera* are found in the southern corner of the MS (Ball and Blake 2007b).

Figure 85. Southern rocklobster *Jasus edwardsii* on the subtidal reef of Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

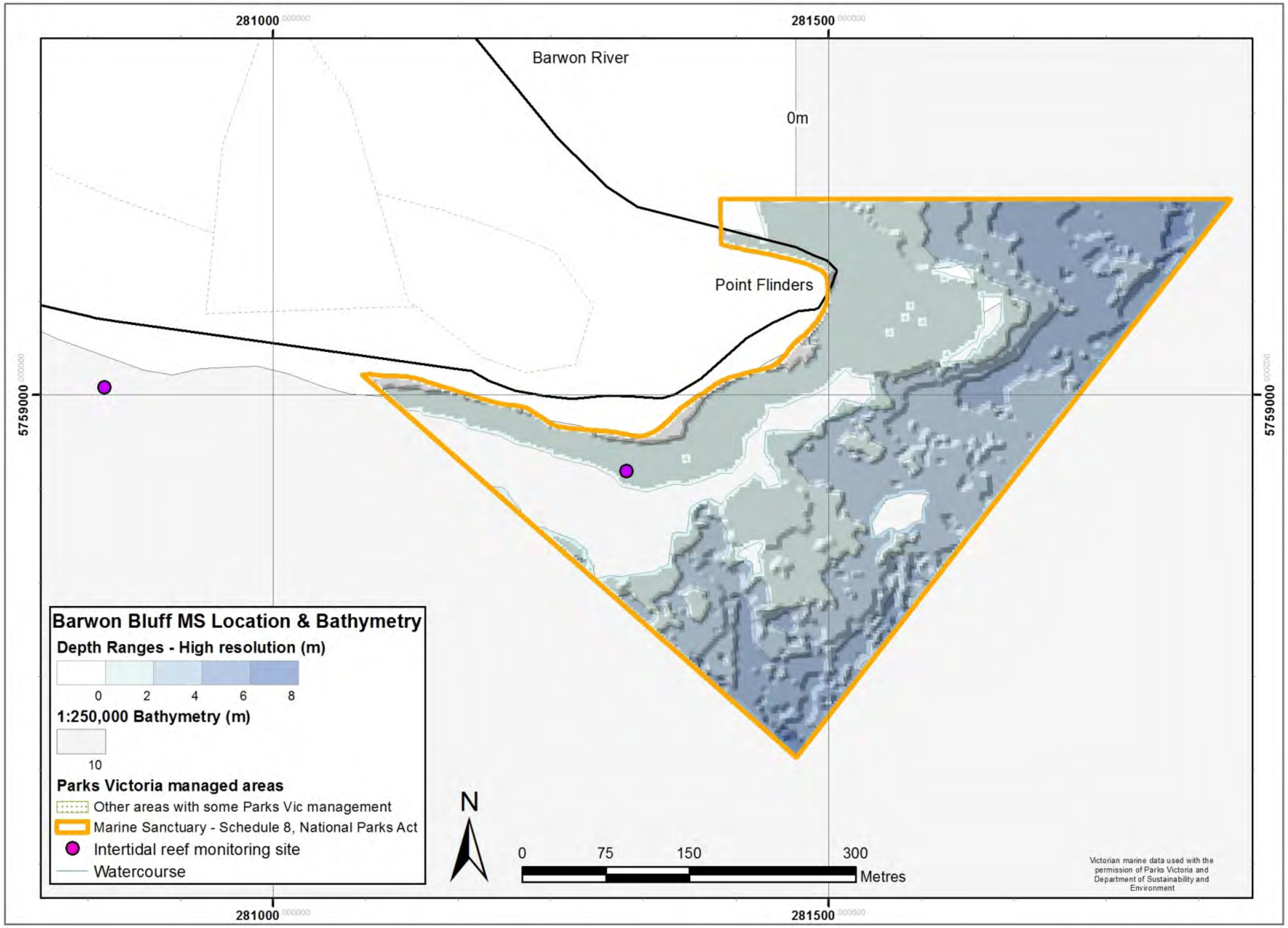


Figure 86. Location map of Barwon Bluff Marine Sanctuary with bathymetry. Intertidal reef monitoring sites inside and outside the MS are shown, there are no subtidal monitoring sites.

Figure 87. Aerial view of Barwon Bluff Marine Sanctuary (Fugro 3/12/04). From Ball and Blake (2007).

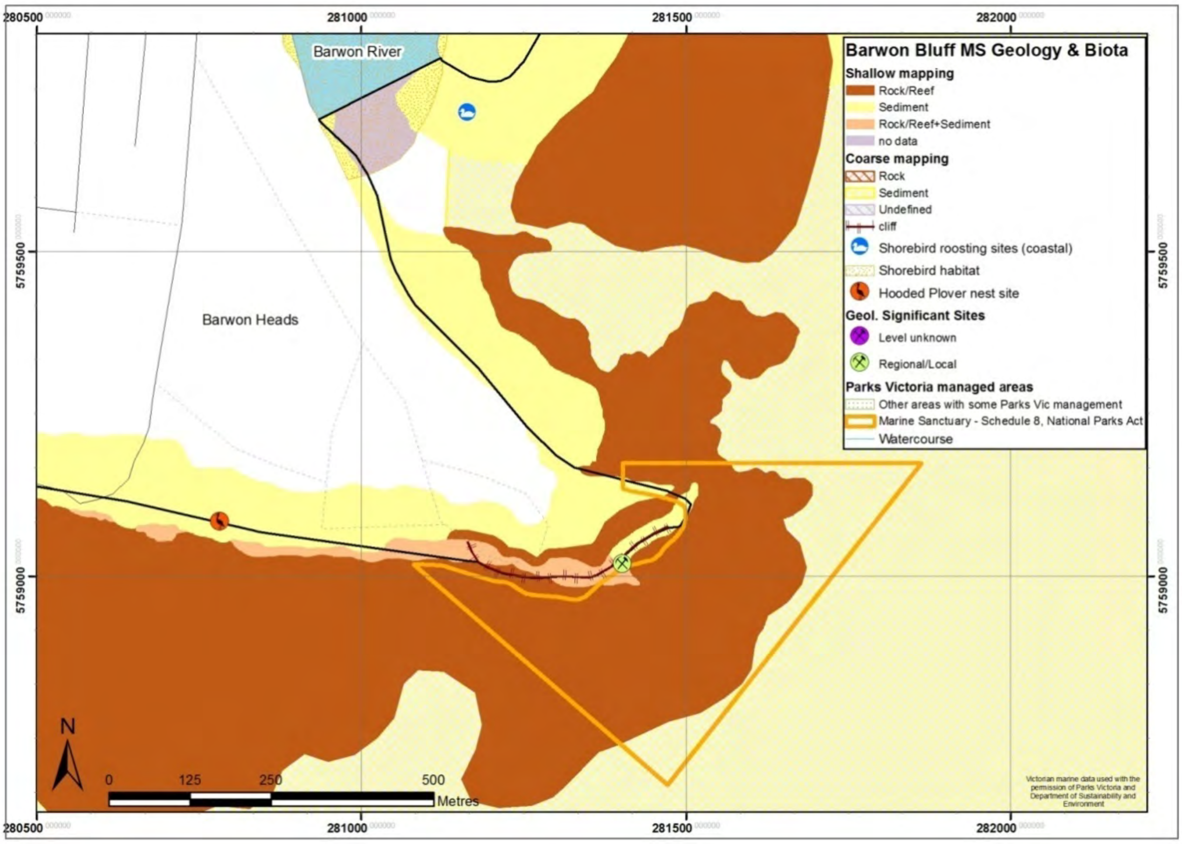


Figure 88. Coarse substrate mapping of Barwon Bluff Marine Sanctuary and surrounds, showing sites of geological and biotic significance.

Figure 89. The common limpet *Cellana tramoserica* on intertidal reef in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

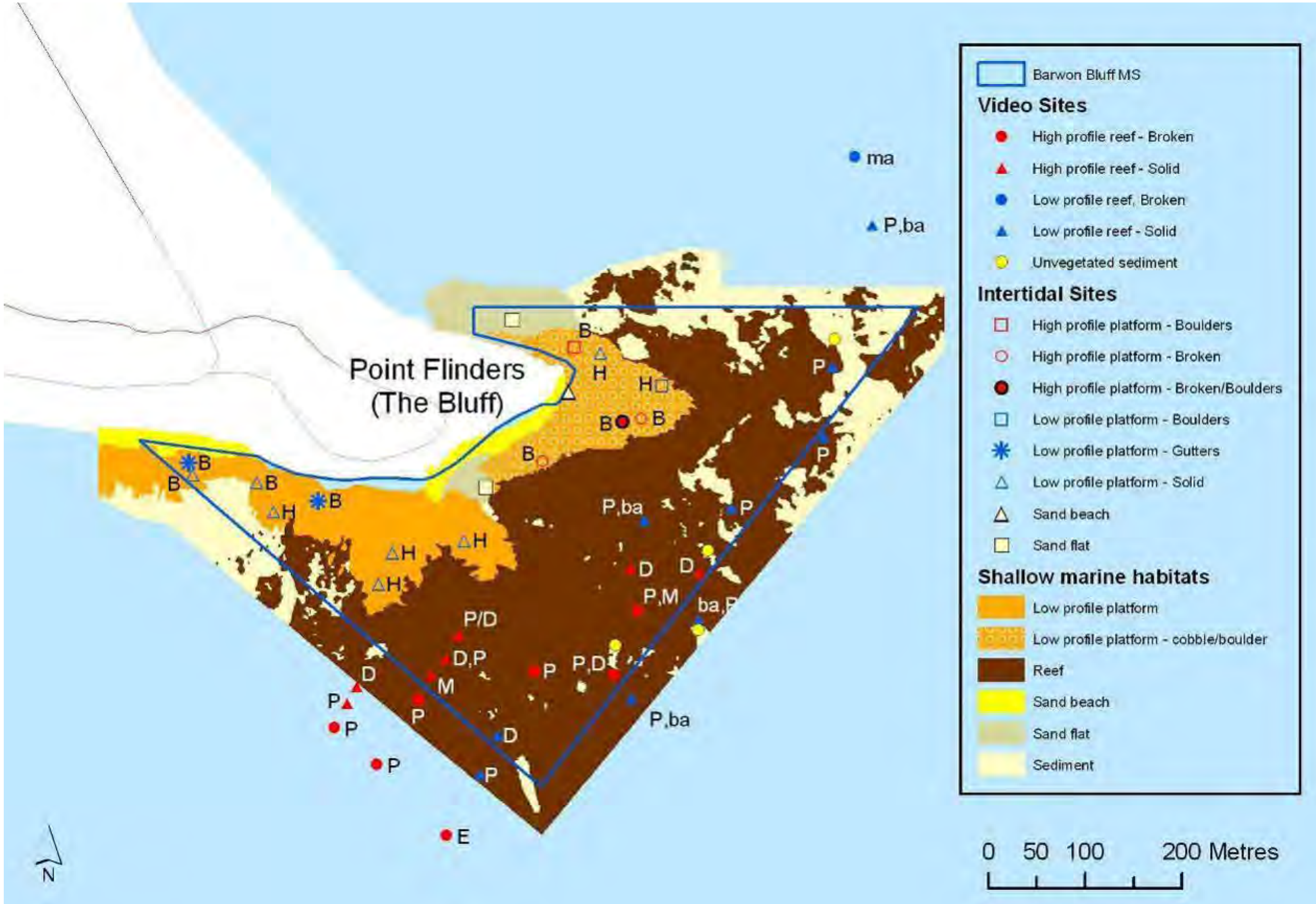


Figure 90. Detailed habitat mapping of Barwon Bluff Marine Sanctuary from Ball and Blake 2007. Dominant biota categories on the map B = bare reef or sediment, ba = mixed brown algae, D = *Durvillea potatorum*, E = *Ecklonia radiata* H = *Hormosira banksii*, M = *Macrocystis pyrifera,* ma = mixed algae and P = *Phyllospora comosa*

3.4.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring and mapping surveys in Barwon Bluff MS. This includes habitat mapping of the MS (Ball and Blake 2007b). The intertidal biota has been surveyed as part of studies on human impacts on intertidal reefs (Costa *et al.* 2010; O'Hara *et al.* 2010), gastropod recruitment (Bathgate 2010) and the efficiency of community monitoring through Sea Search (Koss *et al.* 2005a; Koss *et al.* 2005b). There have been at least six IRMP surveys of the intertidal reef biota of Barwon Bluff MS (Edmunds *et al.* 2004; Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010). Surveys in the MS have found brown algae dominate the diversity of macrophytes, gastropods the invertebrates and birds the vertebrates in Barwon Bluff MS (Table 32, Appendix 1). The subtidal reef fish in the MS has been assessed as part of statewide research into their conservation (Colton and Swearer 2009; Colton and Swearer 2010). There have been no surveys of the biota of soft sediments or the pelagic habitats. Important locations for some birds is shown in Figure 47, but there are no recognised significant biota sites in the MS. West of the MS (Figure 47) Thirteenth Beach is biologically significant due to hooded plovers nesting there (Carey *et al.* 2007b). On the east shore of the Barwon River, Sandy Point is a significant bird roosting site.

Table 32. Summary of the number of species in major biotic groups from surveys in Barwon Bluff Marine Sanctuary.

Biotic group	Number of species
Macrophytes	**29**
Blue-green algae	2
Green algae	5
Brown algae	13
Red algae	9
Invertebrates	**79**
Cnidaria	8
Polychaetes	3
Barnacles	6
Decapod crustaceans	1
Chitons	3
Gastropods	54
Bivalves	3
Sea slugs	1
Vertebrates	**65**
Ascidian	1
Birds	57
Mammals	7

Intertidal

Soft sediment

The fauna of the intertidal soft sediment habitat in Barwon Bluff MS has not been surveyed. Flora is restricted to macroalgae drift and macroalgal epiphytes. 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 91. Intertidal reef in Barwon Bluff Marine Sanctuary dominated by the brown algae Neptune's necklace *Hormosira banksii*. In the foreground the reef is inundated by sand. Photo by AME.

Reef

Rocky intertidal reefs (Figure 91), 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 aggregating invertebrates

The brown algae Neptune's necklace *Hormosira banksii* is a key habitat forming plant on the intertidal sandstone rocky reef (Ball and Blake 2007b; Edmunds *et al.* 2010; Figure 92). Other brown algae growing on the intertidal platform include *Cystophora retorata* and *C. retroflexa* (Edmunds *et al.* 2010). Patches of small coralline and filamentous turfing species, and mat forming mussel *Limnoperna pulex* occur in low abundance (Ball and Blake 2007b; Edmunds *et al.* 2010). Patches of the red turfing algae *Capreolia implexa* can have very high cover

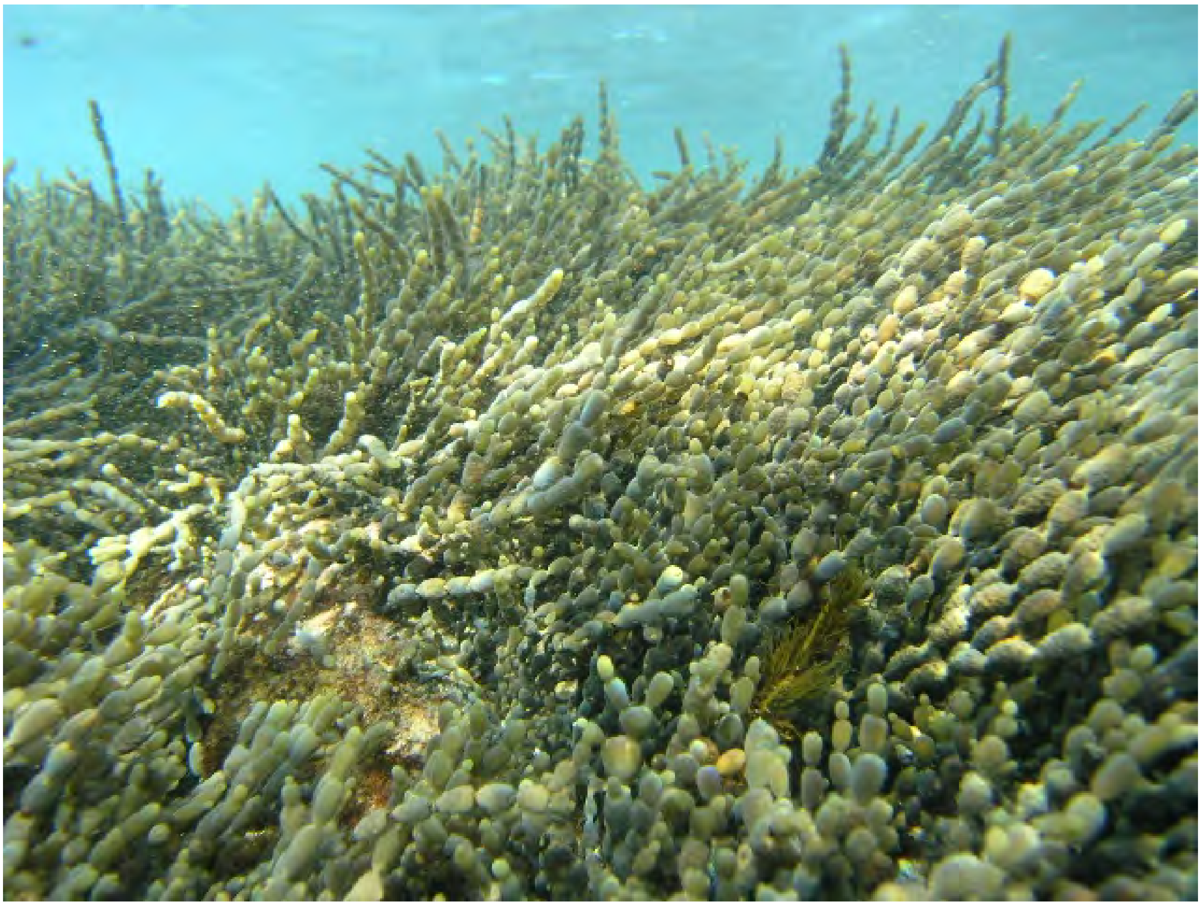


Figure 92. Submerged intertidal reef dominated by Neptune's necklace *Hormosira banksii* in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

(Koss *et al.* 2005a). In the upper tidal zone rosette *Tetraclitella purpurascens* and six-plated *Chthamalus antennatus* barnacles can be found (Plummer *et al.* 2003; Edmunds *et al.* 2010). Plants growing in the rock pools on the intertidal platform include *H. banksii*, mixed brown algae and seagrass *Amphibolis antarctica* (Ball and Blake 2007b). Anemones including *Oulactis* spp. and *Aulactinia veratra,* and the waratah *Actinia tenebrosa* can be found in rock pools (Plummer *et al.* 2003; Edmunds *et al.* 2010). At very low tide a rim of cunjevoi *Pyura stolonifera* are uncovered on the perimeter of the reef (Plummer *et al.* 2003).

Mobile invertebrates

Over 35 species of intertidal invertebrates have been recorded in Barwon Bluff MS including 26 species of mollusc (Costa *et al.* 2010; Edmunds *et al.* 2010; O'Hara *et al.* 2010). The mobile invertebrate assemblages in Barwon Bluff MS are dominated by the gastropod snails *Bembicium nanum*, *Nodilittorina acutispira* and *N. unifasciata* and the limpets *Clypidina rugosa*, *Notoacmea mayi*, *Cellana tramoserica* and *Siphonaria* spp (Koss *et al.* 2005a; Bathgate 2010; Edmunds *et al.* 2010; Figure 93). The periwinkle *Nodilittorina acutispira* and the limpet *Notoacmea mayi* can be present in particularly high densities in the mid to low region of the intertidal platforms (Edmunds *et al.* 2010). The abundance of *N. acutispira, C. rugosa* and *Siphonaria* spp. can be quite variable (Edmunds *et al.* 2010). The predatory gastropods *Cominella lineolata* (Figure 94) and *Dicathais orbita* occur in low abundance (Bathgate 2010; Edmunds *et al.* 2010). The sea hare *Aplysia gigantean* can be found in rock pools along with many other mobile mollusc species that are found on the intertidal platform (Plummer *et al.* 2003; Edmunds *et al.* 2010).Two seastars *Patiriella calcar* and *P. exigua* are common and shore crabs including *Cyclograpsus* spp. and *Paragrapsus* spp. are often found under rocks and in rock pools towards the low tide mark (Plummer *et al.* 2003).

Figure 93. The limpets *Siphonaria* spp. (centre) and *Notoacmea mayi* on the intertidal reef in Barwon Bluff Marine Sanctuary. Photo by AME.

Figure 94. The gastropods *Cominella lineolata* (top) and *Dicathais orbita* and the brown algae *Hormosira banksii* on the intertidal reef in Barwon Bluff Marine Sanctuary. Photo by AME.

Fish

The most common fish on the Barwon Heads intertidal platform are the Tasmanian blenny *Parablennius tasmanianus* and the southern crested weedfish *Cristiceps australis* (Plummer *et al.* 2003).

Subtidal

Soft sediment

The ecological communities on the subtidal soft sediment in Barwon Bluff MS have not been described.

Figure 95. A western blue groper *Achoerodus gouldii* over subtidal sediment near reef in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

Reef

Subtidal reefs (Figures 100 and 101) 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).

Figure 96. Bull kelp *Durvillaea potatorum* covered subtidal reef in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

Flora

Shallow subtidal reefs are often dominated by canopy forming algae. On low profile reef that gets inundated with sand the canopy is formed by a mix of brown algae species (Ball and Blake 2007b). On higher profile reef the canopy is formed by the crayweed *Phyllospora comosa* (Ball and Blake 2007b). On the seaward edge of the intertidal platform bull kelp *Durvillaea potatorum* (Figure 96) forms a narrow band approximately 10–15 m wide (Ball and Blake 2007b). Beds of giant kelp *Macrocystis pyrifera* are found in the deeper southern corner of the MS (Ball and Blake 2007b).

Invertebrate fauna

Common molluscan species include the black lip abalone *Haliotis rubra* (Figure 97), warrener *Turbo undulatus*, elephant snail *Scutus antipodes* and cartrut whelk *Dicathais orbita* (Plummer *et al.* 2003). The echinoderm fauna is diverse and includes eleven-armed seastar *Coscinasterias calamaria*, biscuit stars *Tosia australis*, *Uniophora granifera*, *Nectria* sp. *Patiriella brevispina* and *Echinaster varicolour* (Plummer *et al.* 2003). Also present are sea tulip *Pyura gibbosa* and red bait crab *Plagusia chabrus* (Plummer *et al.* 2003).

The eastern tip of the MS supports many filter-feeding invertebrates such as feather-stars which rely on fast currents to bring food (Plummer *et al.* 2003). Sponges are common beneath small bommies and ledges and opisthobranchs can be found on the reef sides (Plummer *et al.* 2003)

Figure 97. Blacklip abalone *Haliotis rubra* on subtidal reef in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

Fish

Fourty-nine species of fish have been recorded on the subtidal reefs of Barwon Bluff MS and Barwon Heads (Colton and Swearer 2009; Colton and Swearer 2010; Figure 95 and 99). They include reef fish common in the Central Victoria bioregion such as blue-throated wrasse *Notolabrus tetricus*, herring cale *Odax cyanomelas*, scalyfin *Parma victoriae* (Figure 98), sea sweep *Scorpis aequipinnis,* magpie morwong *Cheliodactylus nigripes* and various leatherjackets including the yellow-striped *Meuschenia flavolineata,* and horseshoe *Meuschenia hippocrepis.* Sharks and rays such as the Port Jackson shark *Heterodontus portusjacksoni* (Figure 101), southern eagle ray *Myliobatis australis* and smooth stingray *Dasyatis brevicaudata* have also been recorded on the subtidal reef (Colton and Swearer 2009; Colton and Swearer 2010).

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 fish, shorebirds and seabirds of conservation significance are found in the waters of Barwon Bluff MS.

Figure 98. Scalyfin *Parma victoriae* under a ledge in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

3.4.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing marine ecological communities within the MS, rather than threatened species, is also 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 Barwon Bluff MS.

Fish

In a study assessing the conservation of reef fishes in Victoria, Colton and Swearer (2009; 2010) observed 52 species of fish at Barwon Heads and Barwon Bluff MS. They regarded two of the observed fish species to be at risk of declining as they are numerically and spatially rare at the state level. The dusky morwong, *Pentaceropsis recurvirostris* is thought to be declining due to spearfishing and gill netting outside MPAs but the cause of the decline of the longsnout boarfish, *Pentaceropsis recurvirostris*, is unknown (Colton and Swearer 2010).

Birds

Twenty-seven conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Barwon Bluff MS (Table 33). Twenty-one are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Three, the great knot *Calidris tenuirostris*, Australasian bittern *Botaurus poiciloptilus* and fairy tern *Sternula nereis,* are regarded as endangered. Four birds are listed as threatened at both the state and national level, but would be more typically found in the open ocean than the nearshore of Barwon Heads MS. Eighteen birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA).

Table 33. Conservation listed shorebird and seabird records from Barwon Bluff Marine Sanctuary and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
southern giant-petrel	*Macronectes giganteus*	L	VU	EN		
shy albatross	*Thalassarche cauta*	L	VU	VU		J
fairy prion	*Pachyptila turtur*		VU	VU		J
blue petrel	*Halobaena caerulea*			VU		J
great knot	*Calidris tenuirostris*	L	EN		C	J
eastern great egret	*Ardea modesta*	L	VU		C	J
little tern	*Sternula albifrons*	L	VU		C	J
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
Australasian bittern	*Botaurus poiciloptilus*	L	EN			
fairy tern	*Sternula nereis*	L	EN			
hooded plover	*Thinornis rubricollis*	L	VU			
common sandpiper	*Actitis hypoleucos*		VU		C	J
whimbrel	*Numenius phaeopus*		VU		C	J
eastern curlew	*Numenius madagascariensis*		NT		C	J
Pacific golden plover	*Pluvialis fulva*		NT		C	J
sanderling	*Calidris alba*		NT		C	J
cattle egret	*Ardea ibis*				C	J
curlew sandpiper	*Calidris ferruginea*				C	J
red-necked stint	*Calidris ruficollis*				C	J
ruddy turnstone	*Arenaria interpres*				C	J
sharp-tailed sandpiper	*Calidris acuminata*				C	J
royal spoonbill	*Platalea regia*		VU			
Pacific gull	*Larus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
white-fronted tern	*Sterna striata*		NT			

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

The sanctuary includes important feeding, roosting and nesting sites for shorebirds and seabirds that complement those within the nearby Barwon River Estuary and Lake Connewarre — parts of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (Parks Victoria 2007a). The beaches within the sanctuary are used as feeding areas by threatened shorebirds and seabirds, including the hooded plover *Thinornis rubricollis* (Parks Victoria 2007a). West of the MS (Figure 88) Thirteenth Beach is biologically significant due to hooded plovers nesting there (Carey *et al.* 2007b). On the east shore of the Barwon River, Sandy Point is a significant bird roosting site.

Marine mammals and reptiles
There are no records of marine mammals and reptiles from Barwon Heads MS.

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 Barwon Bluff MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002a).

No biota have been recorded or presumed to be at their distributional limit in Barwon Bluff MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; Plummer *et al.* 2003). The known 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.

Figure 99. Old wife *Enoplosus armatus* on subtidal reef in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

3.4.5 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 MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 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. Poaching or other forms of extraction, and vandalism, resulting in reduced abundances of organisms (intertidal and subtidal reef);
2. Lack of resourcing resulting in insufficient management (research, enforcement and education) and thus changes in species composition (all habitats in MS);
3. Trampling in intertidal zone resulting in decreased abundance and diversity of organisms (intertidal reef);
4. Increasing human population and thus increasing pressure on the intertidal community resulting in a change in ecological condition (intertidal reef);
5. Water-based recreational activities (snorkelling, diving, surfing, jetskiing, etc) resulting in disturbance to wildlife (intertidal and subtidal reef, intertidal soft sediment);
6. Lack of accurate baseline data leading to uninformed management and thus threatening the maintenance of biodiversity (all habitats in MS);
7. Increasing numbers of organised education groups resulting in increased removal and trampling and thus decreased biodiversity (intertidal reef);
8. Introduced species outcompeting indigenous species (all habitats in MS);
9. Failure to document ecological change affecting intertidal and subtidal communities (intertidal and subtidal soft sediment and reef);
10. Increasing nutrients from the Barwon River resulting in changes to ecological processes (all habitats in MS);
11. Lack of appreciation of natural values leading to damage to habitats or organisms (intertidal and subtidal soft sediment and reef); and
12. Marine pollution from commercial shipping (*e.g.* bilge water, domestic effluent) resulting in damage to plant and animal communities (all habitats in MS).

The impact of the discharge of waste water from the Black Rock Ocean Outfall near Breamlea which is managed by Barwon Water is considered to be minimal and is monitored (Parks Victoria 2007a).

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). No introduced species or marine pest has been recorded from Barwon Bluff MS. It is thought that the introduced green shore crab *Carcinus maenas* is found within the MS. A number of introduced marine pests have the potential to colonise within the sanctuary, from nearby waters in Port Phillip Bay and the ocean waters of Bass Strait (Parks Victoria 2007a). Species of particular concern include the marine fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida,* Northern Pacific Seastar *Asterias amurensis* and broccoli weed *Codium fragile (subsp. fragile)* (Parks Victoria 2003). 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). Marine pests can be transported into the sanctuary on contaminated vessels, through ballast water and on diving and snorkeling equipment (Parks Victoria 2007a). Preventing marine pest invasions is the most effective management option (Parks Victoria 2007a). Prevention involves reducing the risk that a pest will be introduced to the sanctuary (Parks Victoria 2007a).

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 is not currently in the Barwon Bluff MS but its spread into the park could have serious long term ecological consequences for rocky reef communities (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 Barwon Bluff MS (Parks Victoria 2007a). 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.

3.4.6 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 Barwon Bluff 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 34 and Appendix 2).

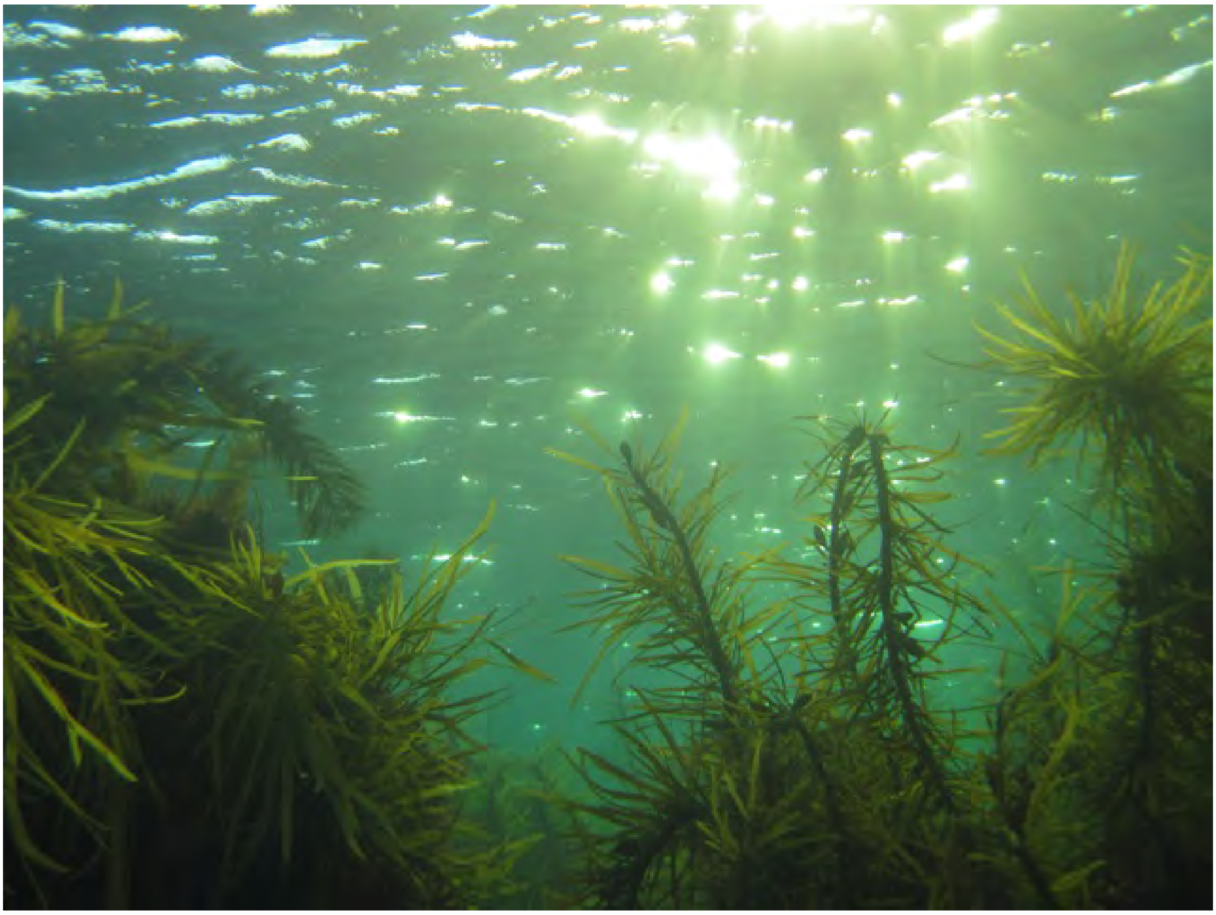


Figure 100. Subtidal reef in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria.

Barwon Bluff MS has an ongoing intertidal reef monitoring program (IRMP) but it does not have a shallow subtidal reef monitoring program (SRMP). The IRMP in and around the Barwon Bluff MS began in 2003 with the explicit aim to track changes in invertebrates and macro-algae abundances due to human use, trampling and fossicking, of the platforms (Power and Boxshall 2007). The MPA site on the western sandstone intertidal reef and reference site outside of the MS (Figure 86) have been surveyed over six census events (Edmunds *et al.* 2004; Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010). The monitoring involves surveying a single reef during a single low tide, targeting the predominant substratum type at each intertidal reef (Hart and Edmunds 2005). The survey is conducted along transects running from the high to the low shore. The density of non-sessile invertebrates and the percentage cover of macroalgae and aggregated sessile invertebrates are surveyed within quadrats along the transects (Hart and Edmunds 2005).

Keough and Carnell's (2009) preliminary analysis of the IRMP data from two census events up to 2006 was done at the Central Victoria bioregion level, including Mushroom Reef, Point Danger and Barwon Bluff MSs and Point Addis MNP. The analysis compared sites within MPAs to reference sites outside the MPAs post declaration. They found there was no significant difference in species richness and number of species between MPA and reference sites (Keough and Carnell 2009). *Austrocochlea constricta*, had greater abundances in MPAs and compared to reference sites, with this pattern consistent between the three MSs, Point Danger, Marengo Reefs and Barwon Bluff, for which it could be analysed (Keough and Carnell 2009). This result needs to be interpreted cautiously as the difference may have been present before declaration of the MPAs (Keough and Carnell 2009).

Limitations of Keough and Carnell's (2009) analysis include no pre-declaration sampling, the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). 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 targeted analysis of IRMP monitoring data in relation to conservation outcomes for the park and review of the monitoring design will be done by 2013.

Table 34. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Barwon Bluff Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising 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 Intertidal Reef Monitoring Program
Community Based Monitoring Sea Search - Intertidal Reefs ReefWatch - Great Victorian Fish Count

*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 (Table 34). 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.

The community group, the Friends of The Bluff have developed 'Living on the Edge', an interactive inventory CD and website that interprets the natural and cultural values of the sanctuary (Parks Victoria 2007a). They monitor the intertidal reef biota through Sea Search and subtidal reef fish through the ReefWatch Great Victorian Fish Count.

3.4.7 KNOWLEDGE GAPS

No quantitative surveys have been done on the ecological communities of intertidal or subtidal soft sediments, flora and invertebrate fauna of the subtidal reef. There is little new data on fish abundances, distributions or interactions except on shallow subtidal reef habitats. No information exists at present for water column assemblages. Major threats have been identified for Barwon Bluff MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.

Figure 101. Port Jackson shark *Heterodontus portusjacksoni* in Barwon Bluff Marine Sanctuary. Photo by Mark Rodrigue, Parks Victoria

3.5 Mushroom Reef Marine Sanctuary

Mushroom Reef MS is the one of five Marine Sanctuaries in the Central Victoria Bioregion, which also contains Point Addis, and Bunurong Marine National Parks. Mushroom Reef MS is on the Bass Strait coast 1 km from Flinders near the western entrance to Western Port, approximately 90 km south of Melbourne (Figure 102 & Figure 103). It abuts the Mornington Peninsula National Park and extends from the high water mark to approximately 1 km offshore (Parks Victoria 2007c). The MS covers 56.7 hectares and extends 702 m along the Flinders Ocean Beach from 300 m east of Kings Street to 500 m west of West Head car park (Parks Victoria 2007c). Bismarck Reef, which is commercially fished for abalone, is outside the sanctuary, approximately 100 metres seaward of the southern boundary (Parks Victoria 2007c)

Mushroom Reef - Aboriginal tradition indicates that the sanctuary is part of *Country* of Boon Wurrung, who continue to have a close relationship with the sanctuary (Parks Victoria 2007c).

Important natural values of Mushroom Reef MS are its highly complex intertidal basalt reef providing a rich variety of microhabitats supporting a highly diverse reef community (ECC 2000; Carey *et al.* 2007b; Figures 102 and 103). It is considered one of most diverse intertidal rocky reef communities in Victoria (Carey *et al.* 2007b). Sandy bottoms in sheltered intertidal pools support beds of seagrass *Amphibolis antarctica* (Carey *et al.* 2007b; Parks Victoria 2007c). Its abalone population and black and white gastric-brooding seastar *Smilasterias multipara* are considered important natural values (Carey *et al.* 2007b).

The intertidal soft sediment is an important feeding and roosting habitat for shorebirds. Macroalgal cover on the intertidal basalt reefs is relatively low and variable, Neptune's necklace *Hormosira banksii* and crustose coralline algae are the dominant species (Edmunds *et al.* 2010). Bull kelp *Durvillaea potatorum* grows on the edges of the platforms. The mobile invertebrate community at Mushroom Reef MS is species rich and highly diverse (Edmunds *et al.* 2010). The top shell *Austrocochlea constricta* is the most abundant species occurring in dense patches across the shoreline (Edmunds *et al.* 2010). The striped conniwink *Bembicium nanum*, black nerite *Nerita atrimentosa* and the pulmonate limpet *Siphonaria* spp. are also present in high densities (Edmunds *et al.* 2010).

The stands of subtidal canopy forming algae at Mushroom Reef MS are crayweed *Phyllospora comosa* and mixed brown algae, and deeper waters are dominated by kelp *Ecklonia radiata* (Ball and Blake 2007a). The seagrass *Amphibolis antarctica* grow on sediment covered reef and in rock pools (Ball and Blake 2007a). *Zostera* sp. grows on subtidal soft sediment (Ball and Blake 2007a). Subtidal invertebrate and fish assemblages have not been described for Mushroom Reef MS.

Mushroom Reef MS provides important feeding and roosting habitat for several threatened bird species such as the grey-tailed tattler *Heteroscelus brevipes*, which is listed under the *Flora and Fauna Guarantee* (*FFG*) Act (1998) and regarded as critically endangered in Victoria. The MS protects feeding areas for 11 internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Three crustaceans are endemic to the MS. Thirty-seven species of marine flora and fauna are believed to be at their distributional limits within the MS.

Serious threats to the Mushroom Reef MS include limited ecological knowledge of important processes. Freshwater, nutrients and sediments from discharges, illegal fishing, trampling, disturbance of birds, invasive marine pests, inadequate monitoring 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 Mushroom Reef MS (Parks

Victoria 2007c). Ongoing intertidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Mushroom Reef MS.

3.5.1 PHYSICAL PARAMETERS & PROCESSES

Mushroom Reef MS is 56.7 hectares in size which makes it the eighth smallest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 35, Figure 104). The MS consists of three intertidal and subtidal basalt reefs rising from a shallow (<9 m) sandy sea floor (Ball and Blake 2007a). The reefs are hexagonal fractured columns formed by the cooling of lava, which weather and break down to form rounded cobbles and boulders (Bird 1993). Mushroom Reef MS is named after the shape of the largest intertidal platform (Parks Victoria 2007c). Its large intertidal isthmus or 'stalk' has been formed by incoming waves refracting around the reef platform and depositing basalt cobbles into the gap between the platform and the shore, an unusual coastal landform known as a tombolo (Bird 1993). Mushroom Reef is protected from large swells by Bismark Reef 100 m further offshore (Edmunds *et al.* 2010). Tidal variation is 2.1 metres for spring tides and 0.7 metres for neap tides (Plummer *et al.* 2003). Surface water temperatures average 17.5° C in the summer and 13.0° C in the winter. The MS is influenced by the ocean waters of Bass Strait and by tidal flows from the western entrance to Western Port, which is about one kilometre east of the sanctuary. There are no direct freshwater discharges into the MS, but Double Creek discharges 500 m west of the MS and receives stormwater from Flinders township (Table 35).

There are no declared sites of geological or geomorphological or biotic significance in the MS (Figure 106). The marine cliffs and bluffs of Flinders, around West Head are considered to be geologically significant. Also, to the west of the MS Ocean Beach at Flinders is biologically significant because hooded plovers *Thinornis rubricollis* have been recorded nesting there and red-necked stint *Calidris ruficollis*, and ruddy turnstone *Arenaria interpres* use it for roosting and feeding.

Figure 102. Intertidal reef and cobble causeway in Mushroom Reef Marine Sanctuary. Photo by AME.

Table 35. Physical attributes of the Mushroom Reef Marine Sanctuary.

Park Name	Mushroom Reef
Conservation status	Marine Sanctuary
Biophysical Region	Central Victoria
Size	56.7 ha (ranked 17th of 24)
Length of coastline	~702 m
Shoreline geology	basalt
Area with depth:	
0-10 m (low res)*	1.67 ha
Supratidal	0.36 ha
Intertidal	30.61 ha
Intertidal-2 m	0.41 ha
2-4 m	14.06 ha
4-6 m	5.12 ha
6-8 m	3.27 ha
8-10 m	1.14 ha
10-12m	0.03 ha
Mean tidal variation - spring	2.1 m
Mean tidal variation - neap	0.7 m
Mean water temp - summer	17.5°C
Mean water temp - winter	13°C
Adjacent catchment	Agricultural, Urban
Discharges into MNP	Double Creek 0.5km west
Nearest major estuary (distance & direction)	Merricks Creek 8 km north east

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

3.5.2 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 target management activities, including emergency response, monitoring and research effectively. 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. Mushroom Reef MS habitat was mapped from two sets of aerial photography flown in 1998 and 2004, and ground-truthed in 2004 by site visits and underwater video (Ball and Blake 2007a).

The intertidal soft sediment is a narrow sand beach fronting a small dune system at the base of a steep slope extending down from the Flinders golf course (Ball and Blake 2007a). Mushroom Reef itself is the dominant intertidal feature and consists of a large expanse of low profile platform with some pebbles and boulders (Ball and Blake 2007a; Edmunds *et al.* 2010). The platform is connected to the shore by a narrow shallow isthmus of bare cobble (Ball and Blake 2007a). The centre of Mushroom Reef is mostly bare with some scattered brown algae, *Hormosira banksii* (Ball and Blake 2007a). The outer platform is dominated by *H. banksii* and platform edges by bull kelp *Durvillaea potatorum* (Ball and Blake 2007a). To the west of Mushroom Reef, two smaller mostly bare intertidal platforms extend seaward directly from the sand beach and have areas of higher profile than Mushroom Reef (Ball and Blake 2007a). On the outer edges of the basalt platforms are almost perfectly rounded rockpools, formed by the grinding of loose cobbles or boulders by waves at high tide (Parks Victoria 2007c).

Subtidally the reef profile varies from low cobble and rubble reef to high profile broken reef with overhanging ledges, boulders, bommies and gutters. Maximum depth is approximately 9 m, with the majority less than 6 m (Ball and Blake 2007a). The shallow (0 – 4 m) north west corner of the MS is primarily a mixture of low profile cobble and rubble reef dominated by *Amphibolis antarctica* and mixed algae (Ball and Blake 2007a). Further south and into the small bay, the substratum is sand and is dominated in areas by monospecific beds of *A. antarctica* and *Zostera* sp. (Ball and Blake 2007a). The south west tip of Mushroom Reef itself is low profile solid reef dominated by mixed brown algae and crayweed *Phyllospora comosa* (Ball and Blake 2007a). South of Mushroom Reef the reef changes to patchy low profile broken reef dominated by a mixture of *A. antarctica* and mixed algae (Ball and Blake 2007a). The shallow bay to the north east of Mushroom Reef is dominated by a mixture of *A. antarctica* and mixed algae over low profile reef (Ball and Blake 2007a). South in deeper water (4 – 9 m) and around the offshore island the substratum becomes high profile and broken in texture, dominated by *P. comosa* and *Ecklonia radiata* (Ball and Blake 2007a).

The inshore region of Mushroom Reef MS is protected from waves and the sandy sediment has been colonised by *Zostera* sp. in places (Ball and Blake 2007a). The more exposed inshore areas support *A. antarctica* growing on sediment and patches of reef (Ball and Blake 2007a).

Figure 103. Intertidal reef and rockpools in Mushroom Reef Marine Sanctuary. Photo by Mark Norman, Museum of Victoria.

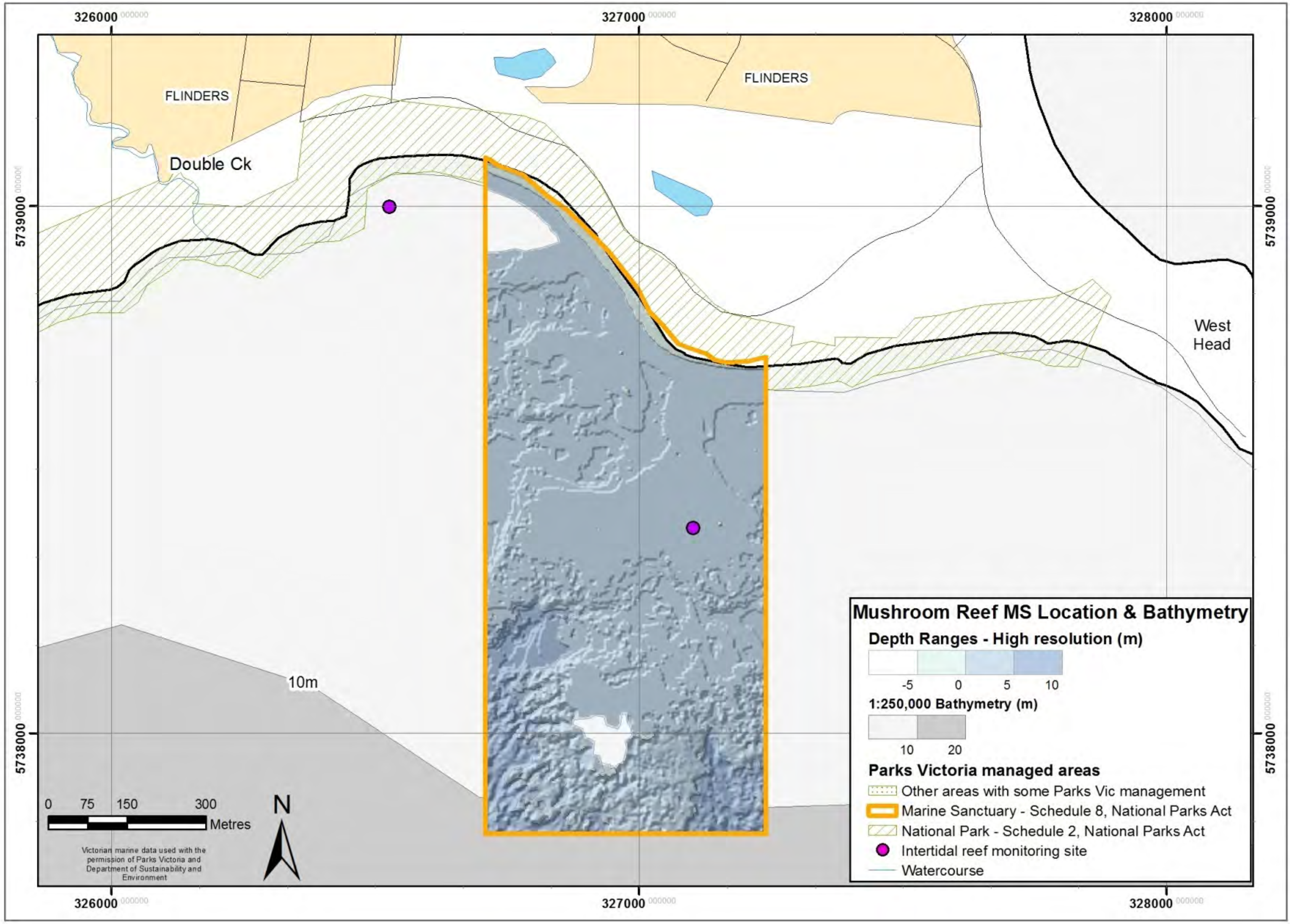


Figure 104. Location map of Mushroom Reef Marine Sanctuary with bathymetry. Intertidal reef monitoring sites inside and outside the MS are shown, there are no subtidal monitoring sites.

Figure 105. Aerial view of Mushroom Reef Marine Sanctuary (QASCO 28/3/04). From Ball and Blake 2007.

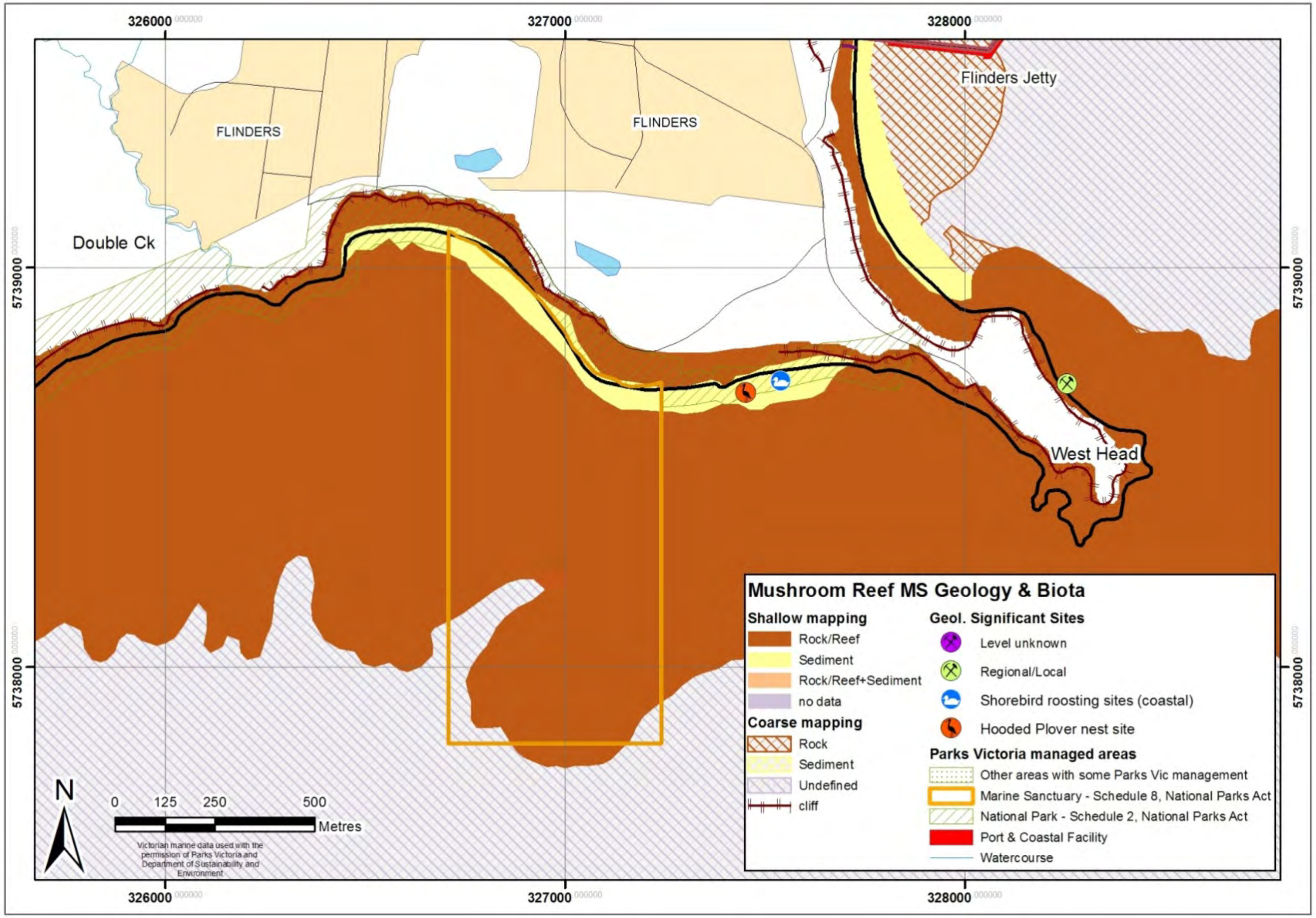


Figure 106. Substrate mapping of Mushroom Reef Marine Sanctuary and surrounds, showing sites of geological and biotic significance.

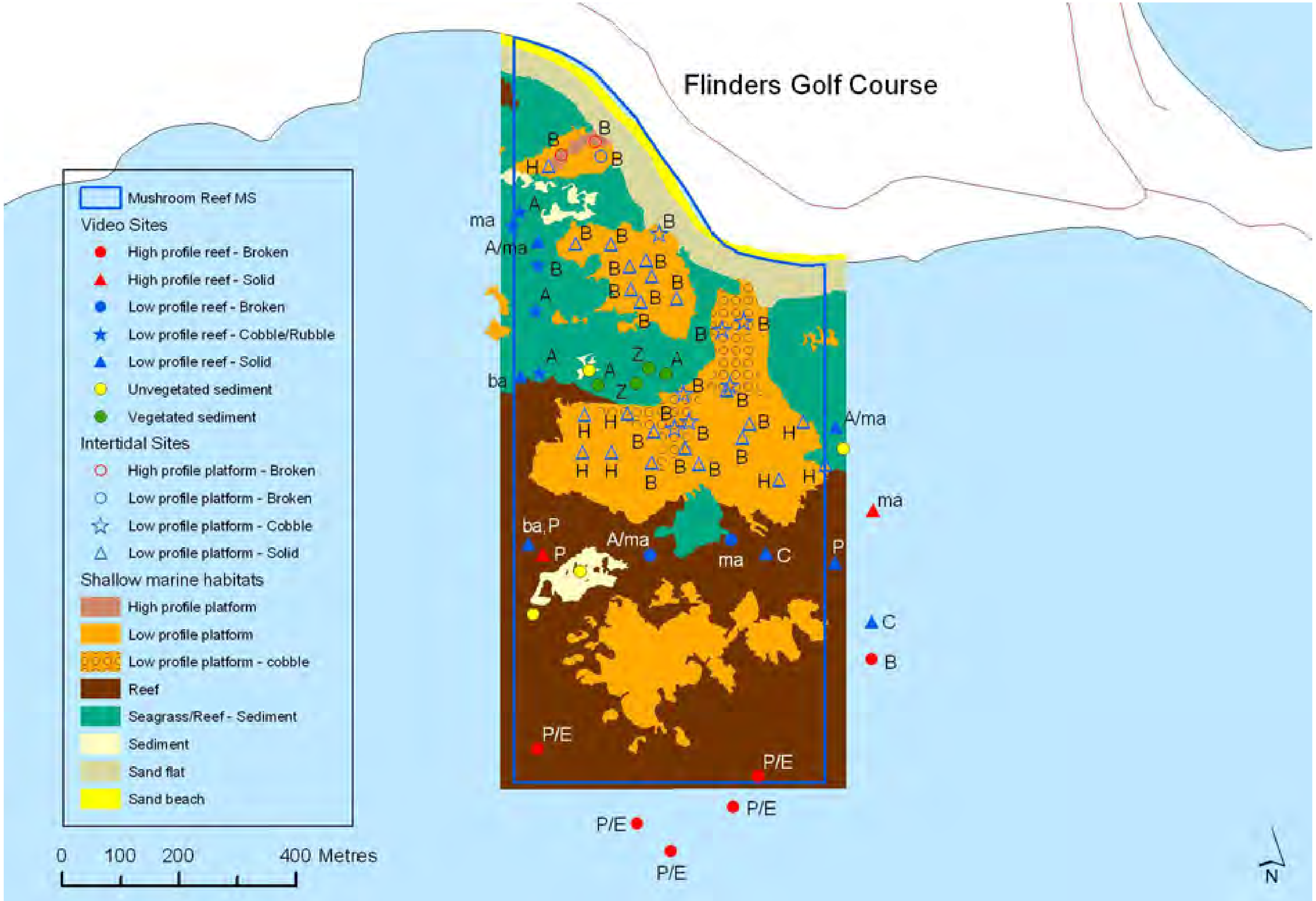


Figure 107. Detailed substrate and habitat mapping of Mushroom Reef Marine Sanctuary from Ball and Blake 2007. Dominant biota categories on the map A = *Amphibolis antarctica* B = bare reef or sediment, ba = mixed brown algae, C = *Cystophora* spp., E = *Ecklonia radiata* H = *Hormosira banksii*, P = *Phyllospora comosa* and Z = *Zostera* spp.

3.5.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring and mapping surveys in Mushroom Reef MS. This includes detailed habitat mapping of the MS (Ball and Blake 2007a; Figure 107). There have been seven IRMP surveys of the intertidal reef biota of Mushroom Reef MS (McArthur *et al.* in prep). Surveys in the MS have found brown and red algae dominate the diversity of macrophytes, gastropods the invertebrates and birds the vertebrates in Mushroom Reef MS (Table 36, Appendix 1). There have been no new surveys of the biota of the soft sediments, subtidal reef or the pelagic habitats. Important locations for some birds is shown in Figure 47, but there are no recognised significant biota sites in the MS.

Table 36. Summary of the number of species in major biotic groups from surveys in Mushroom Reef Marine Sanctuary.

Biotic group	Number of species
Macrophytes	**72**
Blue-green algae	3
Green algae	9
Brown algae	20
Red algae	37
Seagrasses	3
Invertebrates	**142**
Cnidaria	5
Flatworms	1
Polychaetes	3
Barnacles	11
Decapod crustaceans	10
Chitons	10
Gastropods	76
Bivalves	7
Sea slugs	2
Echinoderms	17
Vertebrates	**40**
Birds	33
Mammals	7

Intertidal

Soft sediment

Flora is restricted to macroalgae drift and macroalgal epiphytes. The fauna of the intertidal soft sediment habitat in Mushroom Reef MS has 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. Sooty oystercatchers *Haematopus fuliginosus* feed and roost on the beach (Parks Victoria 2007c). Flocks of curlew sandpipers *Calidris ferruginea* and red-necked stints *Calidris ruficollis* are commonly observed feeding on the shore between August and May, before migrating to Siberia to breed (Parks Victoria 2007c). Ruddy turnstones *Arenaria interpres* feed and roost in the sanctuary, but numbers have decreased in the last decade (Parks Victoria 2007c). The hooded plover *Thinornis rubricollis* has been recorded in the MS (Parks Victoria 2007c).

Figure 108. Intertidal reef in Mushroom Reef Marine Sanctuary. Photo by AME.

Reef

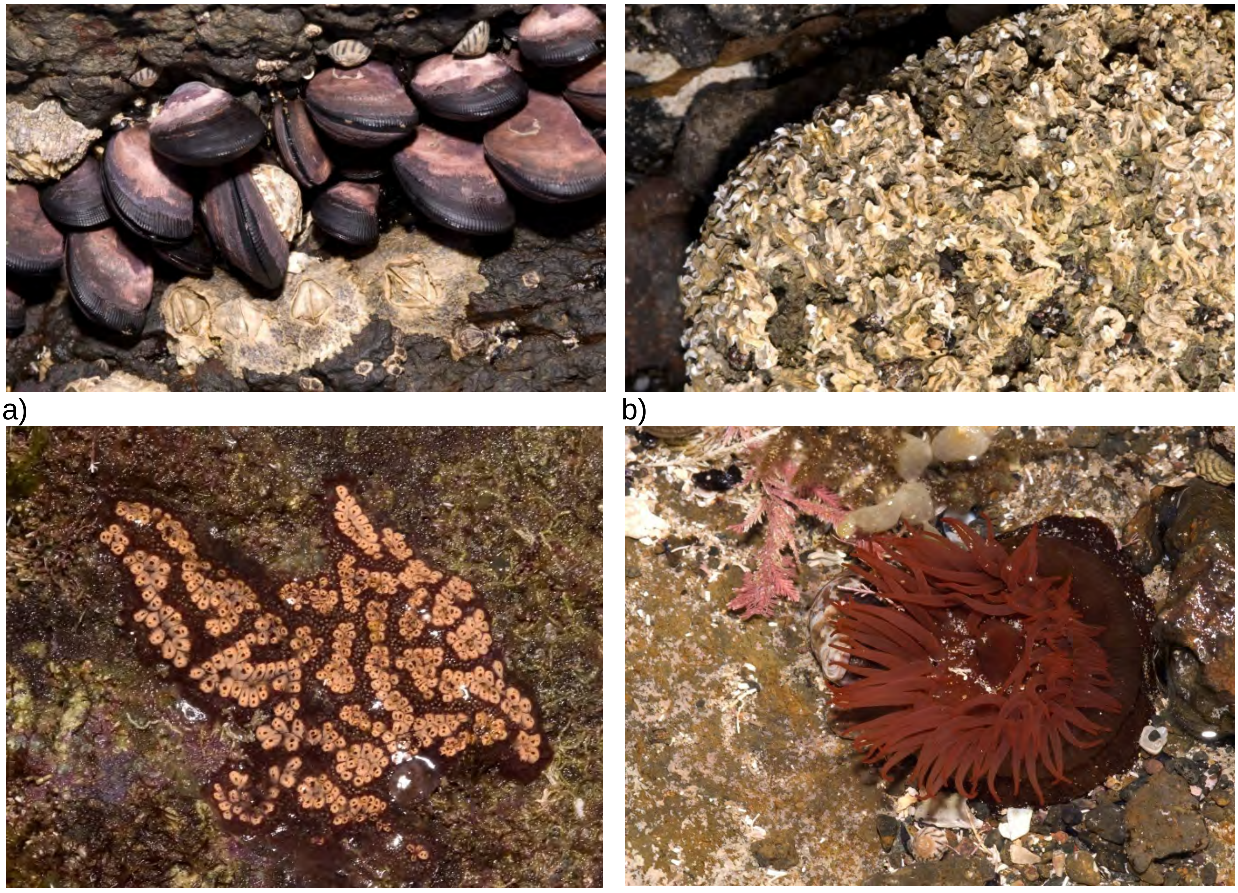
Rocky intertidal reefs (Figure 108), also called rocky reefs or intertidal platforms, are generally found in Victoria on and near headlands with stretches of sandy beaches either side. Along with beaches, intertidal reefs are one of the most accessible components of the marine environment as they are 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 (Figure 109, 112 and 113) 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).

Macroalgae and aggregating invertebrates

Two species of seagrass *Amphibolis antarctica* and *Halophila ovalis,* and 16 species of algae, including 10 species of brown algae, have been found on the intertidal reefs of

Mushroom Reef MS (Costa *et al.* 2010; O'Hara *et al.* 2010). Macroalgal cover at Mushroom Reef is relatively low and variable, Neptune's necklace *Hormosira banksii* and crustose coralline algae are the dominant species (Edmunds *et al.* 2010). The centre of Mushroom Reef is mostly bare with some scattered brown algae, *Hormosira banksii*, black lichen and some beds of small mussels *Limnoperna pulex* (Ball and Blake 2007a; Edmunds *et al.* 2010). *Enteromorpha* spp., sea lettuce *Ulva* spp. and erect coralline algae occur in low densities across the reef (Koss *et al.* 2005a; Edmunds *et al.* 2010). The outer platform is dominated by *H. banksii* and edges dominated by bull kelp *Durvillaea potatorum* (Ball and Blake 2007a). White coralline algae, green algae, mixed brown algae and *A. antarctica* grow in the rock pools (Ball and Blake 2007a). The two smaller intertidal platforms are mostly bare (Ball and Blake 2007a).



a) b)

c) d)

Figure 109. Sessile intertidal reef intvertebrates in Mushroom Reef Marine Sanctuary: a) beaked mussel *Austromytilus rostratus* and barnacle *Catomerus polymerus*; b) tube worm *Galeolaria caespitosa*; c) sea squirt colony *Botrylloides leachii* and d) red waratah anemone *Actinia tenebrosa*. Photos by Mark Norman, Museum of Victoria.

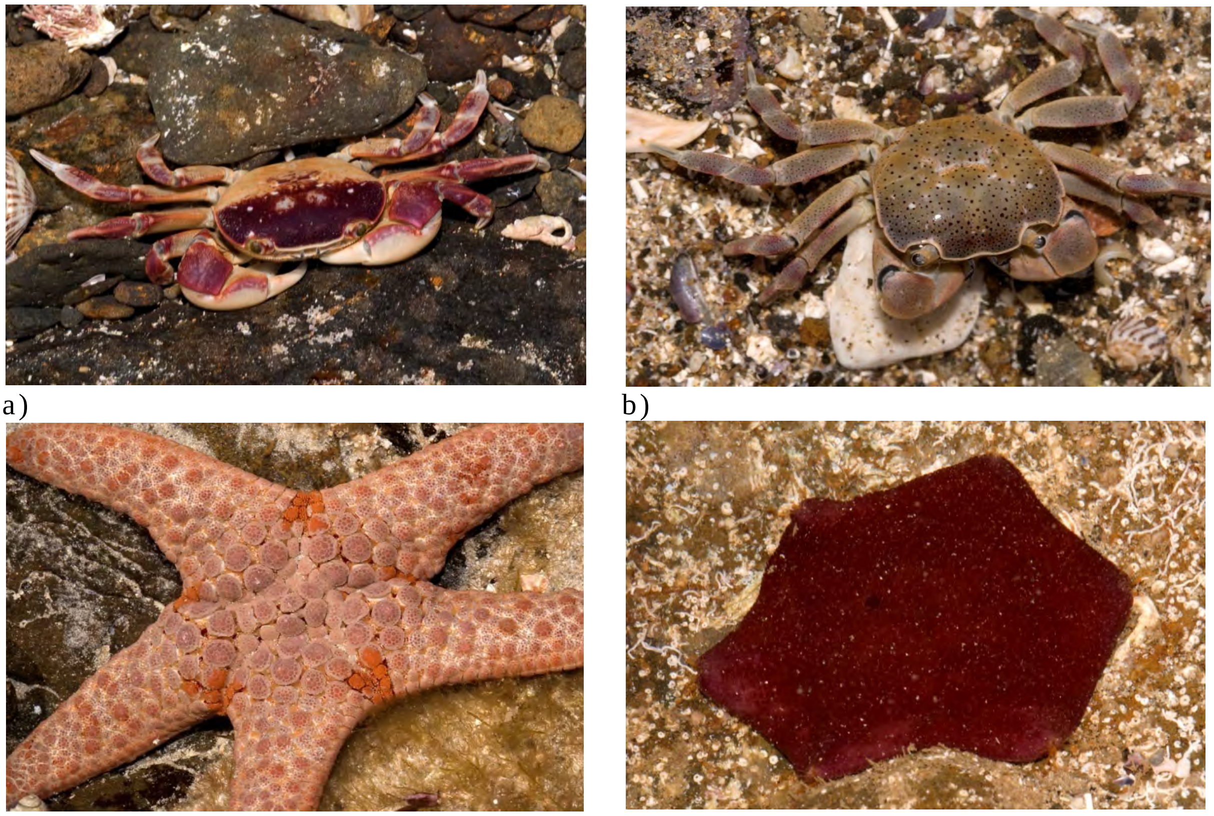
Mobile invertebrates

The mobile invertebrate community (Figures 110 and 111) at Mushroom Reef MS is species rich and highly diverse (Edmunds *et al.* 2010). Sixty-one species of invertebrates, including 42 species of molluscs have been found on the intertidal reefs of the MS (Costa *et al.* 2010; O'Hara *et al.* 2010). The top shell *Austrocochlea constricta* is the most abundant species occurring in dense patches across the shoreline (Edmunds *et al.* 2010). The striped conniwink *Bembicium nanum*, black nerite *Nerita atrimentosa* and the pulmonate limpet *Siphonaria* spp. are also present in high densities (Edmunds *et al.* 2010). The purple shore crab *Cyclograpsus granulosus* has been recorded in cobble microhabitat (Koss *et al.* 2005a; Edmunds *et al.* 2010). The little green seastar *Parvulastra exigua* was common in rock pools along with the red waratah *Actinia tenebrosa* and green/brown anenomes *Aulactinia veratra* (Koss *et al.* 2005a; Edmunds *et al.* 2010).

Figure 110. Mobile intertidal gastropod fauna in Mushroom Reef Marine Sanctuary: a) cartrut whelk *Dicathais orbita*; b) pulmonate limpet *Siphonaria diemenesis*; c) ocean slug *Onchidella patelloides*; d) ribbed top shell *Austrocochlea constricta*; e) top shell *Calliostoma armillata*; and f) striped periwinkle *Bembicium nanum*. Photo by Mark Norman, Museum of Victoria.

Fish

No information is known for the fish species of the intertidal reef (Plummer *et al.* 2003).



a) b) c) d)

Figure 111. Mobile intertidal invertebrates in Mushroom Reef Marine Sanctuary: a) purple shore crab *Cyclograpsus granulosus*; b) shore crab *Paragrapsus quadridentus*; c) sea star *Nectria ocellata*; d) sea star *Meridiaster gunni*. Photos by Mark Norman, Museum of Victoria.

Subtidal

Soft sediment

The inshore region of Mushroom Reef MS is protected from waves and the sandy sediment has been colonised by *Zostera* sp. in places (Ball and Blake 2007a). The more exposed inshore areas support *A. antarctica* growing on sediment and patches of reef (Ball and Blake 2007a). South and into the small sandy bay monospecific beds of *A. antarctica* and *Zostera* sp. grow (Ball and Blake 2007a). No faunal surveys have been undertaken of this community within the sanctuary to date.

Reef

Subtidal reefs 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 seagrass *A. antarctica* and mixed algae in the shallow north and south (Ball and Blake 2007a). Mixed brown algae and *Phyllospora comosa* dominate the south west tip of Mushroom Reef itself, and bull kelp *D. potatorum* its platform edges (Ball and Blake 2007a). In the south of the MS, in deeper water the reef is dominated by *P. comosa* and *E. radiata* (Ball and Blake 2007a). *Cystophora* spp. are also present (Ball and Blake 2007a).

Invertebrate fauna
No specific information on the invertebrate species on subtidal reefs has been found for Mushroom Reef MS (Plummer *et al.* 2003).

Fish
No specific information on the fish species on subtidal reefs has been found for Mushroom Reef 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 variety of shorebirds and seabirds of conservation significance are found in the waters of Mushroom Reef MS.

Figure 112. Black and white gastric-brooding seastar *Smilasteria multipara* in Mushroom Reef Marine Sanctuary. Photo by Mark Norman, Museum of Victoria.

3.5.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MPAs for their marine ecological communities, rather than threatened species, is also 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 Mushroom Reef MS (Parks Victoria 2007c).

Invertebrates

One species of invertebrate, a sea cucumber *Apsolidium densum,* found in Mushroom Reef MS is listed under the *FFG Act 1988*.

Fish

No conservation listed fish species have been recorded in Mushroom Reef MS.

Birds

Fifteen conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Mushroom Reef MS. Eleven are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. One, the grey-tailed tattler *Heteroscelus brevipes* is regarded as critically endangered. Three birds are listed as vulnerable at both the state and national level, including the fairy prion *Pachyptila turtur*, shy *Thalassarche cauta* and black-browed *T. melanophris* albatross. Eleven birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA).

Table 37. Conservation listed shorebird and seabird records from Mushroom Reef 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
fairy prion	*Pachyptila turtur*		VU	VU		J
black-browed albatross	*Thalassarche melanophris*		VU	VU		J
grey-tailed tattler	*Heteroscelus brevipes*	L	CE		C	J
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
Pacific golden plover	*Pluvialis fulva*		NT		C	J
eastern curlew	*Numenius madagascariensis*		NT		C	J
ruddy turnstone	*Arenaria interpres*				C	J
red-necked stint	*Calidris ruficollis*				C	J
short-tailed shearwater	*Ardenna tenuirostris*					J
Arctic jaeger	*Stercorarius parasiticus*					J
Pacific gull	*Larus pacificus*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			

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

Marine mammals and reptiles

Mushroom Reef MS is shallow and dominated by intertidal and subtidal reefs. It does not provide habitat for large marine mammals. The Australian fur seal *Arctocephalus pusillus doriferus* is EPBC listed and has been sighted near the MS (Plummer *et al.* 2003)

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that Mushroom Reef MS (Table 38) has two known endemic crustacean and one presumed to be endemic (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002a).

Table 38. Endemic fauna in Mushroom Reef MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002a).

Phylum	Order	Family	Species
Crustacea	Brachyura	Cucumaridae	*Apsolidium densum**
Crustacea	Caridea	Acanthochitonidae	*Bassethullia glypta**
Crustacea	Thalassinidea	Pyramidellidae	*Syrnola jonesiana*

* Recorded endemic, other presumed

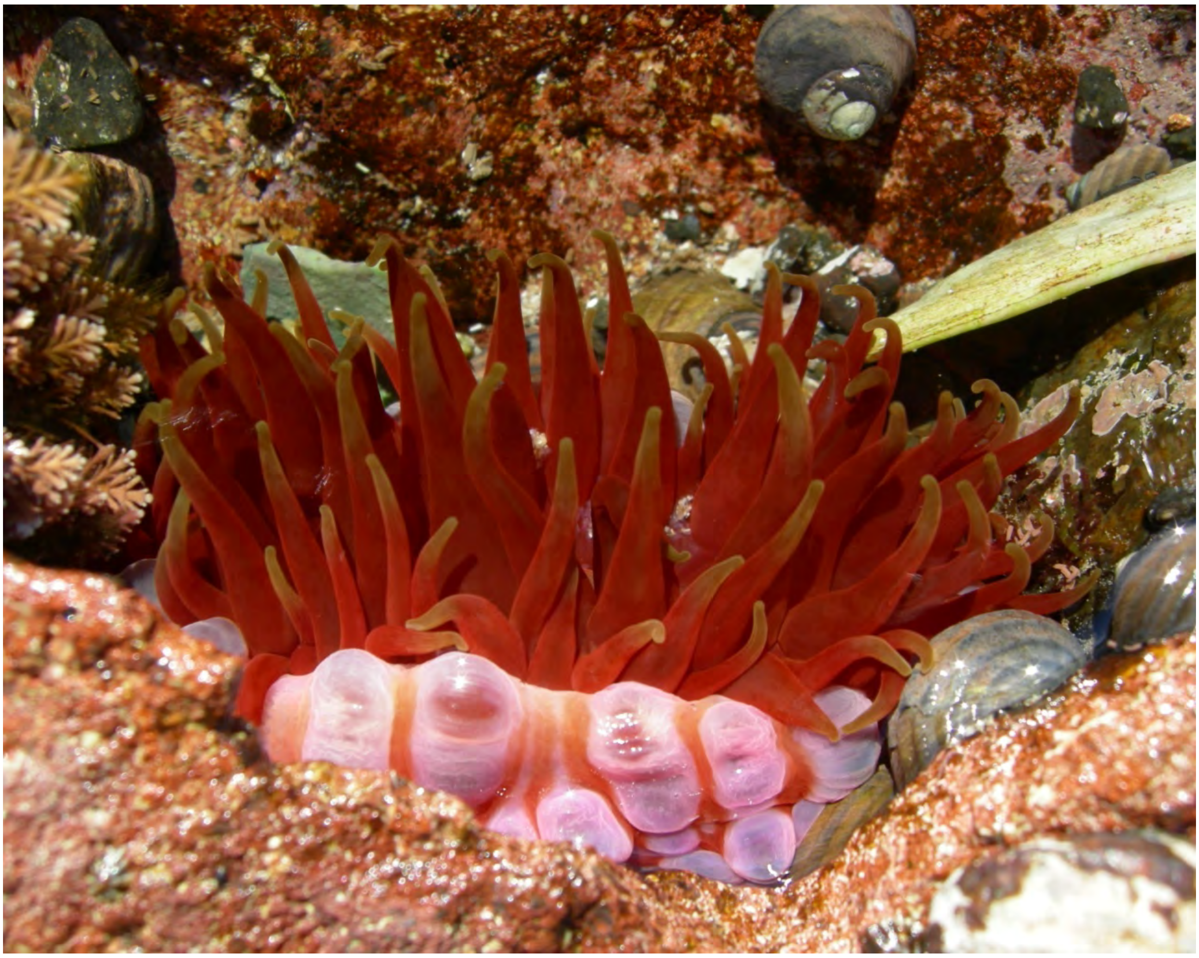


Figure 113. Anenome *Phyctenanthus australis* in Mushroom Reef Marine Sanctuary. Photo by Mark Norman.

Thirty-seven biota (Table 39) have been recorded or are presumed to be at their distributional limit in Mushroom Reef MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; Plummer *et al.* 2003). Seven red and one brown algae, a shrimp and a sea cucumber have been recorded to be at their eastern limit of their distribution in the Mushroom Reef MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). Twenty-two red algae, a crab, a shrimp and a sea cucumber are presumed as being at the easterly limit of their distribution at Mushroom Reef MS. One marine snail has been recorded, and two crabs and another marine snail are presumed to be, at their western limit of distribution. The distributional limits of the biota listed in Table 39 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 39. Marine species at their distribution limits in Mushroom Reef Marine Sanctuary (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002a).

Order	Family	Species	Common name	Category
Dictyotales	Dictyotaceae	*Dictyopteris nigricans*	Brown algae	RE
Ceramiales	Ceramiaceae	*Ceramium tasmanicum*	Red algae	PE
	Ceramiaceae	*Heterothamnion episiliquosum*	Red algae	PE
	Ceramiaceae	*Lamathamnion epicodii*	Red algae	PE
	Ceramiaceae	*Radiathamnion speleiotis*	Red algae	RE
	Ceramiaceae	*Spermothamnion pinnatum*	Red algae	PE
	Ceramiaceae	*Spongoclonium brownianum*	Red algae	RE
	Ceramiaceae	*Wrangelia abietina*	Red algae	PE
	Ceramiaceae	*Wrangelia velutina*	Red algae	PE
Corallinales	Corallinaceae	*Austrolithon intumescens*	Red algae	PE
	Corallinaceae	*Mesophyllum printzianum*	Red algae	PE
	Corallinaceae	*Pneophyllum submersiporum*	Red algae	PE
Gigartinales	Areschougiaceae	*Rhabdonia clavigera*	Red algae	PE
	Cystocloniaceae	*Craspedocarpus blepharicarpus*	Red algae	PE
	Dumontiaceae	*Dudresnaya australis*	Red algae	PE
	Halymeniaceae	*Carpopeltis phyllophora*	Red algae	PE
	Kallymeniaceae	*Kallymenia cribosa*	Red algae	RE
	Kallymeniaceae	*Polycoelia laciniata*	Red algae	PE
	Peyssonneliaceae	*Peyssonnelia splendens*	Red algae	RE
	Mychodeaceae	*Mychodea gracilaria*	Red algae	PE
	Nemastomataceae	*Platoma foliosa*	Red algae	PE
	Nemastomataceae	*Tsengia comosa*	Red algae	PE
	Halymeniaceae	*Zymurgia chondriopsidea*	Red algae	RE
Hildenbrandiales	Hildenbrandiaceae	*Hildenbrandia expansa*	Red algae	PE

Rhodymeniales	Rhodymeniaceae	*Rhodymenia stenoglossa*	Red algae	PE
	Lomentariaceae	*Lomentaria pyramidalis*	Red algae	RE
	Rhodymeniaceae	*Leptosomia rosea*	Red algae	RE
Brachyura	Majidae	*Huenia australis*	Crab	PE
	Grapsidae	*Pachygrapsus transversus*	Crab	PW
	Majidae	*Pseudomicippe maccullochi*	Crab	PW
Caridea	Hippolytidae	*Tozeuma kimberi*	Shrimp	RE
Thalassinidea	Strahlaxiidae	*Strahlaxius plectrorhynchus*	Slow shrimp	PE
Polyplacophora	Ischnochitonidae	*Ischnochiton virgatus*	Chiton	PE
Holothuroidea	Cucumariidae	*Apsolidium handrecki*	Sea Cucumber	PE
	Cucumariidae	*Apsolidium densum*	Sea Cucumber	RE
Gastropoda	Triphoridae	*Cheirodonta labiata*	Marine snail	PW
	Anabathridae	*Pisinna olivacea olivacea*	Marine snail	RW

PE = presumed eastern limit, PW = presumed western limit, PN = presumed northern limit, RE = recorded eastern limit, RW = recorded western limit.

3.5.5 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 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 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). Ten 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. Freshwater in plume from Boags Rocks affecting algal species composition (intertidal and subtidal soft sediment and reef);
2. Individual/recreational fossicking effects on intertidal reef communities (intertidal reef)
3. Shellfish poaching (abalone, sea urchins and crabs) leading to decreased populations of those species (intertidal and subtidal reef);
4. Impact of trampling on intertidal reef communities (intertidal reef);
5. Disturbance from fossicking, trampling and dogs affecting wading birds (intertidal reef and soft sediment);
6. New releases or translocations of exotic marine species affecting marine communities (intertidal and subtidal soft sediment and reef);
7. Educational collecting affecting subtidal and intertidal communities (intertidal reef);
8. Failure to document ecological change affecting marine habitats and communities (all habitats in MS);
9. Nutrients from sewage or fertilizers (golf course, farming) affecting marine communities (intertidal and subtidal soft sediment and reef); and
10. Turbid plume from channel dredging in Port Phillip Bay affecting seagrass (*Amphibolis*) (intertidal and subtidal soft sediment and reef).

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 with particularly invasive species including Japanese kelp *Undaria pinnatifida*, Northern Pacific Seastar *Asterias amurensis* and Eurpoean fanworm *Sabella spallanzanii* (Parks Victoria 2003). Invasive Japanese kelp *Undaria pinnatifida* was successfully removed from near Flinders pier and is not known to be in the MS (Parry and Cohen 2001). 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). The introduced green shore crab *Carcinus maenas* is found within Mushroom Reef MS (Plummer *et al.* 2003). Another species of particular concern is the 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). It is not in the Mushroom Reef MS but its spread into the park could have serious long term ecological consequences for rocky reef communities (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). A large number of species are at the eastern or western limit of their distributional range at Mushroom Reef MS and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in the adjacent Flinders bioregion, has increased its range down the east coast of Australia to Tasmania and that increase is thought to be linked to climate change with the EAC extending further south (Banks *et al.* 2010).

Measures to address or minimise these hazards form part of the management plan for Mushroom Reef MS (Parks Victoria 2007c). For example, research is being conducted into marine pest species, and water quality issues which may impact on park natural values. Management actions have been implemented to minimise these disruptions (Parks Victoria 2007c). 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 114. Intertidal reef and rock pool in Mushroom Reef Marine Sanctuary. Photo by Mark Norman, Museum of Victoria.

3.5.6 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 Mushroom 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 40 and Appendix 2).

Table 40. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Mushroom Reef Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising 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 Intertidal Reef Monitoring Program
Community Based Monitoring Sea Search - Intertidal Reefs

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

Mushroom Reef MS has an ongoing intertidal reef monitoring program (IRMP; Figures 114 and 115), it does not have a shallow subtidal reef monitoring program (SRMP). The IRMP in and around the Mushroom Reef MS began in 2003 with the explicit aim to track changes in invertebrates and macro-algae abundances due to human use, such as trampling and fossicking, of the platforms (Power and Boxshall 2007). The MPA site on Mushroom Reef and reference site outside of the MS (Figure 104) have been surveyed over six census events (Edmunds *et al.* 2004; Gilmour and Edmunds 2007; Stewart *et al.* 2007b; Edmunds *et al.* 2010). The monitoring involves surveying a single reef during a single low tide, targeting the predominant substratum type at each intertidal reef (Hart and Edmunds 2005). The survey is conducted along transects running from the high to the low shore. The density of non-sessile invertebrates and the percentage cover of macroalgae and aggregated sessile invertebrates are surveyed within quadrats along the transects (Hart and Edmunds 2005).

Keough and Carnell's (2009) preliminary analysis of the IRMP data from two census events up to 2006 was done at the Central Victoria bioregion level, including Mushroom Reef, Point Danger and Barwon Bluff MSs and, Point Addis MNP. The analysis compared sites within MPAs to reference sites outside the MPAs post declaration. They found there was no significant difference in species richness and number of species between MPA and reference sites (Keough and Carnell 2009).

Limitations of Keough and Carnell's (2009) analysis include no pre-declaration sampling, the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). 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 targeted analysis of IRMP monitoring data in relation to conservation outcomes for the park and review of the monitoring design will be done by 2013.

Community based monitoring of the intertidal reef, under Sea Search is being conducted by Mushroom Reef Friends group (Koss *et al.* 2005b). Other groups that have a close association with the sanctuary include the Friends of Flinders Coastline, the Victorian Wader Study Group and Reef Watch (Parks Victoria 2007c).

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.

3.5.7 KNOWLEDGE GAPS

No surveys have been conducted on the ecological communities of intertidal or subtidal soft sediments, other than bird surveys and habitat mapping. The understorey flora, and fish and invertebrates on the subtidal reefs are poorly known. No information exists at present for water column assemblages. Major threats have been identified for Mushroom Reef MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.

Figure 115. Intertidal reef in Mushroom Reef Marine Sanctuary. Photo by AME.

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 Central Victoria bioregion on the central 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 Central Victorian bioregion extends from Apollo Bay to Cape Liptrap and out to the limit of Victorian State waters in Bass Strait. It does not include Port Phillip Bay and Western Port, which are in the Victorian Embayments bioregion (IMCRA 2006). It has a temperate climate, a shore characterised by cliffs and sandy beaches and a sea bed that increases from steep to very steep from east to west. It is relatively exposed to swells and weather from the south-west, with moderate wave energy. Its biota is 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.

Within the Central Victoria bioregion, there are two MNPs, Point Addis and Bunurong, and five MSs, Marengo Reefs, Eagle Rock, Point Danger, Barwon Bluff and Mushroom Reef. In addition, there is the Bunurong Marine Park on either side of Bunurong MNP. All MPAs adjoin the coast, except Marengo Reefs MS which is approximately 80 m offshore. Point Addis and Bunurong MNPs extend to the state water limit (~5 km offshore). They are 4418 and 2047 hectares respectively, making them the third and tenth largest Victorian MPAs. Point Danger, Eagle Rock, Barwon Bluff and Marengo Reefs MSs do not extend more than 500m offshore and are all under 26 hectares making them the smallest of Victoria's 24 MPAs. Mushroom Reef MS is 57 hectares in size. All the MPAs are relatively accessible from Victoria's major population centres of Melbourne and Geelong. Two of the MPAs abut terrestrial National Parks, Point Addis MNP abuts the Great Otway National Park and Mushroom Reef MS abuts the Mornington Peninsula National Park. Bunurong MNP abuts the Bunurong Coastal Reserve.

Aboriginal tradition indicates that the Marengo Reefs MS is part of *Country* of Gadubanud people. Point Addis MNP and Eagle Rock, Point Danger and Barwon Bluff MSs are part of the *Country* of the Wathaurung people. Bunurong MNP and Mushroom Reef MS are part of the Country of the *Country* of the Boon Wurrung people.

In Point Danger MS a special management overlay covers 40% of the MS for use by sail and kite boards. Marengo Reefs MS seal haul out is a Special Protection Area with restricted access to limit disturbance to seals. Ship wrecks occur within the Marengo Reefs, Barwon Bluff and Point Danger MSs, and Point Addis and Bunurong MNPs.

Knowledge of the distribution and extent of habitats is required to 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 the shallow waters of all the MPAs, and extends to the whole MPA for Point Addis MNP. All the MPAs have intertidal rocky reef. All the MPAs have some shallow subtidal reef although little is known about this habitat in Point Danger, Barwon Bluff and Mushroom Reef MSs. Point Addis and Bunurong MNP have deep (> 15 m) subtidal reef. The reefs in the MPAs are predominately limestone or sandstone, with some basalt reef in Eagle Rock, Barwon Bluff and Mushroom Reef MSs. The shallow subtidal rocky reefs in Bunurong MNP extend several kilometres from shore. All, except for Marengo Reefs, have intertidal soft sediment habitat or beaches interspersed amongst rocky headlands. Flora in this habitat is restricted to macroalgae drift which, with other wrack material, contributes to the detrital cycle and is a significant source of food for many shore birds and invertebrates. All the MPAs have some subtidal soft sediment habitat, which can have very high numbers of invertebrate species living on and in this habitat. Subtidal soft sediment and open water are the dominant habitat types in Point Addis and Bunurong, but intertidal and shallow subtidal rocky reef are the dominant habitat in the five MSs.

The main habitat forming algae on the intertidal reefs in the MPAs is the brown alga Neptune's necklace *Hormosira banksii*. Algal turf is also abundant at Point Addis MNP, Point Danger and Barwon Bluff MSs. Patches of coralline algae also provide habitat on the reefs at Point Danger, Barwon Bluff and Mushroom Reef MSs. The sea lettuce *Ulva sp.* can be quite abundant in Point Danger MS. Patches of the mat forming mussel *Limnoperna pulex* are found in Point Addis and Bunurong MNPs, and Point Danger and Barwon Bluff MSs. In Point Addis MNP the predominant aggregating sessile invertebrate is the tube worm *Galeolaria caespitosa*. The seagrass *Amphibolis antarctica* grows in rock pools on the intertidal reef of Bunurong MNP, Barwon Bluff and Mushroom Reef MSs. It also grows subtidally in these MPAs and forms extensive beds in Point Addis and Bunurong MNP, and Point Danger MS. The stems and fronds of *A. antarctica* support sessile invertebrates, including large colonies of bryozoans and hydroids. Stands of bull kelp *Durvillaea potatorum* grow on the intertidal reef edge in the shallow subtidal in Point Addis MNP, and Marengo Reefs, Eagle Rock, Barwon Bluff and Mushroom Reef MSs. Sand inundates the intertidal reef in Bunurong MNP, and Eagle Rock and Point Danger MSs.

The mobile intertidal invertebrate fauna on the reefs of the MPAs is dominated by molluscs. The basalt reef at Mushroom Reef MS is considered one of most diverse intertidal rocky reef assemblages in Victoria. The Bunurong coast has a very high diversity of chitons including endemic species. Little is known about the intertidal flora and fauna of Marengo Reefs MS. The striped conniwink *Bembicium nanum* and pulmonate limpet *Siphonaria spp.* are some of the most abundant mobile invertebrates on the intertidal reefs in all the MPAs. Various other limpet species are abundant across the MPAs. The periwinkles *Nodolittorina acutispira* and *N. unifasciata* are also abundant at the two MNPs and Barwon Bluff MS. The top shell *Austrocochlea constricta* is particularly abundant in all the MSs. The black nerite *Nerita atramentos* is abundant amongst the basalt boulders in Eagle Rock and Mushroom Reef MSs.

On the shallow subtidal reef in Point Addis MNP the algae canopy varies from bull kelp *Durvillaea potatorum* in shallower waters to mixed algae, crayweed *Phyllospora comosa,* kelp *Ecklonia radiata* and giant kelp *Macrocystis pyrifera.* The algal assemblage of Ingoldsby Reef is particularly diverse. In Bunurong MNP medium-sized brown algal species such as *Seirococcus axillaris*, *Cystophora* species, *Sargassum* spp., and *Acrocarpia paniculata* form the canopy. Its algal assemblage is unusual with a high diversity of red and brown algae species and low abundance or absence of the large browns such as *E. radiata* and *P. comosa.* The canopy forming subtidal reef algae at both Marengo Reefs and Eagle Rock

MSs is generally *P. comosa* changing to *D. potatorum* in shallower waters, with a diverse assemblage of smaller brown algal species. The understorey in both these MSs has very few species and a low cover of red and green algae. There is no single dominant subtidal canopy species in Point Danger MS, with the shallow subtidal reefs having a mix of brown algae; notably *P. comosa* does not grow in the MS. In Barwon Bluff MS on sand inundated reef the canopy is formed by a mix of brown algae species, on higher profile reef it is formed by *P. comosa* and in the deeper waters *M. pyrifera*. In Mushroom Reef MS the canopy is *P. comosa* and mixed brown algae, and in deeper waters *E. radiata*. The seagrass *Heterozostera nigricaulis* grows in sparse beds on shallow sandy sediment beyond the surf zone in the west of Point Addis MNP and in Mushroom Reef MS *Zostera* sp. grows on the subtidal soft sediment.

The invertebrate assemblage of the subtidal reefs in the MPAs of the Central bioregion is characterised by abundant blacklip abalone *Haliotis rubra*. In Point Addis and Bunurong MNP the warrener *Turbo undulatus* and a diverse variety of sea stars are also abundant. In Barwon Bluff MS *T. undulatus*, elephant snail *Scutus antipodes* and cartrut whelk *Dicathais orbita* are common. Marengo Reefs MS assemblage is characterised by a low abundance of the purple urchin *Heliocidaris erythrogramma,* and Eagle Rock MS by low numbers of all invertebrates other than *H. rubra*. The subtidal invertebrate species richness and diversity is lower at both Eagle Rock and Marengo Reefs MSs than at Point Addis MNP. Point Danger MS has a high diversity of invertebrates, and is particularly recognised for its diverse opisthobranch (sea slug) fauna. The black- and white- gastric-brooding seastar *Smilasterias multipara* is an important natural value of Mushroom Reef MS.

The subtidal reef fish assemblage has not been described for Point Danger or Mushroom Reef MSs. In the other MPAs the blue-throated wrasse *Notolabrus tetricus* is common. As are the Victorian scalyfin *Parma victoriae,* yellow striped leather jacket *Meuschenia flavolineata* and sea sweep *Scorpis aequipinnis,* except in Marengo Reefs MS. Herring cale *Odax* cyanomelas is abundant in all these MPAs but not in Point Addis MNP. The purple wrasse *N. fucicola* is abundant in Point Addis and Bunurong MNPs, and particularly abundant in Marengo Reefs MS. Other fish species such as the senator wrasse *Pictilabrus laticlavius,* horseshoe leatherjacket *M. hippocrepis* magpie morwong *Cheliodactylus nigripes* and zebra fish *Girella zebra* occur in all the MPAs but in varying abundances.

Deep water soft sediments in Point Addis MNP have unique assemblages of sponges, bryozoans, ascidians and hydroids. Its rhodolith beds have a high diversity of algal, invertebrate and fish species. In Bunurong MNP the deep reefs are dominated by sponges, stalked ascidians and bryozoans.

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, from 13 species in Marengo Reefs MS and up to 31 in Bunurong MNP. The endangered hooded plover *Thinornis rubricollis* has been recorded from both Point Danger and Barwon Bluff MSs but is not known to breed in either MS. The MPAs are also important for many migratory birds, from six species in Marengo Reefs MS to 18 in Barwon Bluff MS. Numerous marine species are found at the limit of their distribution range within individual MPAs. In Mushroom Reef over 37 species, including algae and invertebrates are believed to be at the edge of their distributional range, whilst none are known from Barwon Bluff MS. Twenty-one are believed to be at the edge of their range in Bunurong MNP, nine in Marengo Reefs MS, seven in Eagle Rock MS and two in both Point Addis MNP and Point Danger MS. Three crustaceans are believed to be endemic to Mushroom Reef MS.

The two large MNPs cover 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* have been sighted in Point Addis MNP and humpback whales *Megaptera novaeangliae* in Bunurong MNP; both whales are conservation listed. Other marine mammals sighted in both Point Addis and Bunurong MNP are the bottlenose dolphin *Tursiops spp.*, Australian fur seal *Arctocephalus pusillus doriferus* (Figure 116) and leopard seal *Hydrurga leptonyx.* In addition the long-finned pilot whale *Globicephala melas* and killer whale *Orcinus orca* have been sighted in Point Addis MNP, and the common dolphin *Delphinus delphis* in Bunurong MNP. Large whales are not found within the smaller shallower MSs, but they still provide important habitat for smaller marine mammals. Marengo Reefs MS is an important haul out for Australian fur seals *A. pusillus doriferus,* which is also known to use intertidal platforms in Eagle Rock MS as occasional haul-out areas. The endangered warm water vagrant sea turtle the pacific or olive ridley *Lepidochelys olivacea* has been sighted in or near Point Addis MNP and probably occurs in Bunurong MNP too.

The introduction of foreign species or marine pests, by recreational or commercial vessels, threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment. It is presumed that the introduced green meany or green shore crab *Carcinus maenas* occurs on the intertidal reefs of all the MPAs. Other 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)*.

Abalone viral ganglioneuritus has been slowly spreading killing a large percentage of abalone in infected areas from Discovery Bay MNP to Cape Otway. It is not in the Central bioregion but could have serious long term ecological consequences for subtidal reef communities if it spreads into the bioregion. Recreational and commercial boats and diving can be a vector for this virus.

Specific threats to individual MPAs have been identified. Generally recreational boating, as well as being a vector for introduced species and diseases, has been identified as posing a threat to seagrass beds, soft sediments and shallow subtidal reefs through propeller scour or anchors. Disturbance of wildlife is also a threat, *e.g.* shore birds by vehicles, people or dogs; or hauled out seals by boats in Marengo Reefs MS. Damage through trampling and illegal collection pose threats to the highly accessible intertidal reefs in the MPAs. Poaching of abalone or fish is a threat within the MPAs. Commercial vessels that pass near or through the waters of the MPAs also pose a threat due to the risk of oil spills. Increased nutrients and sediments through land use or waste discharge pose a threat to water quality in the MPAs. Measures to address or minimise these threats form part of the management plans for the MPAs.

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. 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 occurs in Point Addis and Bunurong MNPs, and Marengo Reefs and Eagle Rock MSs. Intertidal reef monitoring is conducted in all the MPAs in the bioregion, except Marengo Reefs and Eagle Rock MSs. Statewide projects are currently underway to photograph and document their marine natural values, to determine which MPAs are most at risk from introduced species and to detect poaching.

Detailed bathymetry mapping and substrate mapping has been done for shallow waters in all MPAs, and the bathymetry and substrates for all of Point Addis MNP have been mapped. Mapping in Point Addis MNP has also allowed predictive modelling of the distribution and extent of habitats for the entire MPA. For Bunurong MNP 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 reef subtidal marine monitoring programs. For MSs without subtidal reef monitoring we have a limited understanding of their subtidal natural values. Technological improvements have increased our ability to explore and describe deep habitats, as has been done for soft sediments and reefs in Point Addis MNP. A large hole in our understanding of the natural values of Central bioregion MPAs is the intertidal soft sediment and open waters. Whilst threats to the MPAs have been identified we have limited knowledge of the effect of those threats on the natural values.

Figure 116. Australian fur seal *Arctocephalus pusillus doriferus* over subtidal reef in Marengo Reefs Marine Sanctuary.

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Appendix 1

Compilation of species from databases from:

- Beanland (1985), (MSc – Point Addis only)
- 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 Barwon Bluff MS);
- MAVRIC (Monitoring and Assessment of Victoria's Rocky Intertidal Coast – all except Marengo Reefs MS and Point Danger MS);
- PV intertidal reef monitoring program (IRMP 02-04, all except Marengo Reefs MS and Eagle Rock MS);
- PV subtidal reef monitoring program (SRMP_All, all MPAs except Point Danger MS, Barwon Bluff MS and Mushroom Reef MS); and
- The Sea Search volunteer monitoring program (Barwon Bluff MS, Mushroom Reef MS and Bunurong MNP).

		Number of records by MPA						
Source	Habitat(s)	MaR	ER	PA	PD	BB	MuR	Bun
Beanland	Benthic algae			78				
Fauna100_5kmSea	All	31	26	65	43	64	41	52
MAFRI distribution MNV v1	All	9	7	2	2		38	21
MAFRI endemic MNV v1	All						3	1
MAVRIC	Rocky Intertidal		59	55		45	79	89
IRMP 02-04	Rocky Intertidal			43	32	46	47	41
SRMP_All	Rocky Subtidal	53	71	117				190
Seasearch	Rocky Intertidal					18	46	21

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. MaR – Marengo Reefs MS; ER – Eagle Rock MS; PA – Point Addis MNP; BB – Barwon Bluff MS; MuR – Mushroom Reff MS; Bun – Bunurong MNP.

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
Blue-green algae	Phormidiaceae	*Symploca* sp.	Blue-green alga					1	1	1
	Rivularaceae	*Rivularia firma*	Blue-green alga						1	1
		Rivularia sp.	Blue-green alga			1	1	1	1	1
Total blue-green algae				**0**	**0**	**1**	**1**	**2**	**3**	**3**
Green algae	Caulerpaceae	*Caulerpa annulata*	Green alga			1				1
		Caulerpa brownii	Green alga	1	1	1		1	1	1
		Caulerpa cactoides	Green alga			1			1	1
		Caulerpa flexilis	Green alga			1				1
		Caulerpa flexilis var. *muelleri*	Green alga		1	1				1
		Caulerpa geminata	Bubbled Caulerpa			1			1	1
		Caulerpa longifolia	Green alga			1				1
		Caulerpa resiculifera	Green alga							1
		Caulerpa scalpelliformis	Green alga	1		1				1
		Caulerpa simpliciuscula	Green alga	1		1				1
		Caulerpa vesiculifera	Green alga			1				1
	Cladophoraceae	*Abjohnia laetevirens*	Green alga			1				1
		Apjohnia laetevirens	Green alga			1				
		Chaetomorpha coliformis	Green alga			1				
		Chaetomorpha sp.	Green alga			1				1
		Cladophora feredayi	Green alga		1					
		Cladophora rugulosa	Green alga		1	1			1	
	Codiaceae	*Codium duthieae*	Green alga							1
		Codium fragile	Dead man's fingers			1			1	
		Codium lucasii	Green alga							1
		Codium mamillosum	Green alga							1
		Codium pomoides	Green alga	1	1	1				1
		Codium sp.	Green alga							1
		Codium spongiosum	Green alga							1
	Derbesiaceae	*Pedobesia clavaeformis*	Green alga							1
Green algae	Siphonocladaceae	*Dictyosphaeria sericea*	Green alga			1				1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Udoteaceae	*Rhipiliopsis peltata*	Green alga							1
	Ulvaceae	*Enteromorpha compressa*	Green alga							1
		Enteromorpha intestinalis	Green alga					1	1	1
		Enteromorpha sp.	Green alga			1	1	1	1	
		Ulva sp.	Sea lettuce		1	1	1	1	1	1
	UnknownFamily	Unidentified filamentous green algae	Green alga		1	1				
		Unidentified Green Algae	Green alga				1			1
Total green algae				**4**	**7**	**21**	**3**	**4**	**8**	**26**
Brown algae	Alariaceae	*Ecklonia radiata*	Common kelp		1	1				1
	Cladostephaceae	*Cladostephus spongiosus*	Brown alga	1	1	1		1		1
	Cystoseiraceae	*Acrocarpia paniculata*	Brown alga	1	1	1				1
		Carpoglossum confluens	Brown alga		1					1
		Caulocystis cephalornithos	Brown alga							1
		Caulocystis uvifera	Brown alga							1
		Cystophora monilifera	Brown alga	1		1				1
		Cystophora moniliformis	Brown alga	1	1	1				1
		Cystophora pectinata	Brown alga							1
		Cystophora platylobium	Brown alga			1				1
		Cystophora retorta	Brown alga	1	1	1		1		1
		Cystophora retroflexa	Brown alga	1	1	1				1
		Cystophora siliquosa	Brown alga	1		1				1
		Cystophora sp.	Brown alga					1		1
		Cystophora subfarcinata	Brown alga		1	1		1	1	1
		Cystophora torulosa	Brown alga	1	1				1	1
		Cystoseira trinodis	Brown alga		1					
		Myriodesma tuberosum	Brown alga							1
		Scaberia agardhii	Brown alga							1
Brown algae	Dictyotaceae	*Chlanidophora microphylla*	Brown alga	1		1				1
		Dictyopteris acrostichoides	Brown alga							1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Dictyopteris muelleri	Brown alga		1	1				1
		Dictyopteris nigricans	Brown alga						1	
		Dictyota dichotoma	Brown alga	1	1					1
		Dilophus marginatus	Brown alga		1					
		Dilophus robustus	Brown alga		1					
		Distromium sp.	Brown alga							1
		Glossophora nigricans	Red alga			1				
		Homeostrichus sinclairii	Brown alga			1				1
		Lobophora variegata	Brown alga							1
		Lobospira bicuspidata	Brown alga	1	1	1				1
		Pachydictyon paniculatum	Brown alga			1				
		Pachydictyon polycladum	Brown alga						1	
		Padina fraseri	Brown alga		1	1			1	1
		Zonaria angustata	Brown alga		1	1				1
		Zonaria apiralis	Brown alga			1				
		Zonaria crenata	Brown alga							1
		Zonaria sp.	Brown alga			1				1
		Zonaria spiralis	Brown alga							1
		Zonaria turneriana	Brown alga	1	1	1				1
	Durvillaeaceae	*Durvillaea potatorum*	Bull kelp		1				1	1
	Ectocarpaceae	*Asteronema ferruginea*	Brown alga			1				
		Ectocarpus sp.	Brown alga							1
	Fucaceae	*Xiphophora chondrophylla*	Brown alga	1		1			1	1
	Hormosiraceae	*Hormosira banksii*	Neptune's necklace		1	1	1	1	1	1
	Leathesiaceae	*Leathesia difformis*	Sea potato			1				
	Lessoniaceae	*Macrocystis pyrifera*	Kelp							1
	Notheiaceae	*Notheia anomala*	Brown alga		1	1		1	1	1
Brown algae	Sargassaceae	*Sargassum bracteolosum*	Brown alga			1				
		Sargassum decipiens	Brown alga			1				1
		Sargassum fallax	Brown alga							1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Sargassum heteromorphum	Brown alga							1
		Sargassum sonderi	Brown alga		1	1				1
		Sargassum sp.	Brown alga	1	1	1			1	1
		Sargassum spinuligerum	Brown alga	1	1	1				1
		Sargassum varians	Brown alga			1				1
		Sargassum verruculosum	Brown alga	1		1				1
		Sargassum vestitum	Brown alga	1	1	1				1
	Scytosiphonaceae	*Colpomenia peregrina*	Brown alga	1						
		Colpomenia sinuosa	Globe algae			1			1	1
		Colpomenia sp.	Brown alga						1	
		Scytothamnus australis	Brown alga	1						
	Seirococcaceae	*Phyllospora comosa*	Brown alga	1	1			1	1	
		Scytosiphon lomentaria	Brown alga			1			1	1
		Seirococcus axillaris	Brown alga			1				1
	Splachnidiaceae	*Splachnidium rugosum*	Sausage weed					1		1
	Sporochnaceae	*Bellotia eriophorum*	Brown alga							1
		Carpomitra costata	Brown alga			1				1
		Encyothalia cliftoni	Brown alga			1				
		Perithalia caudata	Brown alga			1				1
	Stypocaulaceae	*Halopteris gracilescens*	Brown alga							1
		Halopteris paniculata	Brown alga							1
		Halopteris pseudospicta	Brown alga			1				
		Halopteris sp.	Brown alga	1	1	1				1
		Phloiocaulon foecundum	Brown alga			1				
	UnknownFamily	Unidentified brown algae	Brown alga	1	1	1	1		1	1
		Unidentified brown turfing algae	Brown alga			1				1
Brown algae		Unidentified filamentous brown algae	Brown alga	1		1				1
	Valoniaceae	*Dictyota apiculata*	Brown alga			1				

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Dictyota sp. (fine)	Brown alga							1
Total brown algae				**23**	**28**	**47**	**2**	**8**	**15**	**61**
Red algae	Areschougiaceae	*Acrotylus australis*	Red alga							1
		Areschougia congesta	Red alga			1				1
		Areschougia sp.	Red alga							1
		Callophycus laxus	Red alga			1				1
		Erythroclonium angustatum	Red alga							1
		Erythroclonium muelleri	Red alga							1
		Erythroclonium sonderi	Red alga			1				1
		Erythroclonium sp.	Red alga		1					1
		Rhabdonia clavigera	Red alga						1	
		Rhabdonia verticillata	Red alga			1				
	Bonnemaisoniaceae	*Asparagopsis armata*	Red alga			1				1
		Asparagopsis taxiformis	Red alga			1				
		Delisea plumosa	Red alga							1
		Delisea pulchra	Red alga			1				1
		Ptilonia australasica	Red alga			1				1
	Ceramiaceae	*Ballia callitricha*	Red alga		1	1				1
		Ceramium lenticulare	Red alga	1						
		Ceramium tasmanicum	Red alga						1	
		Dasyphila preissii	Red alga			1				
		Euptilota articulata	Red alga		1	1				1
		Griffithsia sp.	Red alga							1
		Heterothamnion episiliquosum	Red alga						1	
		Hirsutithallia mucronata	Red alga							1
Red algae		*Lamathamnion epicodii*	Red alga						1	
		Muellerana wattsii	Red alga		1					
		Psilothallia siliculosa	Red alga		1					
		Radiathamnion speleiotis	Red alga						1	
		Spermothamnion pinnatum	Red alga						1	

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Spongoclonium brownianum	Red alga						1	
		Trithamnion aculeatum	Red alga	1						
		Wollastoniella mucranata	Red alga							1
		Wrangelia abietina	Red alga						1	
		Wrangelia velutina	Red alga						1	
	Champiaceae	*Champia affinis*	Red alga			1				
		Champia sp.	Red alga							1
		Champia viridis	Red alga							1
	Corallinaceae	*Amphiroa anceps*	Red alga	1	1	1				1
		Amphiroa gracilis	Red alga							1
		Arthrocardia wardii	Red alga	1	1					1
		Austrolithon intumescens	Red alga						1	
		Cheilosporium elegans	Red alga			1				
		Cheilosporum sagittatum	Red alga	1	1	1				1
		Corallina officinalis	Red alga			1		1	1	1
		Haliptilon curvieri	Red alga			1				
		Haliptilon roseum	Red alga	1	1	1				1
		Jania pusilla	Red alga							1
		Jania sp.	Red alga			1				
		Lesueuria mindeniana	Red alga		1					
		Lithophyllum cystoseirae	Red alga			1				
		Mesophyllum printzianum	Red alga						1	
		Metagoniolithon radiatum	Red alga	1		1				1
		Metamastophora flabellata	Red alga			1				1
Red algae		*Phymatolithon* sp.	Red alga			1				
		Pneophyllum submersiporum	Red alga						1	
		Spongites tunicatus	Red alga	1						
		Unidentified coralline algae	Red alga	1		1	1		1	1
		Unidentified encrusting corallines	Red alga	1	1	1	1	1	1	1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Unidentified erect corallines	Red alga			1				1
	Cystocloniaceae	*Craspedocarpus blepharicarpus*	Red alga						1	
	Dasyaceae	*Dasya clavigera*	Red alga			1			1	
		Dasya villosa	Red alga			1				
		Heterosiphonia gunniana	Red alga							1
	Delesseriaceae	*Hemineura frondosa*	Red alga							1
		Nitophyllum pulchellum	Red alga			1				
	Dicranemataceae	*Tylotus obtusatus*	Red alga							1
	Diogenidae	*Diplocladia patersonis*	Red alga			1		1		1
	Dumontiaceae	*Dudresnaya australis*	Red alga						1	
	Gelidiaceae	*Capreolia implexa*	Red alga			1		1	1	1
		Gelidium asperum	Red alga		1	1		1		1
		Gelidium australe	Red alga		1	1		1		1
		Gelidium ceramoides	Red alga			1				
		Gelidium pusilllum	Red alga						1	
		Gelidium sp.	Red alga							1
		Pterocladia capillacea	Red alga			1				
		Pterocladia lucida	Red alga			1				1
	Gracilariaceae	*Curdiea* sp.	Red alga			1				
		Gracilaria secundata	Red alga			1				
		Melanthalia abscissa	Red alga		1	1				1
		Melanthalia fastigiata	Red alga			1				
		Melanthalia obtusata	Red alga			1				1
Red algae	Halymeniaceae	*Carpopeltis phyllophora*	Red alga						1	
		Halymenia plana	Red alga			1				
		Polyopes constrictus	Red alga		1					1
		Thamnoclonium dichotomum	Red alga							1
		Zymurgia chondriopsidea	Red alga						1	
	Hildenbrandiaceae	*Hildenbrandia expansa*	Red alga	1					1	
		Hildenbrandtia sp.	Red alga			1				

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Hydrocharitaceae	*Haloplegma preissii*	Red alga			1				
	Hypneaceae	*Hypnea ramentacea*	Red alga			1				1
		Hypnea sp.	Red alga			1				
	Kallymeniaceae	*Callophyllis rangiferina*	Red alga			1				1
		Kallymenia cribosa	Red alga						1	
		Polycoelia laciniata	Red alga						1	
	Lomentariaceae	*Lomentaria pyramidalis*	Red alga						1	
	Mychodeaceae	*Mychodea gracilaria*	Red alga						1	
	Nemastomataceae	*Platoma foliosa*	Red alga						1	
		Tsengia comosa	Red alga						1	
	Nizymeniaceae	*Nizymenia australis*	Red alga			1				1
	Peyssonneliaceae	*Peyssonnelia novae-hollandiae*	Red alga							1
		Peyssonnelia splendens	Red alga						1	
		Sonderopelta coriacea	Red alga			1				1
		Sonderophycus australis	Red alga			1				
	Phacelocarpaceae	*Phacelocarpus alatus*	Red alga			1				1
		Phacelocarpus peperocarpos	Red alga		1	1				1
	Phyllophoraceae	*Ahnfeltiopsis humilis*	Red alga		1					
	Plocamiaceae	*Plocamium angustum*	Red alga	1	1	1				1
		Plocamium cartilagineum	Red alga		1	1				1
		Plocamium costatum	Red alga			1				1
		Plocamium dilatatum	Red alga		1	1				1
Red algae		*Plocamium leptophyllum*	Red alga			1				1
		Plocamium mertensii	Red alga			1				1
		Plocamium patagiatum	Red alga			1				
		Plocamium preissianum	Red alga			1				1
	Polyidaceae	*Rhodopeltis australis*	Red alga		1	1				1
		Rhodophyllis gunni	Red alga			1				
	Rhodomelaceae	*Dictymenia harveyana*	Red alga							1
		Dictymenia tridens	Red alga			1				

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Echinothamnion hystrix	Red alga		1	1				1
		Echinothamnion sp.	Red alga							1
		Laurencia botryoides	Red alga			1				
		Laurencia clavata	Red alga			1				
		Laurencia elata	Red alga			1				1
		Laurencia filiformis	Red alga			1				1
		Laurencia heteroclada	Red alga			1				
		Laurencia shepherdi	Red alga			1				
		Laurencia sp.	Red alga							1
		Lenormandia marginata	Red alga			1				1
		Polysiphonia decipiens	Red alga			1				
	Rhodymeniaceae	*Botryocladia obovata*	Red alga							1
		Cordylecladia furcellata	Red alga			1				1
		Epymenia wilsonis	Red alga			1				
		Erythrymenia minuta	Red alga			1				
		Hymenocladia chondricola	Red alga			1				
		Leptosomia rosea	Red alga						1	
		Rhodymenia australis	Red alga		1	1				1
		Rhodymenia obtusa	Red alga			1				1
		Rhodymenia prolificans	Red alga			1				1
		Rhodymenia sp.	Red alga	1						1
Red algae		*Rhodymenia stenoglossa*	Red alga						1	
	Solieriaceae	*Solieria robusta*	Red alga							1
	UnknownFamily	Unidentified filamentous red algae	Red alga	1		1		1	1	1
		Unidentified red turfing algae	Red alga			1	1	1	1	1
		Unidentified thallose red algae	Red alga	1	1	1		1	1	1
Total red algae				**15**	**24**	**82**	**3**	**9**	**35**	**76**
Lichens	UnknownFamily	Lichen species	Lichen			1				
Total lichens				**0**	**0**	**1**	**0**	**0**	**0**	**0**

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
Seagrasses	Cymodoceaceae	*Amphibolis antarctica*	Seagrass			1			1	1
	Hydrocharitaceae	*Halophila ovalis*	Seagrass						1	
	Zosteraceae	*Zostera muelleri*	Seagrass							1
Total seagrasses				**0**	**0**	**1**	**0**	**0**	**2**	**2**
Cnidaria	Actiniidae	*Actinia tenebrosa*	Anemone		1	1	1	1	1	1
		Aulactinia veratra	Anemone		1	1	1	1	1	1
		Oulactis muscosa	Anemone		1	1	1	1		1
	Sagartiidae	*Anthothoe albocincta*	Anemone			1		1		1
Total cnidarians				**0**	**3**	**4**	**3**	**4**	**2**	**4**
Flatworms	Turbellaria	*Notoplana australis*	Flatworm						1	
Total flatworms				**0**	**0**	**0**	**0**	**0**	**1**	**0**
Polychaetes	Serpulidae	*Galeolaria caespitosa*	Tubeworm		1	1	1	1	1	1
Total polychaetes				**0**	**1**	**1**	**1**	**1**	**1**	**1**
Barnacles	Balanidae	*Austromegabalanus nigrescens*	Acorn barnacle							1
	Catophragmidae	*Catomerus polymerus*	Surf barnacle		1	1			1	1
	Chthamalidae	*Chamaesipho tasmanica*	Honeycomb barnacle		1	1		1	1	1
		Chthamalus antennatus	Acorn barnacle		1	1	1	1	1	1
	Iblidae	*Ibla quadrivalvis*	Goose barnacle						1	
	Tetraclitidae	*Tesseropora rosea*	Acorn barnacle					1	1	
	Tetraclitidae	*Tetraclitella purpurascens*	Acorn barnacle		1	1		1	1	1
Barnacles	UnknownFamily	Unidentified barnacle	Barnacle					1		
Total barnacles				**0**	**4**	**4**	**1**	**5**	**6**	**5**
Decapod crustaceans	Callianassidae	*Biffarius ceramicus*	Ceramic ghost shrimp						1	
	Goneplacidae	*Hexapus granuliferus*	Crab				1			
	Grapsidae	*Cyclograpsus granulosus*	Shore crab			1			1	1
		Leptograpsus variegatus	Swift-footed shore crab							1
		Pachygrapsus transversus	Shore crab						1	
		Paragrapsus gaimardii	Shore crab						1	1
	Hippolytidae	*Tozeuma kimberi*	Hippolytid shrimp						1	

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Hymenosomatidae	*Amarinus paralacustris*	Spider crab		1					
		Halicarcinus rostratus	Beaked spider crab						1	
	Leucosiidae	*Phlyixia dentifrons*	Pebble crab							1
	Majidae	*Huenia australis*	Spider crab						1	
		Naxia spinosa	Spiny seaweed crab							1
		Pseudomicippe maccullochi	Spider crab						1	
		Tumulosternum wardi	Spider crab							1
	Pilumnidae	*Pilumnus monilifer*	Beaded hairy-crab							1
	Strahlaxiidae	*Strahlaxius plectrorhynchus*	Slow shrimp						1	
	UnknownFamily	Unidentified crab	Crab					1		1
Total decapod crustaceans				**0**	**1**	**1**	**1**	**1**	**9**	**8**
Chitons	Acanthochitonidae	*Acanthochitona granostriatus*	Chiton							1
		Acanthochitona retrojectus	Chiton	1		1				1
		Bassethullia glypta	Chiton						1	
	Chitonidae	*Chiton (Rhyssoplax) oruktus*	Chiton							1
	Ischnochitonidae	*Ischnochiton australis*	Chiton		1				1	1
		Ischnochiton elongatus	Chiton		1				1	1
		Ischnochiton lineolatus	Chiton						1	
		Ischnochiton thomasi	Chiton							1
Chitons		*Ischnochiton variegatus*	Chiton		1				1	
		Ischnochiton versicolor	Chiton						1	
		Ischnochiton virgatus	Chiton						1	
	Mopaliidae	*Plaxiphora albida*	Chiton			1		1	1	1
	UnknownFamily	Unidentified chiton	Chiton			1	1	1	1	
Total chitons				**1**	**3**	**3**	**1**	**2**	**9**	**7**
Gastropods	Anabathridae	*Pisinna olivacea*	Sea snail						1	
	Buccinidae	*Cominella eburnea*	Whelk						1	
		Cominella lineolata	Whelk		1	1	1	1	1	1
	Cerithiopsidae	*Tubercliopsis septapila*	Gastropod				1			

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Columbellidae	*Mitrella austrina*	Dove shell		1					
		Mitrella pulla	Dove shell						1	
		Mitrella semiconvexa	Dove shell						1	
	Conidae	*Conus anemone*	Gastropod						1	
	Cymatiidae	*Cabestana spengleri*	Triton (Trumpet shell)							1
	Fissurellidae	*Clypidina rugosa*	Keyhole limpet		1	1	1	1	1	1
		Notomella candida	Keyhole limpet		1	1			1	1
		Scutus antipodes	Keyhole limpet		1				1	
	Hipponicidae	*Sabia conica*	Bonnet limpet		1				1	1
	Littorinidae	*Afrolittorina praetermissa*	Periwinkle		1	1		1	1	1
		Austrolittorina unifasciata	Periwinkle		1	1		1	1	1
		Bembicium melanostoma	Periwinkle		1	1		1	1	1
		Bembicium nanum	Periwinkle		1	1	1	1	1	1
		Nodilittorina acutispira	Periwinkle			1		1		1
		Nodilittorina unifasciata	Periwinkle			1	1	1	1	1
	Lottiidae	*Lottia mixta*	Limpet		1	1				1
		Notoacmea alta	Limpet			1		1	1	1
		Notoacmea flammea	Limpet		1	1		1	1	1
		Notoacmea mayi	Limpet		1	1	1	1	1	1
Gastropods		*Notoacmea petterdi*	Limpet		1	1		1		1
		Patelloida alticostata	Limpet		1	1	1	1	1	1
		Patelloida insignis	Limpet			1	1		1	1
		Patelloida latistrigata	Limpet		1	1		1	1	1
	Muricidae	*Dicathais orbita*	Gastropod		1	1	1	1	1	1
		Lepsiella reticulata	Gastropod					1		1
	Muricidae	*Lepsiella vinosa*	Gastropod		1	1	1	1	1	1
	Nacellidae	*Cellana solida*	Limpet						1	
		Cellana tramoserica	Limpet		1	1	1	1	1	1
	Neritidae	*Nerita atramentosa*	Nerite		1	1		1	1	1
		Nerita morio	Nerite		1					

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Olividae	*Belloliva leucozona*	Gastropod		1					
	Onchidiidae	*Onchidella nigricans*	Pulmonate sea slug						1	
		Onchidella patelloides	Pulmonate sea slug		1	1	1	1	1	1
	Patellidae	*Patella chapmanii*	Patellid limpet						1	
		Patella peronii	Patellid limpet		1			1		1
		Scutellastra peronii	Scaly limpet							1
	Pyramidellidae	*Syrnola jonesiana*	Gastropod						1	
	Rissoidae	*Rissoina variegata*	Variegated Rissoina						1	
	Siphonariidae	*Siphonaria diemenensis*	Pulmonate limpet		1	1		1	1	1
		Siphonaria funiculata	Pulmonate limpet		1	1		1	1	1
		Siphonaria sp.	Pulmonate limpet			1	1	1	1	1
		Siphonaria tasmanica	Pulmonate limpet			1				
		Siphonaria zelandica	Pulmonate limpet		1	1		1	1	1
	Triphoridae	*Cheirodonta labiata*	Gastropods						1	
	Trochidae	*Austrocochlea constricta*	Ribbed top shell		1	1	1	1	1	1
		Austrocochlea porcata	Top shell					1	1	1
		Calliostoma armillata	Top shell			1		1		
		Cantharidus pulcherrimus	Top shell					1		
Gastropods		*Chlorodiloma adelaidae*	Top shell		1	1		1	1	1
		Chlorodiloma odontis	Top shell		1	1	1	1	1	1
		Clanculus flagellatus	Top shell						1	
		Clanculus plebejus	Top shell						1	1
		Diloma concamerata	Wavy top shell			1		1	1	1
		Phasianotrochus eximius	Top shell			1		1		
		Prothalotia lehmanni	Top shell			1				
		Thalotia conica	Top shell		1				1	1
	Turbinidae	*Astralium aureum*	Turban shell						1	1
		Turbo undulatus	Common warrener (Turban shell)		1	1	1	1	1	1
	UnknownFamily	Unidentified limpet	Limpet						1	

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Velutinidae	*Lamellaria ophione*	Gastropod						1	
	Volutidae	*Notovoluta kreuslerae*	Volutes	1						
Total gastropods				**1**	**32**	**35**	**16**	**34**	**48**	**40**
Bivalves	Galeommatidae	*Lasaea australis*	Bivalve			1			1	
	Mytilidae	*Austromytilus rostratus*	Beaked mussel		1	1	1	1	1	1
		Limnoperna pulex	Mussels		1	1	1	1	1	1
Total bivalves				**0**	**2**	**3**	**2**	**2**	**3**	**2**
Sea slugs	Aplysiidae	*Aplysia gigantea*	Sea slug					1		
		Aplysia parvula	Sea slug						1	
	Dorididae	*Neogoniolithon finitium*	Sea slug			1				
Total sea slugs				**0**	**0**	**1**	**0**	**1**	**1**	**0**
Cephalopods	UnknownFamily	Unidentified Squid	Squid							1
Total cephalopods				**0**	**0**	**0**	**0**	**0**	**0**	**1**
Echinoderms	Asteriidae	*Allostichaster polyplax*	Sea Star						1	
		Coscinasterias muricata	Eleven-armed Sea Star							1
		Smilasterias multipara	Sea Star						1	
Echinoderms	Asterinidae	*Parvulastra exigua*	Sea Star						1	1
		Patiriella calcar	Sea Star		1				1	
		Patiriella exigua	Sea Star		1				1	1
	Chiridotidae	*Taeniogyrus roebucki*	Sea Cucumber							1
	Cucumaridae	*Pentocnus bursatus*	Sea Cucumber							1
		Apsolidium densum	Sea Cucumber	1					1	
		Apsolidium handrecki	Sea Cucumber						1	
		Neocnus bimarsupiis	Sea Cucumber							1
		Squamocnus aureoruber	Sea Cucumber							1
	Echinometridae	*Heliocidaris erythrogramma*	Sea Star						1	
	Goniasteridae	*Tosia australis*	Sea Star						1	
	Ophiacanthidae	*Ophiacantha shepherdi*	Brittle Star							1
	Ophionereididae	*Ophionereis schayeri*	Brittle Star						1	

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Oreasteridae	*Nectria ocellata*	Sea Star		1					1
		Nectria saoria	Sea Star							1
	Phyllophoridae	*Lipotrapeza ventripes*	Sea Cucumber						1	
		Lipotrapeza vestiens	Sea Cucumber						1	
Total echinoderms				**1**	**3**	**0**	**0**	**0**	**12**	**10**
Ascidian	Pyuridae	*Pyura stolonifera*	Cunjevoi		1			1		1
Total ascidians				**0**	**1**	**0**	**0**	**1**	**0**	**1**
Fish	Aplodactylidae	*Aplodactylus arctidens*	Marblefish	1		1				1
	Aracanidae	*Aracana aurita*	Shaw's Cowfish	1						1
		Aracana ornata	Ornate Cowfish							1
	Callionymidae	*Callopeltis phyllophora*	Fish			1				
	Carangidae	*Pseudocaranx dentex*	White Trevally			1				
		Trachurus declivis	Common Jack Mackerel							1
	Centrolophidae	*Seriolella brama*	Black Trevally							1
	Cheilodactylidae	*Cheilodactylus nigripes*	Magpie Perch	1	1	1				1
Fish		*Cheilodactylus spectabilis*	Banded Morwong			1				1
		Dactylophora nigricans	Dusky Morwong		1	1				1
	Clinidae	*Heteroclinus* sp.	Unidentified weedfish species			1				
	Dasyatididae	*Dasyatis brevicaudata*	Smooth Stingray							1
	Dinolestidae	*Dinolestes lewini*	Longfin Pike	1	1	1				1
		Diodon nichthemerus	Globefish			1				1
	Enoplosidae	*Enoplosus armatus*	Old Wife	1		1				1
	Galaxiidae	*Galaxias truttaceus*	Spotted Galaxias			1				
	Gastropteridae	*Sagaminopteron ornatum*	Nudibranch							1
	Gempylidae	*Thyristes atun*	Barracouta							1
	Girellidae	*Girella tricuspidata*	Luderick							1
		Girella zebra	Zebrafish	1	1	1				1
	Gnathanacanthidae	*Gnathanacanthus goetzeei*	Red Velvetfish							1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
	Heterodontidae	*Heterodontus portusjacksoni*	Port Jackson Shark		1					1
	Labridae	*Dotalabrus aurantiacus*	Castelnau's Wrasse	1	1	1				1
		Notolabrus fucicola	Purple Wrasse	1	1	1				1
		Notolabrus	Blue-throated Wrasse	1	1	1				1
		Ophthalmolepis lineolata	Maori Wrasse							1
		Pictilabrus laticlavius	Senator Wrasse	1	1	1				1
		Pseudolabrus psittaculus	Rosy Wrasse			1				1
	Latridae	*Latridopsis forsteri*	Bastard Trumpeter	1						
	Monacanthidae	*Acanthaluteres vittiger*	Toothbrush Leatherjacket		1	1				1
		Eubalichthys gunnii	Gunn's Leatherjacket							1
		Eubalichthys mosaicus	Mosaic Leatherjacket			1				
		Meuschenia australis	Brownstriped Leatherjacket			1				
		Meuschenia flavolineata	Yellowstriped Leatherjacket		1	1				1
		Meuschenia freycineti	Sixspine leather jacket		1	1				1
		Meuschenia galii	Bluelined Leatherjacket			1				1
Fish		*Meuschenia hippocrepis*	Horseshoe Leatherjacket	1	1	1				1
		Scobinichthys granulatus	Rough Leatherjacket							1
	Mullidae	*Upeneichthys vlamingii*	Bluespotted Goatfish	1	1	1				1
	Odacidae	*Haletta semifasciata*	Blue Weed-whiting	1						
		Odax acroptilus	Rainbow Cale	1	1	1				1
		Odax cyanomelas	Herring Cale	1	1	1				1
		Siphonognathus attenuatus	Slender Weed Whiting							1
	Orectolobidae	*Orectolobus ornatus*	Banded Wobbegong							1
	Parascyllidae	*Parascyllium variolatum*	Varied Carpetshark		1					1
	Pemperididae	*Pempheris multiradiata*	Bigscale Bullseye		1	1				1
	Pentacerotidae	*Parequula melbournensis*	Silverbelly							1
	Plesiopidae	*Trachinops caudimaculatus*	Southern Hulafish			1				
	Pomacentridae	*Parma microlepis*	White-ear							1
		Parma victoriae	Scalyfin		1	1				1
	Scorpididae	*Atypichthys strigatus*	Mado							1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Scorpis aequipinnis	Sea Sweep		1	1				1
		Scorpis lineolata	Silver Sweep		1	1				1
		Tilodon sexfasciatus	Moonlighter	1	1	1				1
	Scyliorhinidae	*Cephaloscyllium laticeps*	Draughtboard Shark							1
	Sepiidae	*Sepia apama*	Giant Cuttlefish							1
	Sparidae	*Pagrus auratus*	Snapper		1					
	Sphyraenidae	*Sphyraena novaehollandiae*	Snook							1
	Tetraodontidae	*Tetractenos glaber*	Smooth Toadfish		1					1
	Urolophidae	*Urolophus gigas*	Spotted Stingaree							1
		Urolophus paucimaculatus	Sparsely-spotted Stingaree		1					1
Total fish				**17**	**25**	**33**	**0**	**0**	**0**	**51**
Birds	Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea-Eagle		1			1	1	
	Anatidae	*Cygnus atratus*	Black Swan			1	1	1		
	Ardeidae	*Ardea ibis*	Cattle Egret			1	1	1		1
Birds		*Ardea intermedia*	Intermediate Egret			1				
		Ardea modesta	Eastern Great Egret	1		1	1	1		
		Ardea pacifica	White-necked Heron			1	1		1	
		Botaurus poiciloptilus	Australasian Bittern	1				1		
		Nycticorax caledonicus	Nankeen Night Heron			1				
	Charadriidae	*Charadrius bicinctus*	Double-banded Plover				1	1	1	1
		Charadrius ruficapillus	Red-capped Plover	1		1	1	1	1	1
		Elseyornis melanops	Black-fronted Dotterel			1	1	1		
		Pluvialis fulva	Pacific Golden Plover					1	1	
		Pluvialis squatarola	Grey Plover							1
		Thinornis rubricollis	Hooded Plover	1		1	1	1		1
		Vanellus miles	Masked Lapwing	1	1	1	1	1	1	1
	Ciconiiformes	*Egretta garzetta*	Little Egret			1				
		Egretta novaehollandiae	White-faced Heron	1	1	1	1	1	1	1
	Diomedeidae	*Diomedea exulans*	Wandering Albatross			1	1			1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Thalassarche cauta	Shy Albatross	1		1	1	1	1	1
		Thalassarche chlororhynchos	Yellow-nosed Albatross			1				1
		Thalassarche melanophris	Black-browed Albatross			1	1		1	1
	Haematopodidae	*Haematopus fuliginosus*	Sooty Oystercatcher	1				1	1	1
		Haematopus longirostris	Pied Oystercatcher			1				1
	Hydrobatidae	*Oceanites oceanicus*	Wilson's Storm Petrel			1				
		Pelagodroma marina	White-faced Storm-Petrel			1				1
	Laridae	*Chroicocephalus novaehollandiae*	Silver Gull	1	1	1	1	1	1	1
		Hydroprogne caspia	Caspian Tern		1	1	1	1		
		Larus dominicanus	Kelp Gull					1	1	1
		Larus pacificus	Pacific Gull	1	1	1	1	1	1	1
		Sterna bergii	Crested Tern	1	1	1	1	1	1	1
		Sterna hirundo	Common Tern							1
Birds		*Sterna paradisaea*	Arctic Tern					1		
		Sterna striata	White-fronted Tern	1				1		1
		Sternula albifrons	Little Tern					1		1
		Sternula nereis	Fairy Tern			1	1	1		
	Meliphagidae	*Epthianura albifrons*	White fronted Chat		1	1	1	1	1	1
	Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican			1	1	1		
	Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant	1	1	1	1	1	1	1
		Phalacrocorax carbo	Great Cormorant	1	1	1	1	1	1	1
		Phalacrocorax fuscescens	Black-faced Cormorant	1	1	1			1	1
		Phalacrocorax sulcirostris	Little Black Cormorant	1		1	1	1	1	1
		Phalacrocorax varius	Pied Cormorant	1		1	1	1	1	
	Podicipedidae	*Podiceps cristatus*	Grest Crested Grebe					1		
		Poliocephalus poliocephalus	Hoary-headed Grebe	1		1		1		
	Procellariidae	*Ardenna grisea*	Sooty Shearwater		1		1			
		Ardenna tenuirostris	Short-tailed Shearwater	1	1	1	1		1	1
		Daption capense	Cape Petrel			1				1

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Fulmarus glacialoides	Southern Fulmar						1	
		Halobaena caerulea	Blue Petrel					1		1
		Macronectes giganteus	SouthernGiant-Petrel			1		1		1
		Macronectes halli	Northern Giant Petrel							1
		Pachyptila belcheri	Slender-billed Prion					1	1	1
		Pachyptila desolata	Antarctic Prion					1		
		Pachyptila turtur	Fairy Prion			1		1	1	1
		Pelecanoides urinatrix	Common Diving-petrel		1		1			1
		Procellaria cinerea	Grey Petrel		1			1		
		Pterodroma macroptera	Great-winged Petrel			1				
		Pterodroma nigripennis	Black-winged Petrel		1					
		Puffinus gavia	Fluttering Shearwater		1	1	1	1		1
		Puffinus huttoni	Hutton's Shearwater							1
Birds	Psittacidae	*Neophema chrysostoma*	Blue-winged Parrot		1	1	1	1		
	Rallidae	*Fulica atra*	Eurasian Coot		1	1		1		
		Gallinula ventralis	Black-tailed native hen			1				
		Gallirallus philippensis	Buff-banded Rail			1			1	
		Porzana fluminea	Australian Spotted Crake			1				
	Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt					1		
	Scolopacidae	*Actitis hypoleucos*	Common Sandpiper	1		1		1		
		Arenaria interpres	Ruddy Turnstone	1		1		1	1	1
		Calidris acuminata	Sharp-tailed Sandpiper				1	1		
		Calidris alba	Sanderling					1		
		Calidris ferruginea	Curlew Sandpiper					1		
		Calidris minuta	Little Stint					1		
		Calidris ruficollis	Red-necked Stint			1	1	1	1	1
		Calidris tenuirostris	Great Knot					1		
		Gallinago hardwickii	Latham's snipe			1	1			
		Heteroscelus brevipes	Grey-tailed Tattler						1	
		Numenius madagascariensis	Eastern Curlew					1	1	

Biotic group	Family	Species	Common Name	MaR	ER	PA	PD	BB	MuR	Bun
		Numenius phaeopus	Whimbrel					1		
		Tringa flavipes	Lesser Yellowlegs					1		
	Spheniscidae	*Eudyptula minor*	Little Penguin	1	1	1	1	1	1	1
	Stercorcariidae	*Stercorarius parasiticus*	Arctic Jaeger			1	1		1	1
		Stercorarius pomarinus	Pomarine Jaeger	1		1				1
		Stercorarius skua	Great Skua				1			1
	Sulidae	*Morus serrator*	Australasian Gannet	1	1	1	1	1	1	1
	Threskiornithidae	*Platalea regia*	Royal Spoonbill			1	1	1		
		Plegadis falcinellus	Glossy Ibis			1				
		Threskiornis molucca	White Ibis		1	1	1	1	1	1
Total birds				**24**	**22**	**54**	**38**	**56**	**33**	**44**
Reptiles	Cheloniidae	*Lepidochelys olivacea*	Pacific (Olive) Ridley			1				
	Hydrophiidae	*Pelamis platurus*	Yellow-bellied Sea Snake			1				
Total reptiles				**0**	**0**	**2**	**0**	**0**	**0**	**0**
Mammals	Balaenidae	*Eubalaena australis*	Southern Right Whale	1	1	1	1	1	1	1
	Balaenopteridae	*Balaenoptera musculus*	Blue Whale			1		1		
		Megaptera novaeangliae	Humpback Whale	1						1
	Delphinidae	*Delphinus delphis*	Common Dolphin	1		1		1	1	1
		Globicephala melas	Long-finned Pilot Whale		1	1			1	
		Orcinus orca	Killer Whale	1		1	1	1	1	
		Tursiops truncatus	Bottlenose Dolphin	1	1	1	1	1	1	1
	Otariidae	*Arctocephalus pusillus doriferus*	Australian Fur-seal	1		1	1	1	1	1
		Arctophocatropicalis	Subantarctic Fur-seal							1
	Phocidae	*Hydrurga leptonyx*	Leopard Seal		1	1	1	1	1	1
		Mirounga leonina	Southern Elephant Seal	1						
Total mammals				**7**	**4**	**8**	**5**	**7**	**7**	**7**

Appendix 2

Completed research, mapping and monitoring projects carried out under *National Parks Act 1975* research permits in or relevant to Central Victoria 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. Point Addis 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.
Deakin University: Christine Porter, Geoff Wescott Rocky Shores of Marine National Parks and Sanctuaries on the Surf Coast Shire: Values, uses and impacts. Porter, C. and Wescott, G. (2010). Rocky Shores of Marine National Parks and Sanctuaries on the Surf Coast: Values, Uses and Impacts prior to protection. Parks Victoria Technical Series No. 22. Parks Victoria, Melbourne.
University of Melbourne: Jan Carey, Mark Burgman Risk Assessment for Marine National Parks and Sanctuaries. Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne. Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries*. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne. Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281. Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the New York Academy of Sciences* 1128: 13–17.
University of Melbourne: Rachael Bathgate, Mick Keough, Stephen Swearer Population Connectivity in Marine Protected Areas. Bathgate, R.S. (2010). Ecological Processes and Connectivity of Gastropod Populations in a System of Marine Protected Areas. Ph.D. Thesis. Department of Zoology, University of Melbourne.
Department of Primary Industries: Simon Heislers, Greg Parry Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast. Heislers, S. and Parry, G.D. (2007). Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast. Parks Victoria Technical Paper Series No. 53. Parks Victoria, Melbourne.
University of Melbourne: Kate York, Belinda Appleton, Ary Hoffman Genetics and Recruitment of Invertebrates in MPAs. York, K. (2008). Taxonomy, biogeography and population genetic structure of the southern Australian intertidal barnacle fauna. Ph.D. Thesis. Department of Genetics, University of Melbourne. York, K.L., Blacket, M.J. and Appleton, B.R. (2008). The Bassian Isthmus and the major ocean currents of southeast Australia influence the phylogeography and population structure

of a southern Australian intertidal barnacle *Catomerus polymerus* (Darwin). *Molecular Ecology* 17: 1948–1961.

University of Melbourne: Jessica Taylor, Jan Carey
Impacts on Intertidal Platforms - an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries.

Taylor, J. (2007). Monitoring the outcomes of an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Honours Thesis. School of Botany, University of Melbourne.

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott
Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program.

Keough, M.J., Ross, D.J. and Knott, N.A. (2007). Ecological performance measures for Victorian Marine Protected Areas: Review of existing biological sampling program. Parks Victoria Technical Series No. 51. Parks Victoria, Melbourne.

University of Melbourne: Masters students from Industry Project in Science program
Investigation and assessment of Water Quality Issues affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas.

Colautti, A., Errey, J., Chi Lam, M., Lewis, M., Michael, M. and Wright, M. (2010). Investigation and Assessment of Water Quality Issues Affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas. University of Melbourne MSc Industry Project.

Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake
Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries.

Ball, D. and Blake, S. (2007). Shallow water habitat mapping at Victorian Marine National Parks and Marine Sanctuaries, Volume 1: Western Victoria. Parks Victoria Technical Series No.36. Parks Victoria, Melbourne.

Ball, D., Blake, S. and Plummer, A. (2006). Review of Marine Habitat Classification Systems. Parks Victoria Technical Series No. 26. Parks Victoria, Melbourne.

University of Western Australia / Fugro / Deakin University / Department of Primary Industries:
Karen Holmes, Ben Radford, Kimberly Van Niel, Gary Kendrick, Simon Grove, Brenton Chatfield
Mapping the Benthos in Victoria's Marine National Parks (Deep Water Mapping).

Holmes, K.W., Grove, S.L., Van Niel, K.P. and Kendrick, G.A. (2007) Mapping the benthos in Victoria's Marine National Parks. Volume 3: Point Addis Marine National Park. Parks Victoria Technical Series No. 42. Parks Victoria, Melbourne.

Holmes, K.W., Van Niel, K.P., Radford, B., Kendrick, G.A. and Grove, S.L. (2008). Modelling distribution of marine benthos from hydroacoustics and underwater video. *Continental Shelf Research* 28: 1800-1810.

Completed Monitoring Surveys and Associated Reports

Subtidal and Intertidal Reef Monitoring Programs

Crozier, J., Edmunds, M., Stewart, K. and Gilmour, P. (2007). Victorian Subtidal Reef Monitoring Program: Western Victorian Coast – Survey 3, (Volume 3). Parks Victoria Technical Series No. 47 Parks Victoria, Melbourne.

Edmunds, M. and Hart, S. (2003). Parks Victoria Standard Operating Procedure: Biological Monitoring of Subtidal Reefs. Parks Victoria Technical Series No. 9. Parks Victoria, Melbourne.

Edmunds, M., Hart, S.P., Elias, J. and Power, B. (2004). Victorian Intertidal Reef Monitoring Program: The reef biota in Central Victoria and Port Phillip Bay Marine Sanctuaries. Parks Victoria Technical Series No. 11. Parks Victoria, Melbourne.

Edmunds, M., Stewart, K., Pritchard, K., and Zavalas, R. (2010). Victorian Intertidal Reef Monitoring Program: The reef biota of central Victoria's marine protected areas. Volume 3.

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Gilmour, P. and Edmunds, M. (2007). Victorian intertidal reef monitoring program: the intertidal reef biota of central Victoria's marine protected areas (Volume 2). Parks Victoria Technical Series No.46. Parks Victoria, Melbourne.

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Hart, S.P., Edmunds, M., Elias, J. and Ingwersen, C. (2005). Victorian Subtidal Reef Monitoring Program: The Reef Biota on the Western Victorian Coast. Volume 2. Parks Victoria Technical Series No. 25. Parks Victoria, Melbourne.

Hart, S.P., Edmunds, M., Ingwersen, C. and Elias, J. (2004). Victorian Subtidal Reef Monitoring Program: The reef biota on the Western Victorian Coast. Parks Victoria Technical Series No. 14. Parks Victoria, Melbourne.

Power, B. and Boxshall, A. (2007). Marine National Park and Sanctuary Monitoring Plan 2007-2012. Parks Victoria Technical Series No. 54. Parks Victoria, Melbourne.

Pritchard, K., Edmunds, M., Stewart, K., Davis, S., Dickens, L. and Donnelly, D. (2011). Victorian intertidal reef monitoring program: the intertidal reef biota of central Victoria's marine protected areas. Parks Victoria Technical Series No. 70. Parks Victoria, Melbourne.

Stewart, K., Judd, A. and Edmunds, M. (2007). Victorian intertidal reef monitoring program: the intertidal reef biota of Victoria's marine protected areas. Parks Victoria Technical Series No. 52. Parks Victoria, Melbourne.

Other reports produced for other research under *National Parks Act 1975* permits

O'Hara, T.D. (2005). Monitoring and Assessment of Victoria's Rocky Intertidal Coast. Museum Victoria. Report for DSE Research Permit under the National Parks Act 1975.

O'Hara, T. (2006). Monitoring and Assessment of Victoria's Rocky Intertidal Coast. Museum Victoria. Report for DSE Research Permit under the National Parks Act 1975.

O'Hara, T.D., Addison, P.F.E., Gazzard, R., Costa, T.L. and Pocklington, J.B. (2010). A rapid biodiversity assessment methodology tested on intertidal rocky shores. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20: 452-463.

2. Bunurong 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.
University of Melbourne: Jan Carey, Mark Burgman Risk Assessment for Marine National Parks and Sanctuaries. Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne. Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries*. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne. Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281. Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the* New York *Academy of Sciences* 1128: 13–17.
University of Melbourne: Jessica Taylor, Jan Carey Impacts on Intertidal Platforms - an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Taylor, J. (2007). Monitoring the outcomes of an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Honours Thesis. School of Botany, University of Melbourne.
University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program. Keough, M.J., Ross, D.J. and Knott, N.A. (2007). Ecological performance measures for Victorian Marine Protected Areas: Review of existing biological sampling program. Parks Victoria Technical Series No. 51. Parks Victoria, Melbourne.
University of Melbourne: Masters students from Industry Project in Science program Investigation and assessment of Water Quality Issues affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas. Colautti, A., Errey, J., Chi Lam, M., Lewis, M., Michael, M. and Wright, M. (2010). Investigation and Assessment of Water Quality Issues Affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas. University of Melbourne MSc Industry Project.
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Department of Primary Industries: David Ball, Sean Blake Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries. Ball, D., Blake, S. and Plummer, A. (2006). Review of Marine Habitat Classification Systems. Parks Victoria Technical Series No. 26. Parks Victoria, Melbourne.
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Edmunds, M., Stewart, K., Pritchard, K., and Zavalas, R. (2010). Victorian Intertidal Reef Monitoring Program: The reef biota of central Victoria's marine protected areas. Volume 3. Parks Victoria Technical Series No.61. Parks Victoria, Melbourne.

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Power, B. and Boxshall, A. (2007). Marine National Park and Sanctuary Monitoring Plan 2007-2012. Parks Victoria Technical Series No. 54. Parks Victoria, Melbourne.

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Hidas, E.Z. (2007). The Patterns of Abundance and Demography of rocky intertidal marine invertebrates indicate that recruitment can set geographical range limits. MSc Research Thesis. School of Biological Sciences and Institute for Conservation Biology. University of Wollongong.

Hidas, E.Z., Costa, T.L., Ayre, D.J. and Minchinton T.E. (2007). Is the species composition of rocky intertidal invertebrates across a biogeographic barrier in south-eastern Australia related to their potential for dispersal? *Marine and Freshwater Research* 58: 835-842.

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3. Marengo Reefs MS

Completed RPP (and RPP-like) Projects and Associated Reports

Department of Primary Industries: Anthony Plummer, Liz Morris, Sean Blake, David Ball
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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.

University of Melbourne: Madhavi Colton, Stephen Swearer
The Conservation Status of Reef Fish Communities in Victorian Waters.

Colton, M.A. (2011). Patterns in the Distribution and Abundance of Reef Fishes in South Eastern Australia. Ph.D. Thesis. Department of Zoology, University of Melbourne.

Colton, M.A. and Swearer, S. E. (2009). The Conservation Status of Reef Fish Communities in Victorian Waters. Final Project Report, Regional Catchment Investment Plan. *Submitted to* Port Phillip and Western Port Catchment Management Authority, Frankston, Vic, Australia by the University of Melbourne, Australia.

Colton, M.A. and Swearer, S. E. (2010). A comparison of two survey methods: differences between underwater visual census and baited remote underwater video. *Marine Ecology Progress Series*. 400: 19-36.

University of Melbourne: Jan Carey, Mark Burgman
Risk Assessment for Marine National Parks and Sanctuaries.

Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne.

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Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281.

Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the* New York *Academy of Sciences* 1128: 13–17.

Department of Primary Industries: Simon Heislers, Greg Parry
Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast.

Heislers, S. and Parry, G.D. (2007). Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast. Parks Victoria Technical Paper Series No. 53. Parks Victoria, Melbourne.

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott
Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program.

Keough, M.J., Ross, D.J. and Knott, N.A. (2007). Ecological performance measures for Victorian Marine Protected Areas: Review of existing biological sampling program. Parks Victoria Technical Series No. 51. Parks Victoria, Melbourne.

University of Melbourne: Masters students from Industry Project in Science program
Investigation and assessment of Water Quality Issues affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas.

Colautti, A., Errey, J., Chi Lam, M., Lewis, M., Michael, M. and Wright, M. (2010). Investigation and Assessment of Water Quality Issues Affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas. University of Melbourne MSc Industry Project.

Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake
Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries.

Ball, D. and Blake, S. (2007). Shallow water habitat mapping at Victorian Marine National Parks and Marine Sanctuaries, Volume 1: Western Victoria. Parks Victoria Technical Series No.36. Parks Victoria, Melbourne.

Ball, D., Blake, S. and Plummer, A. (2006). Review of Marine Habitat Classification Systems. Parks Victoria Technical Series No. 26. Parks Victoria, Melbourne.

Completed Monitoring Surveys and Associated Reports

Subtidal Reef Monitoring Program

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Power, B. and Boxshall, A. (2007). Marine National Park and Sanctuary Monitoring Plan 2007-2012. Parks Victoria Technical Series No. 54. Parks Victoria, Melbourne.

4. Eagle Rock MS

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.
Deakin University: Christine Porter, Geoff Wescott Rocky Shores of Marine National Parks and Sanctuaries on the Surf Coast Shire: Values, uses and impacts. Porter, C. and Wescott, G. (2010). Rocky Shores of Marine National Parks and Sanctuaries on the Surf Coast: Values, Uses and Impacts prior to protection. Parks Victoria Technical Series No. 22. Parks Victoria, Melbourne.
University of Melbourne: Jan Carey, Mark Burgman Risk Assessment for Marine National Parks and Sanctuaries. Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne. Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries*. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne. Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281. Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the* New York *Academy of Sciences* 1128: 13–17.
University of Melbourne: Rachael Bathgate, Mick Keough, Stephen Swearer Population Connectivity in Marine Protected Areas. Bathgate, R.S. (2010). Ecological Processes and Connectivity of Gastropod Populations in a System of Marine Protected Areas. Ph.D. Thesis. Department of Zoology, University of Melbourne.
University of Melbourne: Kate York, Belinda Appleton, Ary Hoffman Genetics and Recruitment of Invertebrates in MPAs. York, K. (2008). Taxonomy, biogeography and population genetic structure of the southern Australian intertidal barnacle fauna. Ph.D. Thesis. Department of Genetics, University of Melbourne. York, K.L., Blacket, M.J. and Appleton, B.R. (2008). The Bassian Isthmus and the major ocean currents of southeast Australia influence the phylogeography and population structure of a southern Australian intertidal barnacle *Catomerus polymerus* (Darwin). *Molecular Ecology* 17: 1948–1961.
University of Melbourne: Jessica Taylor, Jan Carey Impacts on Intertidal Platforms - an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Taylor, J. (2007). Monitoring the outcomes of an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Honours Thesis. School of Botany, University of Melbourne.
University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program. Keough, M.J., Ross, D.J. and Knott, N.A. (2007). Ecological performance measures for Victorian Marine Protected Areas: Review of existing biological sampling program. Parks

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University of Melbourne: Masters students from Industry Project in Science program
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Colautti, A., Errey, J., Chi Lam, M., Lewis, M., Michael, M. and Wright, M. (2010). Investigation and Assessment of Water Quality Issues Affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas. University of Melbourne MSc Industry Project.

Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake
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O'Hara, T.D. (2005). Monitoring and Assessment of Victoria's Rocky Intertidal Coast. Museum Victoria. Report for DSE Research Permit under the National Parks Act 1975.

O'Hara, T.D., Addison, P.F.E., Gazzard, R., Costa, T.L. and Pocklington, J.B. (2010). A rapid biodiversity assessment methodology tested on intertidal rocky shores. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20: 452-463.

5. Point Danger MS

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.
Deakin University: Christine Porter, Geoff Wescott Rocky Shores of Marine National Parks and Sanctuaries on the Surf Coast Shire: Values, uses and impacts. Porter, C. and Wescott, G. (2010). Rocky Shores of Marine National Parks and Sanctuaries on the Surf Coast: Values, Uses and Impacts prior to protection. Parks Victoria Technical Series No. 22. Parks Victoria, Melbourne.
University of Melbourne: Jan Carey, Mark Burgman Risk Assessment for Marine National Parks and Sanctuaries. Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne. Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries*. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne. Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281*.* Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the* New York *Academy of Sciences* 1128: 13–17.
University of Melbourne: Rachael Bathgate*,* Mick Keough, Stephen Swearer Population Connectivity in Marine Protected Areas. Bathgate, R.S. (2010). Ecological Processes and Connectivity of Gastropod Populations in a System of Marine Protected Areas. Ph.D. Thesis. Department of Zoology, University of Melbourne.
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University of Melbourne: Jessica Taylor, Jan Carey Impacts on Intertidal Platforms - an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Taylor, J. (2007). Monitoring the outcomes of an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Honours Thesis. School of Botany, University of Melbourne.
University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program. Keough, M.J., Ross, D.J. and Knott, N.A. (2007). Ecological performance measures for Victorian Marine Protected Areas: Review of existing biological sampling program. Parks

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University of Melbourne: Masters students from Industry Project in Science program Investigation and assessment of Water Quality Issues affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas.

Colautti, A., Errey, J., Chi Lam, M., Lewis, M., Michael, M. and Wright, M. (2010). Investigation and Assessment of Water Quality Issues Affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas. University of Melbourne MSc Industry Project.

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Department of Primary Industries: David Ball, Sean Blake
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Ball, D. and Blake, S. (2007). Shallow water habitat mapping at Victorian Marine National Parks and Marine Sanctuaries, Volume 1: Western Victoria. Parks Victoria Technical Series No.36. Parks Victoria, Melbourne.

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Stewart, K., Judd, A. and Edmunds, M. (2007). Victorian intertidal reef monitoring program: the intertidal reef biota of Victoria's marine protected areas. Parks Victoria Technical Series No. 52. Parks Victoria, Melbourne.

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O'Hara, T.D., Addison, P.F.E., Gazzard, R., Costa, T.L. and Pocklington, J.B. (2010). A rapid biodiversity assessment methodology tested on intertidal rocky shores. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20: 452-463.

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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.
Monash University: David Hurst, Sharron Pfueller. Engaging communities in monitoring park values and threats. Hurst, D. (2007). The Community in Monitoring. Exploring the Concept of Social Capital. Honours Thesis. School of Geography and Environmental Science, Monash University.
Deakin University: Milyika Scales, Ashley Bunce, Geoff Wescott, Kelly Miller. Sea Search: Community-based monitoring of Marine Protected Areas (MPAs) in Victoria (Honours). Scales, M. (2006). Training and experience in community-based monitoring: value-adding for MPA management. Honours Thesis. School of Life Sciences, Deakin University.
Deakin University: Rebecca Koss, Ashley Bunce, Geoff Wescott, Kelly Miller. Sea Search: Community-based monitoring of Victorian Marine Protected Areas (MPAs) (Post Graduate). Koss, R. (2010). The Role of Environmental Stewardship in Nature Conservation. Ph.D. Thesis. School of Life and Environmental Sciences, Deakin University. Koss, R., Gilmour, P., Miller, K., Bellgrove, A., McBurnie, J., Wescott, G. and Bunce, A. (2005). Community - Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries. Parks Victoria Technical Series No. 19. Parks Victoria, Melbourne. Koss, R., Gilmour, P., Wescott, G., Bunce, A., and Miller, K. (2005). Sea Search: Community - Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries: Intertidal Monitoring. Parks Victoria Technical Series No. 17. Parks Victoria, Melbourne. Koss, R.S. and Kingsley, J.Y. (2010). Volunteer health and emotional wellbeing in marine protected areas. *Ocean and Coastal Management* 53: 447-453. Koss, R. S., Miller, K., Wescott, G., Bellgrove, A., Boxshall, A., McBurnie, J., Bunce, A., Gilmour, P. and Ierodiaconou, D. (2009). An evaluation of *Sea Search* as a citizen science programme in Marine Protected Areas. *Pacific Conservation Biology* 15: 116–127.
University of Melbourne: Jan Carey, Mark Burgman Risk Assessment for Marine National Parks and Sanctuaries. Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne. Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries*. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne. Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281. Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the* New York *Academy of Sciences* 1128: 13–17.
University of Melbourne: Rachael Bathgate, Mick Keough, Stephen Swearer Population Connectivity in Marine Protected Areas. Bathgate, R.S. (2010). Ecological Processes and Connectivity of Gastropod Populations in a System of Marine Protected Areas. Ph.D. Thesis. Department of Zoology, University of Melbourne.

University of Melbourne: Jessica Taylor, Jan Carey
Impacts on Intertidal Platforms - an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries.

Taylor, J. (2007). Monitoring the outcomes of an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Honours Thesis. School of Botany, University of Melbourne.

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott
Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program.

Keough, M.J., Ross, D.J. and Knott, N.A. (2007). Ecological performance measures for Victorian Marine Protected Areas: Review of existing biological sampling program. Parks Victoria Technical Series No. 51. Parks Victoria, Melbourne.

University of Melbourne: Madhavi Colton, Stephen Swearer
The Conservation Status of Reef Fish Communities in Victorian Waters.

Colton, M.A. (2011). Patterns in the Distribution and Abundance of Reef Fishes in South Eastern Australia. Ph.D. Thesis. Department of Zoology, University of Melbourne.

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Colautti, A., Errey, J., Chi Lam, M., Lewis, M., Michael, M. and Wright, M. (2010). Investigation and Assessment of Water Quality Issues Affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas. University of Melbourne MSc Industry Project.

Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake
Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries.

Ball, D. and Blake, S. (2007). Shallow water habitat mapping at Victorian Marine National Parks and Marine Sanctuaries, Volume 1: Western Victoria. Parks Victoria Technical Series No.36. Parks Victoria, Melbourne.

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Power, B. and Boxshall, A. (2007). Marine National Park and Sanctuary Monitoring Plan 2007-2012. Parks Victoria Technical Series No. 54. Parks Victoria, Melbourne. Pritchard, K., Edmunds, M., Stewart, K., Davis, S., Dickens, L. and Donnelly, D. (2011). Victorian intertidal reef monitoring program: the intertidal reef biota of central Victoria's marine protected areas. Parks Victoria Technical Series No. 70. Parks Victoria, Melbourne. Stewart, K., Judd, A. and Edmunds, M. (2007). Victorian intertidal reef monitoring program: the intertidal reef biota of Victoria's marine protected areas. Parks Victoria Technical Series No. 52. Parks Victoria, Melbourne.
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O'Hara, T. D. (2005). Monitoring and Assessment of Victoria's Rocky Intertidal Coast. Museum Victoria. Report for DSE Research Permit under the National Parks Act 1975.
O'Hara, T. D. (2006). Monitoring and Assessment of Victoria's Rocky Intertidal Coast. Museum Victoria. Report for DSE Research Permit under the National Parks Act 1975.
O'Hara, T.D., Addison, P.F.E., Gazzard, R., Costa, T.L. and Pocklington, J.B. (2010). A rapid biodiversity assessment methodology tested on intertidal rocky shores. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20: 452-463.
Costa, T. L., O'Hara, T.D. and Keough, M.J. (2010). "Measures of taxonomic distinctness do not reliably assess anthropogenic impacts on intertidal mollusc communities." *Marine Ecological Progress Series* 413: 81-93.

7. Mushroom Reef MS

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.

Monash University: David Hurst, Sharron Pfueller.
Engaging communities in monitoring park values and threats.

Hurst, D. (2007). The Community in Monitoring. Exploring the Concept of Social Capital. Honours Thesis. School of Geography and Environmental Science, Monash University.

Deakin University: Milyika Scales, Ashley Bunce, Geoff Wescott, Kelly Miller.
Sea Search: Community-based monitoring of Marine Protected Areas (MPAs) in Victoria (Honours).

Scales, M. (2006). Training and experience in community-based monitoring: value-adding for MPA management. Honours Thesis. School of Life Sciences, Deakin University.

Deakin University: Rebecca Koss, Ashley Bunce, Geoff Wescott, Kelly Miller.
Sea Search: Community-based monitoring of Victorian Marine Protected Areas (MPAs) (Post Graduate).

Koss, R. (2010). The Role of Environmental Stewardship in Nature Conservation. Ph.D. Thesis. School of Life and Environmental Sciences, Deakin University.

Koss, R., Gilmour, P., Miller, K., Bellgrove, A., McBurnie, J., Wescott, G. and Bunce, A. (2005). Community - Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries. Parks Victoria Technical Series No. 19. Parks Victoria, Melbourne.

Koss, R., Gilmour, P., Wescott, G., Bunce, A., and Miller, K. (2005). Sea Search: Community - Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries: Intertidal Monitoring. Parks Victoria Technical Series No. 17. Parks Victoria, Melbourne.

Koss, R.S. and Kingsley, J.Y. (2010). Volunteer health and emotional wellbeing in marine protected areas. *Ocean and Coastal Management* 53: 447-453.

Koss, R. S., Miller, K., Wescott, G., Bellgrove, A., Boxshall, A., McBurnie, J., Bunce, A., Gilmour, P. and Ierodiaconou, D. (2009). An evaluation of *Sea Search* as a citizen science programme in Marine Protected Areas. *Pacific Conservation Biology* 15: 116–127.

University of Melbourne: Jan Carey, Mark Burgman
Risk Assessment for Marine National Parks and Sanctuaries.

Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne.

Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries*. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne.

Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281.

Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the* New York *Academy of Sciences* 1128: 13–17.

University of Melbourne: Jessica Taylor, Jan Carey
Impacts on Intertidal Platforms - an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries.

Taylor, J. (2007). Monitoring the outcomes of an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries. Honours Thesis.

School of Botany, University of Melbourne.

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott
Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program.

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Investigation and assessment of Water Quality Issues affecting Natural Values in the Parks Victoria Managed Estuaries and Marine Protected Areas.

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Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake
Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries.

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O'Hara, T.D. (2006). Monitoring and Assessment of Victoria's Rocky Intertidal Coast. Museum Victoria. Report for DSE Research Permit under the National Parks Act 1975.

O'Hara, T.D., Addison, P.F.E., Gazzard, R., Costa, T.L. and Pocklington, J.B. (2010). A rapid biodiversity assessment methodology tested on intertidal rocky shores. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20: 452-463.

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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