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Marine Natural Values Study Vol 2: Marine Protected Areas of the Victorian Embayments Bioregion

Part 1 Port Phillip Bay

Jan Barton, Adam Pope and Steffan Howe

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Marine Natural Values Study (Vol 2)

Marine Protected Areas of the Victorian Embayments Bioregion

**Part 1
Port Phillip Bay**

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August 2012



EXECUTIVE SUMMARY

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

This report updates the first Marine Natural Values Study (Plummer *et al.* 2003) for the MPAs in the Port Phillip Bay area of the Victorian Embayments bioregion 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 Victorian Embayments bioregion is a discontinuous region that includes all Victorian bays, inlets and estuaries to a minimum water area of $> 1 \text{ km}^2$ (IMCRA 1998b; IMCRA 2006). In this bioregion only PPB, Western Port Bay and Corner Inlet contain MPAs (IMCRA 2006). The bioregion has a moist temperate climate, varying west to east in runoff and seasonality, and has more variable water temperature and salinity than the open coast. The embayments vary in form but their maximum depth is generally $< 20 \text{ m}$. The biota of the Victorian embayments include a diverse range of biotic assemblages found in estuarine and open coast environments depending on the water body's characteristics (Parks Victoria 2003; IMCRA 2006). Port Phillip Bay is a marine embayment with constricted water exchange, deep central muds; eastern sandy shores, *Pyura* beds and shallow reef habitats; and sheltered reef, seagrass, drift algae and estuarine habitats in the west. The benthic assemblages in the muddy central region are distinct from those in the sand to the west and east. The west coast of PPB supports important bird habitat most of which is included in Ramsar Sites.

Within the Victorian Embayments bioregion, there are five Marine National Parks and three Marine Sanctuaries. The Port Phillip Heads MNP is the only MNP in PPB but incorporates six different sections near the entrance to the bay. The three MSs (Point Cooke, Jawbone and Ricketts Point) are all in PPB. All MPAs adjoin the coast, except the Popes Eye, Mud Islands and Portsea Hole sections of the Port Phillip Heads MNP. The MPAs range in size from the large, multisection Port Phillip Heads MNP (3475 ha) to Jawbone MS (30.5 ha). Point Cooke MS (292 ha) is the largest MS in Victoria. All the MPAs in the bioregion, except Corner Inlet MNP, are relatively accessible from Victoria's major population centers of Melbourne and Geelong. Part of Port Phillip Heads and Corner Inlet MNP adjoin terrestrial National Park but all other MPAs adjoin reserves or other conservation areas.

All MPAs in PPB have a mix of intertidal and subtidal soft sediment and rocky habitats. Intertidal habitat is predominately beaches amongst rocky headlands, with Jawbone MS also having extensive mudflats. On beaches flora 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. On the intertidal mudflats seagrass, saltmarsh, mangroves and significant amounts of benthic microalgae can grow. Subtidal soft sediment

habitat, can have very high numbers of invertebrate species living on and in it. The reefs in the MPAs are calcarenite in Port Phillip Heads MNP, and basalt in the MSs. The exceptions to this are the artificial basalt reef of Popes Eye in Port Phillip Heads MNP and sandstone reef in Ricketts Point MS. Port Phillip Heads MNP has deep (> 15 m) subtidal reef in Point Lonsdale, Point Nepean and Portsea Hole. The dominant habitat type in the MPAs is subtidal soft sediment, the MSs also have substantial intertidal and shallow subtidal rocky reef.

Intertidal seagrass, usually *Zostera muelleri*, is an important habitat in Port Phillip Heads MNP, particularly in Swan Bay and Mud Islands, and in Point Cooke and Jawbone MSs (Blake and Ball 2001; Hirst *et al.* 2009; Edmunds *et al.* 2010d). The aquatic macrophyte *Lepilaena marina* is also important in Swan Bay. Distinct invertebrate fauna inhabit Swan Bay intertidal seagrass beds (Plummer *et al.* 2003). The invertebrate fauna of unvegetated intertidal soft sediments in Swan Bay are dominated by a few taxa (Morris and Keough 2003). Wrack on the shore in Swan Bay in Port Phillip Heads MNP and Point Cooke MS can be considerable, extensive enough to cover the inshore seagrass beds (Hirst *et al.* 2009; Edmunds *et al.* 2010d).

The main habitat forming algae on the intertidal reefs in the MPAs is Neptune's necklace *Hormosira banksii* in Port Phillip Heads MNP and Ricketts Point MS, and an ephemeral coverage of sea lettuce *Ulva* spp. and *Enteromorpha* spp. in Point Cooke and Jawbone MSs (Edmunds *et al.* 2010d). The intertidal reefs of Port Phillip Heads MNP are diverse compared to the MSs with one species of seagrass *Amphibolis antarctica*, and over 29 species of algae (Costa *et al.* 2010; O'Hara *et al.* 2010). The intertidal reefs in Port Phillip Heads MNP are dominated by limpets and striped conniwink (Edmunds *et al.* 2010d). In the north of PPB in the MSs, the herbivorous zebra top shell is the most abundant invertebrate (Edmunds *et al.* 2010d). Other molluscs are found in low densities on these reefs (Bathgate 2010; Edmunds *et al.* 2010d). The Tasmanian blenny *Parablennius tasmanianus* and the weedfish Clinidae are commonly found in the intertidal pools in Point Cooke and Ricketts Point MSs (Plummer *et al.* 2003).

Seagrass is an important habitat in Port Phillip Heads MNP, particularly on the soft subtidal sediments in Mud Islands and Swan Bay. Deeper waters in the south and centre of Swan Bay tend to be dominated by algae (Blake and Ball 2001). The seagrasses *Heterozostera nigricalis* and *Halophila australis* form patches of habitat on the subtidal soft sediment in the Point Cooke MS (Blake and Ball 2001; Edmunds *et al.* 2011). In the north west of Jawbone MS there is a large bed of seagrass *Zostera/Heterozostera* (Blake and Ball 2001). A small amount of seagrass *H. nigricalis* has been mapped in Ricketts Point MS (Blake and Ball 2001). In Point Cooke MS beds of habitat forming cunjevoi *Pyura stolonifera* and large beds of *Caulerpa remotifolia*, *C. longifolia*, *C. brownii* and *C. flexilis* also grow on the soft sediment (Edmunds *et al.* 2011). The *H. nigricalis* habitat in Mud Islands supports at least twenty-seven species of finfish and one species of squid (Hutchinson *et al.* 2011).

Macroalgae provide important habitat structure for other organisms on shallow subtidal reefs. There is considerable difference in species and structure of the canopy forming algae on the subtidal reefs in Port Phillip Heads MNP compared to the three MSs. Around 20 - 50 species of macroalgae are found on the shallow subtidal reefs of Port Phillip Heads MNP, with a number of rare species found in Point Nepean (Edmunds *et al.* 2009b; Edmunds *et al.* 2010c). There are four general macroalgal communities corresponding with four subtidal reef groupings in Port Phillip Heads MNP: outside the Heads; inside the Heads in Point Lonsdale; inside the Heads in Point Nepean; and well inside the Heads at Popes Eye (Edmunds *et al.* 2010c). These groupings correspond with differences in wave exposure and depth (Edmunds *et al.* 2010c).

The number of macroalgae species in the MSs ranges from 16 in Jawbone to over 32 in Ricketts Point (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). Like the macroalgae there are substantial differences in species diversity and abundance in shallow subtidal reef invertebrate fauna communities of Port Phillip Heads MNP and the three MSs. Within Port Phillip Heads MNP there are four general invertebrate communities, corresponding to the four site groupings (Edmunds *et al.* 2010c).

Over 71 species of fish are found on the shallow subtidal reefs of Port Phillip Heads MNP (Edmunds *et al.* 2009b). Popes Eye has a fish community that is distinct from elsewhere in the MNP (Edmunds *et al.* 2009b). Fishing has been banned since 1976 and the reef has higher species richness, as well as abundance of fish, including larger fish, than elsewhere in southern PPB (Edmunds *et al.* 2009b; Keough and Carnell 2009). The number of fish species observed in the MSs ranges from 16 in Point Cooke MS to over 35 in Ricketts Point MS.

The deep (> 19 m) subtidal reef *Ecklonia radiata* kelp beds in Port Phillip Heads MNP are different to shallower *E. radiata* beds in the MNP, they have a lower abundance of understory algae and mobile invertebrates, and a different fish community (Edmunds 2007). The deep subtidal reef sessile invertebrate reef community in Port Phillip Heads MNP has a high abundance and diversity of sessile invertebrates (Edmunds *et al.* 2004a; Edmunds 2007). It has a substantial proportion of the known sponge species from Victoria and Australia, and at least 115 species are endemic to the MNP (Edmunds 2007). Its sessile invertebrate community is also quite distinct compared to deep subtidal reefs in The Arches MS and Twelve Apostles, Point Addis and Wilsons Promontory MNPs (Edmunds 2007).

All the MPAs in PPB 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 11 species in Ricketts Point MS and up to 58 in Port Phillip Heads MNP. The MPAs are also important for many migratory birds, from seven species in Ricketts Point MS to 43 in Port Phillip Heads MNP. Numerous marine species are found at the limit of their distribution range within individual MPAs. In Port Phillip Heads MNP 104 species, including algae and invertebrates are believed to be at the edge of their distributional range, compared to two in Ricketts Point MS. Six are believed to be at the edge of their range in Point Cooke MS and five in Jawbone MS. Five invertebrates are believed to be endemic to Port Phillip Heads MNP and one to Ricketts Point MS. The northwest corner of Popes Eye is a minor haul-out area for the *EPBC Act 1999* listed Australian fur seal *Arctocephalus pusillus doriferus* (Edmunds *et al.* 2009b).

Specific threats to individual MPAs have been documented (Carey *et al.* 2007b). These include invasive marine pests (six species so far established in PPB MPAs), the impact of sediment from dredging, the lack of ecological knowledge and consequently inadequate monitoring and management, spills of oil or pollutants, increased nutrients from their urban catchments, major oil spills from commercial shipping, trampling of intertidal reefs, disturbance of wildlife and illegal fishing. Climate change represents a serious threat to marine ecosystems but the specific ecological consequences are not well understood in marine systems. Predicted changes in physical environmental conditions 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 could 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 and intertidal reef monitoring occurs in all four MPAs in PPB. 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 and broad substrate mapping has been done for shallow waters in all MPAs. Most of our detailed knowledge about the flora and fauna of the MPAs is from the relatively recent intertidal and shallow reef subtidal marine monitoring programs. Even with that we have limited knowledge of fish in the intertidal zone. Technological improvements have increased our ability to explore and describe deep habitats, as has been done for soft sediments and reefs in Point Lonsdale in Port Phillip Heads MNP (Edmunds *et al.* 2007). A major gap in our understanding of the natural values of Victorian Embayments MPAs is the lack of knowledge about the habitat values and species associated with soft sediment seafloors 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.

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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
PPB – Port Phillip Bay
PW – presumed to be at or near western limit in MPA
PV Parks Victoria
RE – recorded to be at eastern limit in MPA
RPP – Research Partners Panel
RW – recorded to be at western limit in MPA
ROV - remote operated vehicle
SRMP - Subtidal Reef Monitoring Program
VU - Vulnerable
VROTS - Victorian Rare or Threatened Species
WPB – Western Port Bay

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).

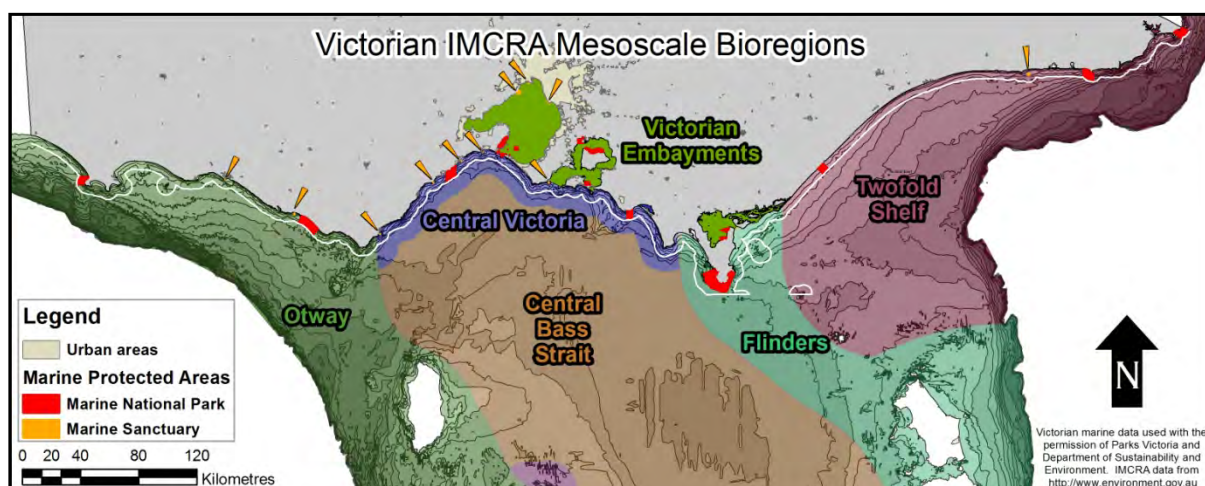


Figure 1. Locations of IMCRA mesoscale (i.e. 100 – 1000 km) bioregions (IMCRA 2006 v4)

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

Sites for the Marine Protected Areas (MPAs) were chosen to be representative of the diversity of Victoria's marine environment (ECC 2000) and the 24 parks are spread across Victoria's five marine bioregions (Figure 1). More than one park and/or sanctuary was usually selected within each bioregion, to reflect as far as possible the range of habitats and biological communities within each, to incorporate the variability within habitats, and to insure against loss due to unforeseen or future catastrophic events (Parks Victoria 2003). These parks and sanctuaries now protect 5.3 % of Victoria's coastal waters, incorporating important marine habitats and species, significant natural features, cultural heritage and aesthetic values (Parks Victoria 2003). The MPAs are highly protected areas where no fishing, extractive or damaging activities are allowed but to which access is unrestricted. Recreation, tourism, education and research are encouraged and properly managed (Power and Boxshall 2007). Marine Sanctuaries are much smaller than MNPs. MPAs are generally

classified Category II (MNP) and III (MS) under the International Union for Conservation of Nature (IUCN) classification (Power and Boxshall 2007); the exceptions are Point Cooke, Ricketts Point and Beware Reef MSs which are all IUCN Category II. There are also Marine Parks, Marine Reserves, and Marine and Coastal Parks which have the primary objective of conservation but allow a larger range of ecologically sustainable uses than MNPs or MSs (Parks Victoria 2003).

1.2 Purpose of Report

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

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

This report updates the first MNVS (Plummer *et al.* 2003) for the Victorian Embayments bioregion specifically the MPAs within PPB and is one of a series of five 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 Flinders and Twofold Shelf bioregions.

1.3 Structure

This report firstly describes the Victorian Embayments bioregions and the MPAs within PPB. 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 Parks are not specifically addressed in this report.

1.4 Methods

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

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

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

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

- Intertidal and Subtidal 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 respectively at 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.

Detailed multi-category Ecological Vegetation Class mapping in the Victorian Saltmarsh Study (2011) was reclassified to allow clearer display on the maps as follows:

- Any mapped area containing Mangrove Shrubland, either singly or in mosaic were grouped as 'Mangrove';
- Any mapped area containing Estuarine Wetland or Saline Aquatic Meadow, either single or in mosaic were grouped as 'Wetland'; and
- All remaining mapped areas (except bare and terrestrial categories) were grouped as 'Saltmarsh'.

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 reef flora and fauna in MPAs in the Port Phillip Bay section of the Victorian Embayments bioregion (Appendix 1).

1.5 Victorian Embayments Bioregion

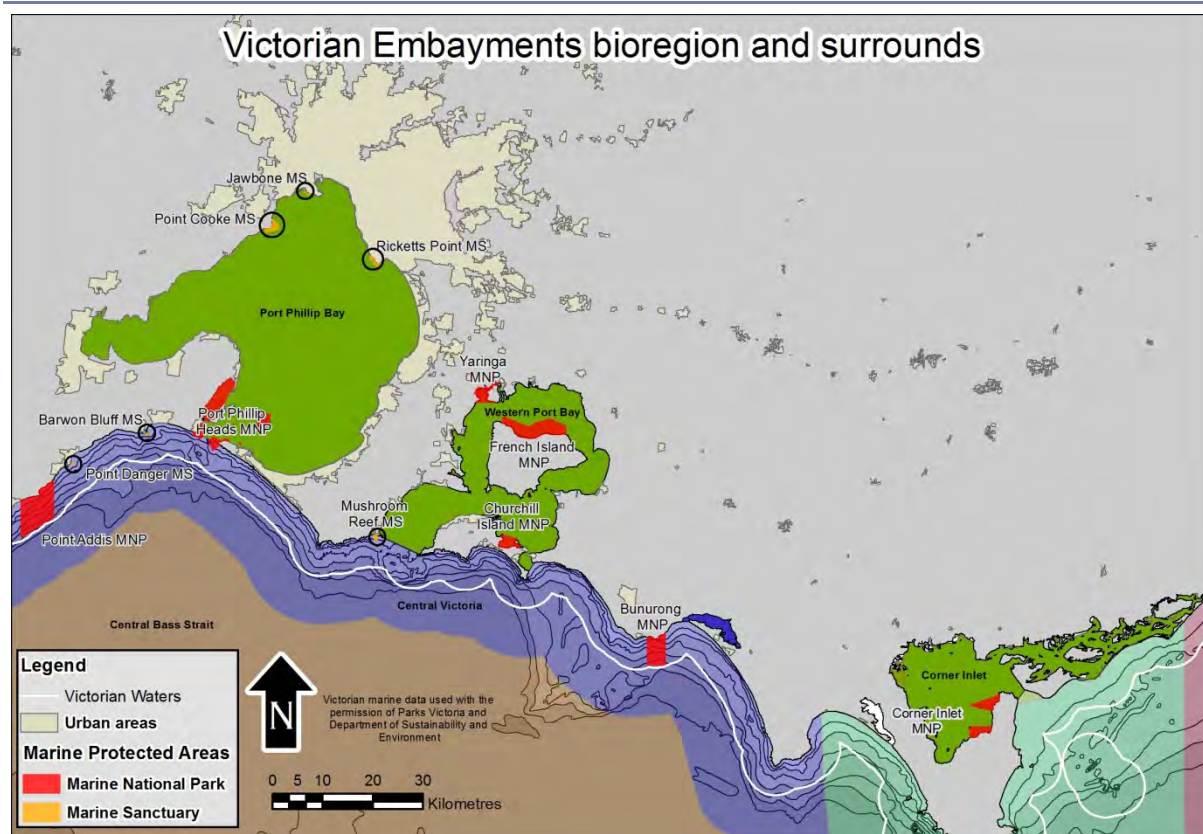


Figure 2. Victorian Embayments with IMCRA mesoscale bioregions, Marine National Parks and Marine Sanctuaries.

The Victorian Embayments bioregion is a discontinuous region that contains the major embayments, inlets and some of the major estuaries along the Victorian coast (Figure 2, IMCRA 2006). Within the bioregion, there are five MNPs, Port Phillip Heads in Port Phillip Bay, Yaringa, French Island, Churchill Island in Western Port, and Corner Inlet. Port Phillip Heads MNP is discontinuous and consists of six sites in the southern region of Port Phillip Bay. Three MSs, Point Cooke, Jawbone and Ricketts Point in Port Phillip Bay, also occur in the bioregion. The climate is moist temperate, with a pronounced west to east variation in catchment run off and seasonality. Variations in salinity and temperature are much higher than on the open coast (Parks Victoria 2003). The embayments have a variety of forms from drowned river valleys to impounded drainage behind dune barrier systems, their maximum depth is generally less than 20 m, but reaches depths of approximately 50 metres in Port Phillip Heads. They have low energy coastlines with large tides, influencing the extensive areas of subtidal and intertidal sediments. Rock outcrops are limited mainly to the margins (IMCRA 2006). Some shallow reef areas are present in Port Phillip and Western Port (Parks Victoria 2003). The biota of the Victorian embayments include a diverse range of biotic assemblages found in estuarine and open coast environments depending on the embayments morphological and hydrological characteristics (Parks Victoria 2003; IMCRA 2006). Port Phillip Bay is a marine embayment with deep central muds; eastern sandy shores, *Pyura* beds and shallow reef habitats; and sheltered reef, seagrass, drift algae and estuarine habitats in the west. The benthic assemblages in the muddy central region are distinct from those in the sand to the west and east. The areas of Swan Bay, Mud Islands and along the west coast support important bird habitat and are listed as Ramsar Sites.

Western Port Bay and Corner Inlet are large muddy estuaries with extensive mudflats, mangroves, saltmarshes and seagrass beds (IMCRA 2006). Western Port is a highly tidal environment characterised by a network of sediment channels and intertidal mud flats.

Significant tracts of mangroves and saltmarsh habitat occurs around the fringes of Western Port and remnant patches of intertidal and shallow subtidal seagrass occur on the mudflats. Western Port is an important bird feeding and roosting area and is a Ramsar wetland site. Significant marine communities include those of Crawfish Rock, San Remo and sediment channels. The rare and listed ghost shrimps *Michelea microphylla*, *Eucalliax tooradin* and *Paraglypturus Tooradin* are only known from the North Arm sediment channel of Western Port (Edmunds *et al.* 2010a).

Corner Inlet and Nooramunga has very large intertidal mudflat areas and substantial fringing mangrove stands. The intertidal and subtidal sediment banks also support stands of four species of seagrass, including significant stands of *Posidonia australis* which is largely restricted to Corner Inlet in Victoria (Edmunds *et al.* 2010a). Corner Inlet also has an extensive network of sediment channels. This inlet is listed as a Ramsar wetland, being a significant wetland for waterfowl. Listed species include the sea cucumber *Trochodota shepherdii* in seagrass beds of Nooramunga and Corner Inlet and the brittlestars *Amphiura trisacantha* and *Ophiocoma australis* in seagrass beds of Nooramunga (Edmunds *et al.* 2010a).

Gippsland Lakes includes a system of estuarine lakes with considerable areas of seagrass, estuarine grass *Ruppia* spp. and saltmarsh habitat (Edmunds *et al.* 2010a). This region is listed as a Ramsar site. The environment in Gippsland Lakes has been highly modified through construction of the permanent opening to the sea at Lakes Entrance and changes to riparian vegetation and river flows. The smaller Andersons Inlet, Shallow Inlet and Mallacoota Inlet are important wetland and water fowl sites.

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 Central Victorian Bioregion extends from Apollo Bay to Cape Liptrap, it does not include Port Phillip Bay and Western Port, which are included in the Victorian Embayments Bioregion (IMCRA 1998a). Within the Central Victoria Bioregion, there are two MNPs, Point Addis and Bunurong, and five MSs, Marengo Reef, Eagle Rock, Point Danger, Barwon Bluff and Mushroom Reef. It has a temperate climate with moist winters and warm summers. The shore is characterised by cliffs with sandy beaches and has the western-most occurrence of granites in its eastern region. Offshore gradients are steep in the east to very steep in the

west (IMCRA 1998a). It is relatively exposed to swells and weather from the south-west, but less so than the Otway Bioregion (Parks Victoria 2003). Sea surface temperatures are representative of Bass Strait waters and wave energy is moderate (IMCRA 1998a). Tides change from twice to four times a day from west to east (IMCRA 1998a). The habitats include shallow near-shore reefs and sandy beaches along with large areas of subtidal sandy sediment and patchy, low profile subtidal reef. Reefs can be limestone, basalt, granite or mudstone (Parks Victoria 2003). The limestone reefs are usually offshore from a surf beach and readily erode to provide a complex habitat for a diverse array of macroalgae, sponges, bryozoans, corals and ascidians as well as mobile crevice dwellers (Parks Victoria 2003). The dominant biota of this region consists of a diverse mixture of species from all of the adjacent biogeographical provinces – western, eastern and southern temperate species – in addition to cosmopolitan southern Australian species (Parks Victoria 2003).

The 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 Port Phillip Heads Marine National Park

Port Phillip Heads Marine National Park (MNP) is the one of five MNPs in the Victorian Embayments bioregion, which also contains Yaringa, French Island, Churchill Island and Corner Inlet MNPs. The bioregion also has three Marine Sanctuaries (MS), all of which are in Port Phillip Bay, these are Point Cooke, Jawbone and Ricketts Point MSs. Port Phillip Heads MNP is in the southern part of Port Phillip Bay (PPB), approximately 100 km south of Melbourne (**Figure 4**). It comprises six sections: the headlands on both sides of PPB entrance (Point Lonsdale and Point Nepean), Popes Eye, Portsea Hole (The Annulus), Mud Islands, and Swan Bay.

1. Point Lonsdale: on the Bellarine Peninsula extends along and offshore from Clarkes Beacon in Lonsdale Bay to outside of PPB west of Point Lonsdale, excluding an area 50 m on each side of the Point Lonsdale Pier (Figure 4 & Figure 9);
2. Point Nepean: on the Mornington Peninsula and extends from Observatory Point in Nepean Bay 250 m offshore to Corsair Beacon– Rock Beacon, and then forms a large wedge to the south outside of PPB until it rejoins the coast at Cheviot Beach (Figure 4 & Figure 10);
3. Popes Eye: in PPB on the Great Sands is a circular area 100 m in radius, centered on the Annulus (Figure 4 & Figure 13);
4. Portsea Hole: in PPB is a rectangular section approximately 400 m by 250 m which is 600 m offshore from the Portsea Pier (Figure 4 & Figure 14);
5. Mud Islands: in PPB on the Great Sands is a 2.5 km by 2.5 km square around the islands (Figure 4 & Figure 17); and
6. Swan Bay: on the Bellarine Peninsula includes almost the entire bay (Figure 4 & Figure 18). Areas not within the MNP include the inlet west of Burnt Point, the waters north and south of Rabbit Island, a narrow area of water along the western side of Duck Island and Edwards Point, and a 300 m wide channel, identified by in-water navigation markers and extending from Swan Bay Jetty to the park boundary north of Duck Island.

Aboriginal tradition indicates that the Bellarine Peninsula side of the MNP is part of *Country* of the Wathaurung people, and the Mornington Peninsula side of the MNP, including Mud Islands, is part of *Country* of the Boon Wurrung people (Parks Victoria 2006).

Port Phillip Heads MNP is readily accessible from the Bellarine and Mornington Peninsulas. Visitors can access the Point Lonsdale and Swan Bay sections of the MNP through many shore-based access points and a network of paths, stairs and car parking areas on the adjacent foreshore (Parks Victoria 2006). Shore based access to the intertidal beach in Point Nepean is limited to between The Bend and Observatory Point in Nepean Bay (Parks Victoria 2006). All other access to the intertidal region is prohibited because of the hazard of unexploded ordnance (Parks Victoria 2006). The waters of Point Nepean can only be accessed by boat. Access to Popes Eye, Portsea Hole and Mud Islands is only by boat. Boats can only enter the intertidal areas in Swan Bay at designated boat ramps (Parks Victoria 2006).

Three Sea Use Designation overlays apply over the MNP off inner Point Nepean, including the Ticonderoga Bay Sanctuary Zone for bottlenose dolphin *Tursiops truncatus* protection and two public safety areas (Parks Victoria 2006). A Special Protection Area overlay also applies in Swan Bay to protect seagrass beds, seabird and shorebird habitat (Parks Victoria 2006). The shore of Point Lonsdale, the inside shore of Point Nepean, all of Popes Eye, Mud Islands and Swan Bay are 5 knot speed limited boating zones (Parks Victoria 2006).

All sections of Port Phillip Heads MNP, except Portsea Hole, were originally gazetted as part of the Harold Holt Marine Reserves in 1979 and re-gazetted as the Harold Holt Fisheries Reserves in 1998 (Parks Victoria 2006). Line fishing was allowed in both Point Lonsdale and Point Nepean until MNP declaration, fishing of any kind was prohibited in Popes Eye since 1976. Small areas of the Harold Holt Fisheries Reserves, in Point Nepean and Swan Bay, were not included in the MNP (Parks Victoria 2006). Port Phillip Heads MNP also includes the area between the high and low water mark at Point Nepean that was formerly part of Point Nepean National Park (Parks Victoria 2006). Popes Eye is a natural sand shoal, with a partially completed bluestone fortification, the Annulus, from the late 1880s (Parks Victoria 2006). Portsea Hole is a steep remnant section of the ancient Yarra River (Parks Victoria 2006). Mud Islands, formerly known as Swan Isles, Signet Island and Flat Islands, was proclaimed a sanctuary for all native game in 1931 after a long history of guano mining (Parks Victoria 2006). Swan Bay and Mud Islands are internationally significant shorebird habitats and form part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula RAMSAR site listed under the RAMSAR convention and on the Register of the National Estate (Parks Victoria 2006).

Sections of the Port Phillip Heads MNP abut conservation managed terrestrial areas. Point Nepean section abuts Point Nepean National Park, and adjacent to Point Lonsdale is foreshore reserve (Parks Victoria 2006). Swan Bay is both privately and publicly managed. Its south-western foreshore is privately owned, in the north it is Edwards Point Wildlife Faunal Reserve, in the west a Public Purpose Reserve, and adjacent to Swan Island it is managed by the Department of Defence (Parks Victoria 2006).

Thirty-one of the 120 shipwrecks known to have occurred within a 10 nautical mile radius of Port Phillip Heads are thought to be within the MNP in Point Lonsdale and Point Nepean (Parks Victoria 2006). The wrecks of the *Holyhead* and *George Roper* within the park are part of Heritage Victoria's Underwater Shipwreck Discovery Trail (Parks Victoria 2006).

Port Phillip Heads MNP contains a diversity of habitats, from complex calcarenite reefs supporting many endemic species to seagrass meadows, sponge gardens, mud flats and sandy deltas (Parks Victoria 2006). These habitats, their geology and geomorphology, and the biotic communities they support are the important natural values of Port Phillip Heads MNP (ECC 2000; Parks Victoria 2006; Carey *et al.* 2007b). Many of these habitats have sites of geological or biotic significance (Figure 8 & Figure 29).

Habitats in the MNP include its dynamic intertidal sandy beaches, sheltered intertidal and subtidal soft sediment habitat, intertidal and subtidal seagrass beds, calcarenite intertidal and subtidal reef, subtidal artificial basalt reef, and deep waters of Port Phillip Heads (ECC 2000; Parks Victoria 2006; Carey *et al.* 2007b). The intertidal and subtidal seagrass beds on the soft sediment in Mud Islands and Swan Bay, and on sand covered subtidal reef in Point Nepean, support abundant invertebrates and juvenile fish. The intertidal calcarenite reef supports a high invertebrate diversity. In Popes Eye the intertidal and subtidal reef is an artificial basalt structure and supports abundant large fish. The shallow subtidal calcarenite reefs have high algal diversity and abundance. In Point Lonsdale and Point Nepean the reef can be high or low profile, with rubble, gutters, ledges and overhangs. The reef can be solid or patchy and inundated by sand. It can be dominated by large canopy forming brown algae, or as in parts of Point Nepean, extensive beds of seagrass *Amphibolis antarctica*. The kelp *Ecklonia radiata* grows on shallow down to moderate depth reefs in Point Lonsdale, Point Nepean and Portsea Hole. Deep subtidal reef is found in Point Lonsdale, Point Nepean and Portsea Hole, and is dominated by sessile invertebrates, predominately diverse sponges.

The intertidal and shallow subtidal beach, flats and reef throughout the MNP support shorebird feeding habitat, including some of international significance (RAMSAR & Register of National Estate) at Mud Island and Swan Bay. Popes Eye, Mud Islands and Swan Bay

have significant wader and seabird roosts. Australian gannets *Morus serrator* breed on Popes Eye, and Mud Island supports large breeding colonies of terns, cormorants and gulls. The saltmarsh in both Mud Island and Swan Bay are an important wintering site for the threatened orange-bellied parrot *Neophema chrysogaster*, with the Mud Islands saltmarsh being largely protected from human disturbance. Bottlenose dolphin *Tursiops truncatus* frequent the waters off Point Nepean.

Port Phillip Heads MNP provides important feeding and roosting habitat for fifty-eight 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 MNP protects feeding areas for forty-three internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Three invertebrates are endemic and two molluscs are presumed to be endemic to the MNP. One hundred and four species of marine flora and fauna are believed to be at their distributional limits within the MNP.

Serious threats to the Port Phillip Heads MNP include limited ecological knowledge of important processes. Invasive marine pests; sediment from dredging impacting seagrass, benthic fauna, birds and the water column; inadequate monitoring and management; major oil spills; and climate change all pose serious threats to the integrity of the MNP (Carey *et al.* 2007b). Measures to address or minimise these threats form part of the management plan for Port Phillip Heads MNP (Parks Victoria 2006). Ongoing intertidal and subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Port Phillip Heads MNP.



Figure 3. Western blue devil fish *Paraplesiops meleagris* on deep subtidal reef at Point Lonsdale in the Port Phillip Heads Marine National Park. Photo by Don Love.

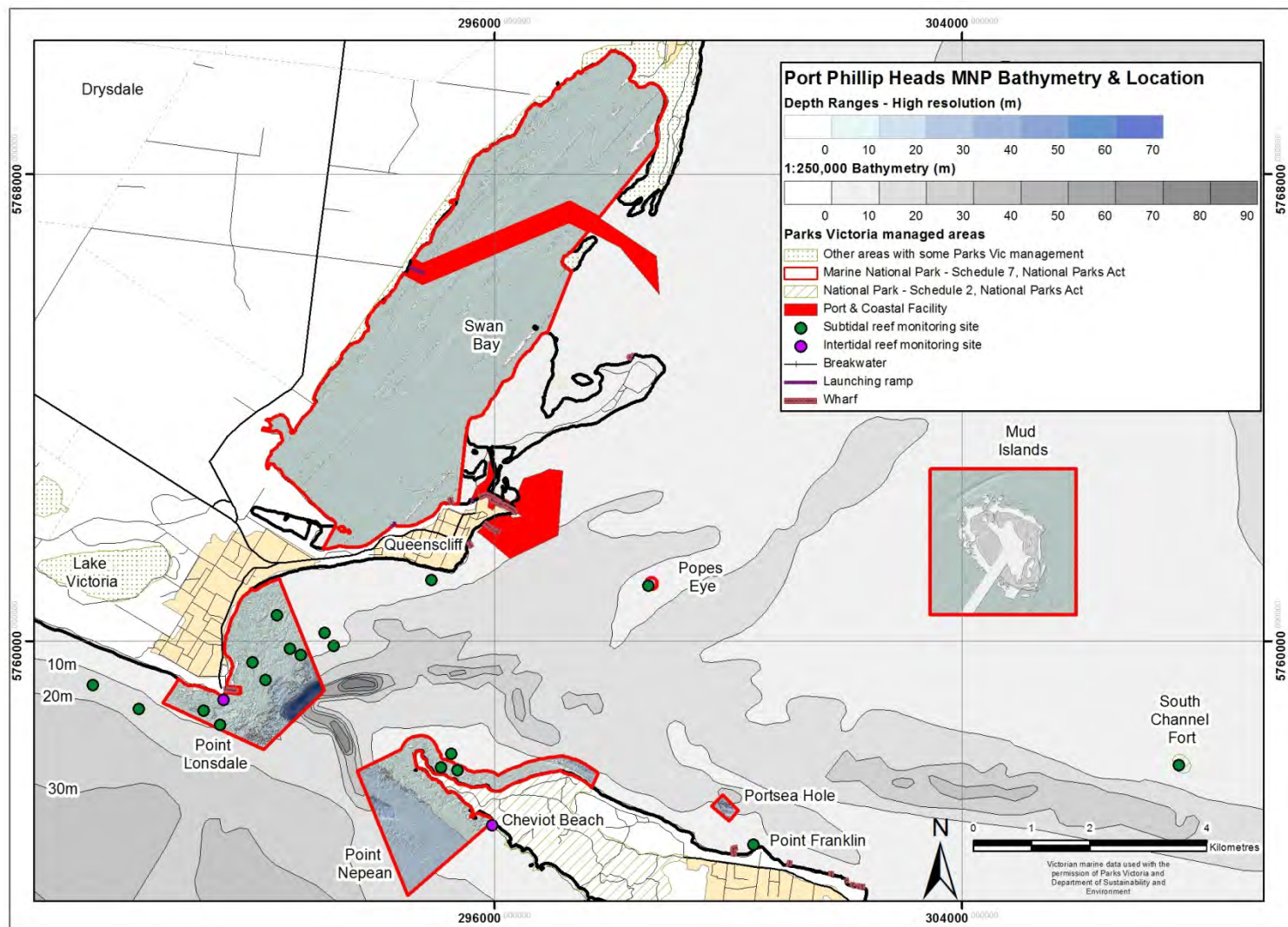


Figure 4. Location map of Port Phillip Heads Marine National Park with bathymetry. Intertidal and subtidal reef monitoring sites inside and outside the MNP are shown.

2.1.1 PHYSICAL PARAMETERS & PROCESSES

Port Phillip Heads MNP is 3475 hectares in size which makes it the seventh largest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 2, Figure 4). The MNP consists of six sections: Point Lonsdale (377 ha, Figure 9 and 20), Point Nepean (377 ha, Figure 10), Popes Eye (3.1 ha, Figure 13 and 15), Portsea Hole (9.8 ha, Figure 14), Mud Islands (625 ha, Figure 17) and Swan Bay (2083 ha, Figure 18 and 19). It stretches along approximately 34 km of coastline with some sections, Popes Eye, Portsea Hole and Mud Islands, not joined to the coast (Figure 4).

Port Phillip Heads ('the Heads') is the entrance to Port Phillip Bay (PPB). Outside of the Heads the southern coasts of Point Lonsdale (Figures 5 and 11) and Point Nepean (Figures 6 and 12) are exposed to south-westerly weather and swells of Bass Strait. These beaches receive ocean waves averaging about 1.7 m, which break on the outer reef flats and arrive on the beach with reduced energy and a wave height averaging only 0.5 m (Short 1996). Within the Heads is a narrow, deep (100 m) stretch of water ('the Rip') between Point Lonsdale and Point Nepean. The waters of the Rip are very turbulent due to its exposure to ocean swells, waves and weather, the relatively shallow reef extending out from the Points, and the strong tidal flow in and out of the Heads. Tidal currents through the Rip dominate the circulation of water in the southern part of PPB. During the peak floods and ebbs the current can be as fast as 2.5 m/s (Harris *et al.* 1996). Point Nepean has strong currents which decrease only for a short time on a flooding tide in shallow water (Edmunds *et al.* 2009b). Lonsdale Bay and Nepean Bay are more protected than the ends of the Points. The beaches on the inside coast of Point Lonsdale and Point Nepean receive low wave energy, with waves between 0.5 and 2.5 m (Short 1996). Seasonal wave conditions, current patterns, and storm energy create a dynamic environment in which there is natural accretion and attrition of beaches, causing sand to cover and uncover the reefs and other habitats (Bird 1993). Further inside PPB, Popes Eye and Portsea Hole have moderate exposure to waves and currents. North of the Great Sands tidal delta the peak tidal current slows to 0.1 m/s (Harris *et al.* 1996). Here the islands of Mud Islands create a sheltered lagoon. Strong tidal currents and storm events continually alter the shape of Mud Islands and the Great Sands (Bird 1993). Swan Bay is a large shallow sheltered lagoon, with a constricted connection to PPB by natural and artificial channels either side of Swan Island.



Figure 5. Intertidal reef on the south coast of Point Lonsdale in Port Phillip Heads Marine National Park. Photo by Don Love.

Tides vary in the different sections of Port Phillip Heads MNP (Table 1 & Table 2), from 1.2 m spring and 0.6 m neap in Point Lonsdale and Point Nepean, to 0.7 m spring and 0.1 m neap in Portsea Hole and Mud Islands (Plummer *et al.* 2003). PPB is microtidal (< 2 m) and its tides are smaller than those in Bass Strait. It has an unequal semidiurnal tidal pattern, with flooding and ebbing having both a higher and lower event per day. The flushing time of PPB varies from 0 days at the Rip to about 260 days in the main body of the bay (Harris *et al.* 1996). Tidal currents diminish before they reach Swan Bay, with a tidal amplitude <1 m and flushing time of approximately 1.5 days. These currents circulate through both the southern and northern entrance to Swan Bay.

Surface water temperature varies in the MNP from a mean summer temperature of 17.5 °C in Point Lonsdale and Point Nepean to 20.5 °C in Swan Bay, and a mean winter temperature of 13.5 °C in Point Lonsdale and Point Nepean to 11.2 °C in Mud Islands and Swan Bay (Table 1 & Table 2). The water temperature in PPB shows very little day to day variation. In summer the average surface water temperature in PPB is 21 °C, and in winter is 11 °C (Harris *et al.* 1996). There is only one direct freshwater discharge into Port Phillip Heads MNP, Yarram Creek discharges onto the western shoreline of Swan Bay (Table 1). The nearest estuary to the MNP is Barwon River 9 km to the west outside the Heads (Table 1). For the sections of the MNP that abut the coast, land use varies from urban at Point Lonsdale, agricultural and some urban at Swan Bay, to conservation at Point Nepean which abuts Point Nepean National Park (Table 2).

The geology of Point Lonsdale and Point Nepean peninsulas is Pleistocene dune calcarenite (limestone) (Bird 1993). The round, broad foreland of Observatory Point in Nepean Bay displays sustained sandy accretion, a feature rarely seen in PPB (Bird 1993). The accretion is evidence of a dynamic movement of sand by tidal and wave movement through the Rip (Bird 1993). Popes Eye, Portsea Hole and Mud Islands (Figure 7) are in the Great Sands. Popes Eye has an artificial structure of basalt blocks.



Figure 6. The coast of Point Nepean inside the Heads in Port Phillip Heads Marine National Park. Photo by Steffan Howe.

Table 1. Physical attributes of the Port Phillip Heads Marine National Park.

Park Name	Port Phillip Heads
Conservation status	Marine National Park
Biophysical Region	Victorian Embayments
Size	3475 ha (ranked 7 th of 24)
Length of coastline	~34 km
Shoreline geology	Calcarene and basalt
Area with depth:	
(low res)* 0-10 m	134.97 ha
(high res) Supratidal	59.53 ha
Intertidal	1329.31 ha
Intertidal-2 m	1187.07 ha
2-4 m	197.81 ha
4-6 m	109.44 ha
6-8 m	105.49 ha
8-10 m	66.71 ha
10-20 m	242.44 ha
20-30 m	20.66 ha
30-40 m	2.71 ha
40-50 m	7.85 ha
(low-res)*40-60 m	0.02 ha
50-60 m	7.99 ha
60-70 m	3.08 ha
Mean tidal variation - spring	0.7-1.2 m
Mean tidal variation - neap	0.1-0.6 m
Mean water temp - summer	17.5-20.5°C
Mean water temp - winter	11.2-13.5°C
Discharges into MNP	Yarram Creek in to Swan Bay
Nearest major estuary (distance & direction)	Barwon River ~9 km west Balcombe Creek ~20 km east Yarra River ~45 km north Hovells Creek ~45 km north west

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

**Figure 7.** Mud Islands in Port Phillip Heads Marine National Park. Photo by Mark Rodrigue, Parks Victoria.

Table 2. Physical attributes of individual sections of the Port Phillip Heads Marine National Park.

Park Name Section Name	Point Lonsdale	Port Phillip Heads Point Nepean	Marine National Park Popes Eye	Portsea Hole	Mud Islands	Swan Bay
Size	377 ha	377 ha	3.1 ha	9.8 ha	625 ha	2083 ha
Length of coastline	~3.3 km	~5.8 km	~0.3 km	NA	~9.9 km	~25 km
Area with depth (ha):						
(low res)* 0-10 m	4.81	1.64		0.12	104.98	23.39
(high res) Supratidal	6.70	2.99	0.05		45.78	4.81
Intertidal	15.35	18.26	0.07		113.37	1181.58
Intertidal-2 m	21.89	23.00	0.41		327.74	813.85
2-4 m	51.23	55.15	0.48		32.30	58.56
4-6 m	69.30	38.99	0.27		0.83	
6-8 m	85.36	19.71	0.36			
8-10 m	45.80	20.04	0.34	0.44		
10-20 m	52.40	183.52	1.11	5.04		
20-30 m	3.06	13.46		4.06		
30-40 m	2.54			0.16		
40-50 m	7.85					
(low-res)* 40-60 m	0.02					
50-60 m	7.99					
60-70 m	3.08					
Mean tidal variation - spring	1.2 m	1.2 m	0.9 m	0.7 m	0.7 m	0.8 m
Mean tidal variation - neap	0.6 m	0.6 m	0.2 m	0.1 m	0.1 m	0.2 m
Mean water temp - summer	17.5°C	17.5°C	18.2°C	18.4°C	20.0°C	20.5°C
Mean water temp - winter	13.5°C	13.5°C	12.5°C	12.5°C	11.2°C	11.2°C
Adjacent catchment	urban	National Park	NA	NA	NA	agriculture

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

There are nine sites of regional or state geological significance in Port Phillip Heads MNP (Figure 8). In Point Lonsdale, the broad calcarenite shore platforms and cliffs cut into Pleistocene dune calcarenite, exposing lithified dune structures, calcrete horizons and ancient soils, are of regional significance. As are the complex calcarenite Pleistocene dune sequences in Lonsdale Bight. In Point Nepean, the platforms off the Point in the entrance to the Heads are of national significance due to the role they play in controlling many features of PPB. The entrance to PPB and the Great Sands to the north of it are a sandy flood tide delta on a rocky platform that is of state significance. Observatory Point in Point Nepean is regionally significant as it is one of the few sites in the Bay to show sustained sandy accretion. Mud Islands consists of shelly sand ridges capped by dunes which enclose a shallow lagoon and salt marshes, which are uncommon and of state geological significance. There are three sites of regional geological significance in the MNP in Swan Bay. Swan Bay is a shallow tidal embayment with a constricted tidal entrance and a muddy shoreline fringed with extensive saltmarshes, lagoons and locally significant alluvial fans and tidal flats. It is the best example of a distributary delta in PPB and is of regional significance. In the south of Swan Bay the low energy tidal flat, which is a fine grained, shell rich depositional environment is significant. In the north of Swan Bay the alluvial fans complex is regarded as regionally significant. Adjacent to the park and part of Swan Bay, Swan Island and the Edwards Point Spit comprise part of the most complex depositional feature of Port Phillip and are of state significance (Figure 8).

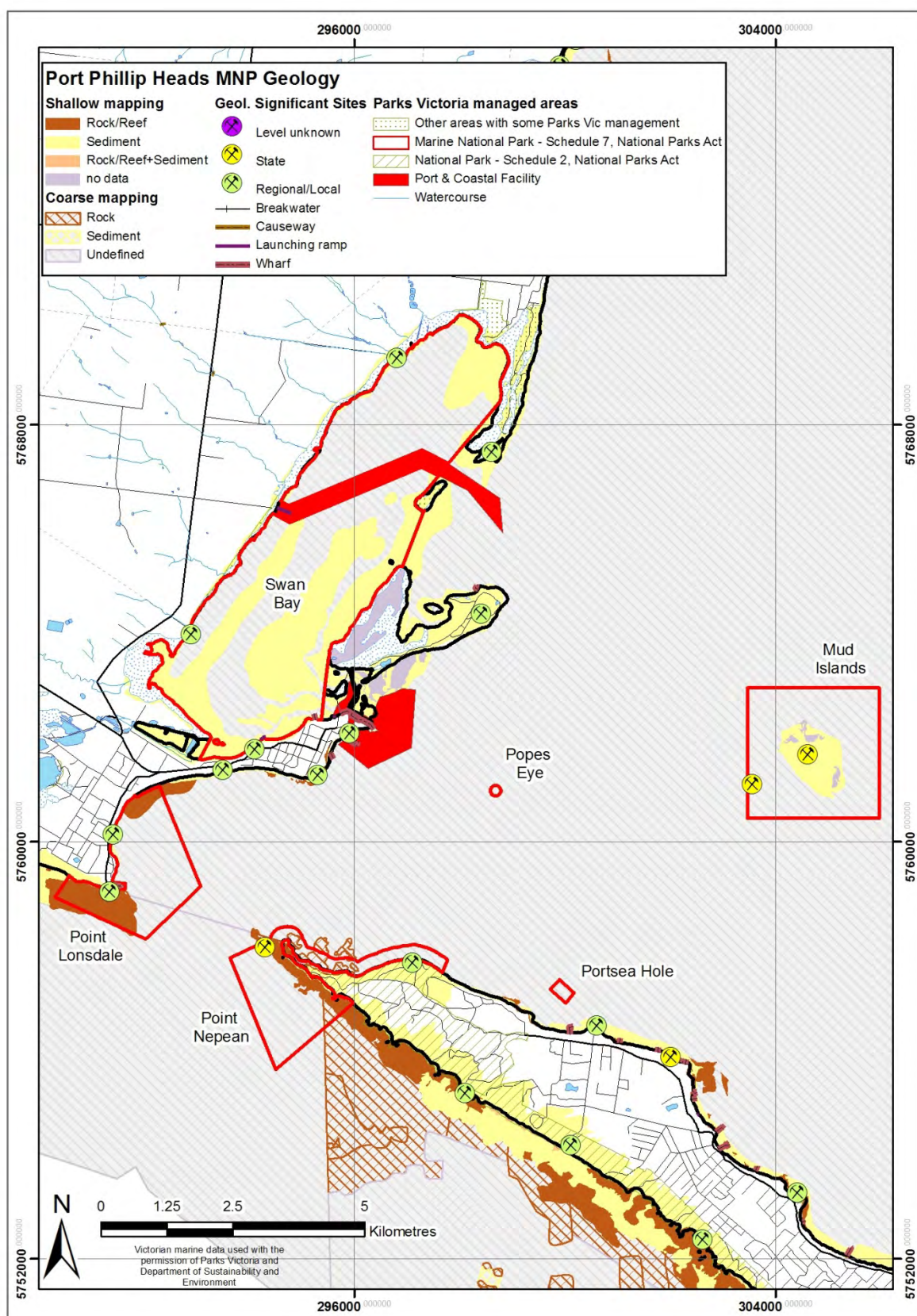


Figure 8. Substrate mapping of Port Phillip Heads Marine National Park and surrounds, showing sites of geological significance.

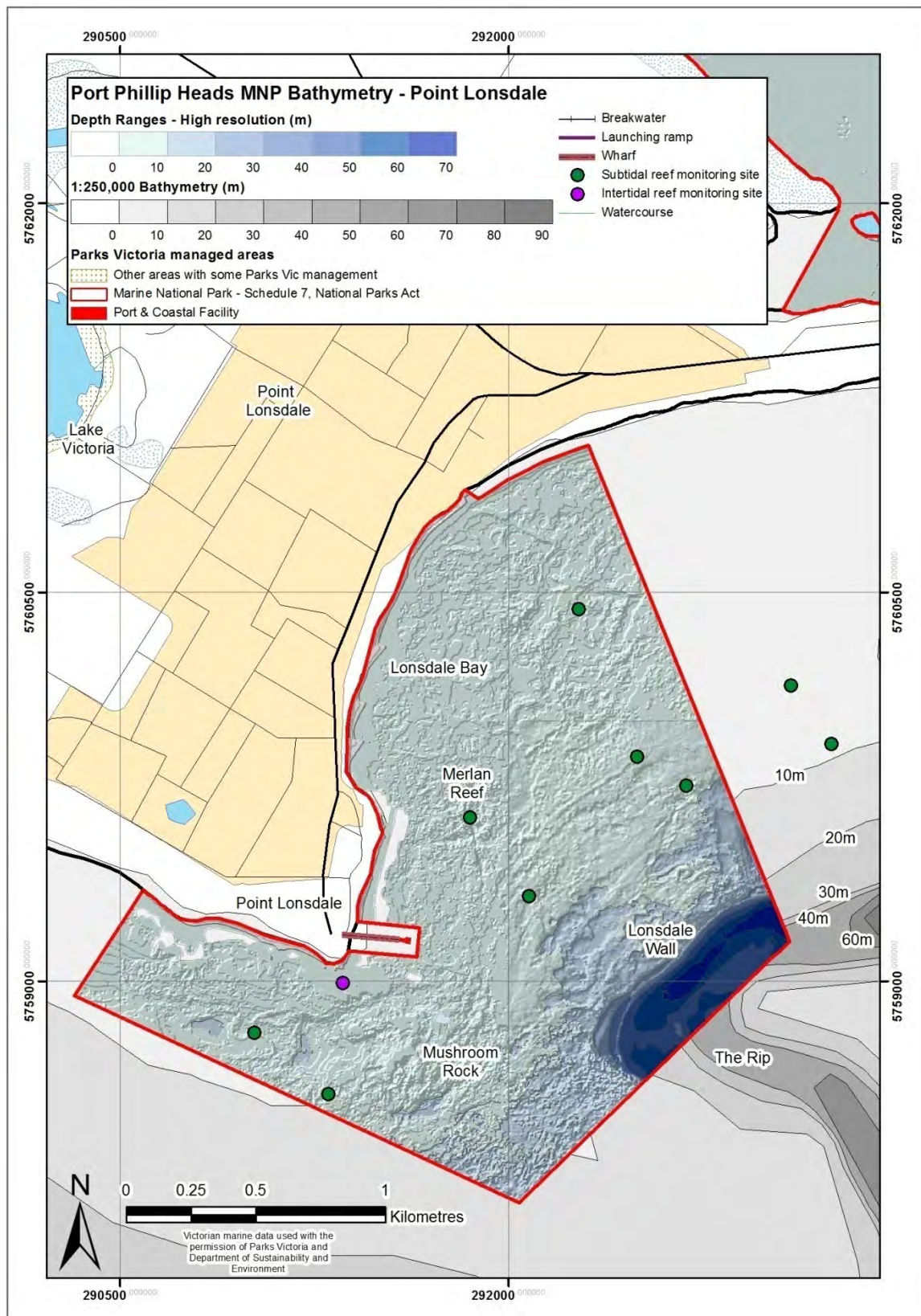


Figure 9. Location map of Point Lonsdale - Port Phillip Heads Marine National Park with bathymetry. Ongoing intertidal and subtidal reef monitoring sites are shown. Reference sites outside the MNP for intertidal monitoring are at Cheviot Beach, and for subtidal monitoring are in Lonsdale Bay and off the ocean beach.

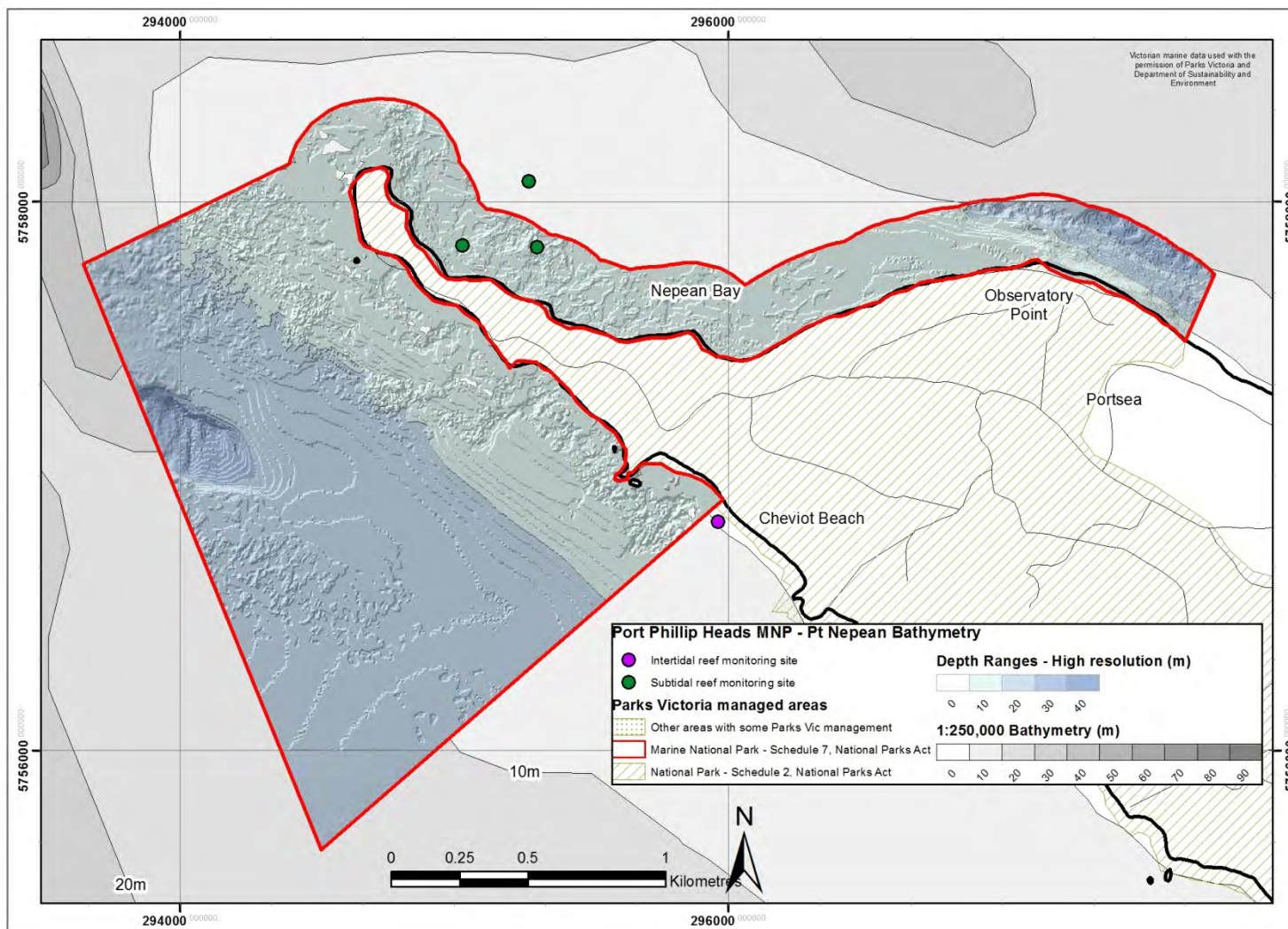


Figure 10. Location map of Point Nepean - Port Phillip Heads Marine National Park with bathymetry. Ongoing intertidal and subtidal reef monitoring sites are shown. Reference sites for intertidal monitoring are at Cheviot Beach, and subtidal monitoring in Nepean Bay.



Figure 11. Point Lonsdale, Port Phillip Heads Marine National Park. Photo by Don Love.



Figure 12. Point Nepean, looking across the Heads to Point Lonsdale, Port Phillip Heads Marine National Park. Photo by Steffan Howe.

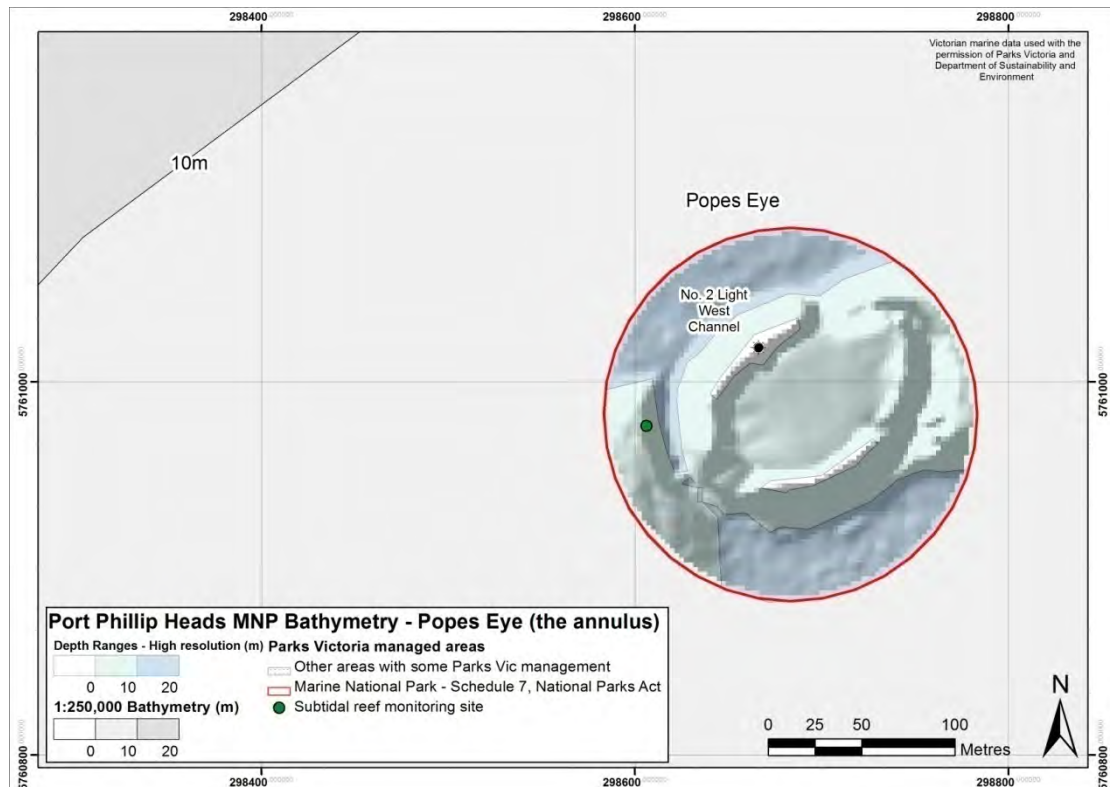


Figure 13. Location map of Popes Eye - Port Phillip Heads Marine National Park with bathymetry. Ongoing subtidal reef monitoring site is shown, the reference site is at South Channel Fort.

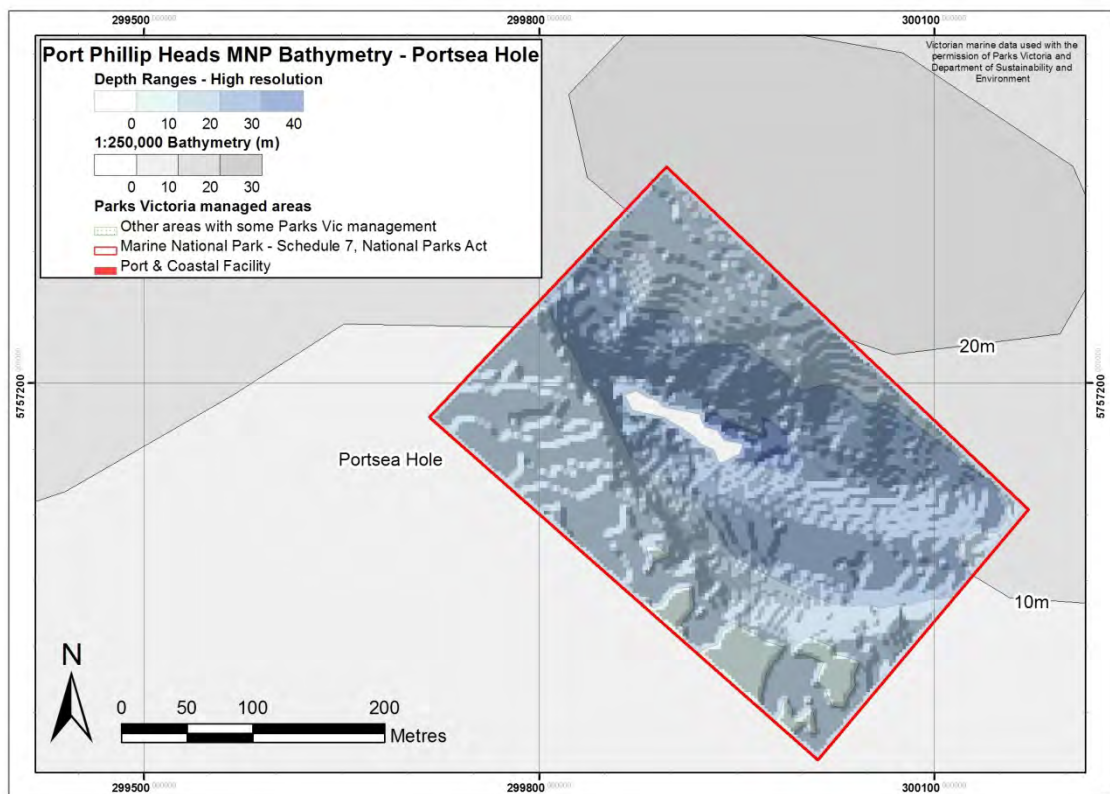


Figure 14. Location map of Portsea Hole - Port Phillip Heads Marine National Park with bathymetry. There is no ongoing subtidal monitoring.



Figure 15. Popes Eye, Port Phillip Heads Marine National Park from the air. Photo by Tim Allen.



Figure 16. Mud Islands, Port Phillip Heads Marine National Park from the air showing subtidal seagrass beds. Photo by Tim Allen.

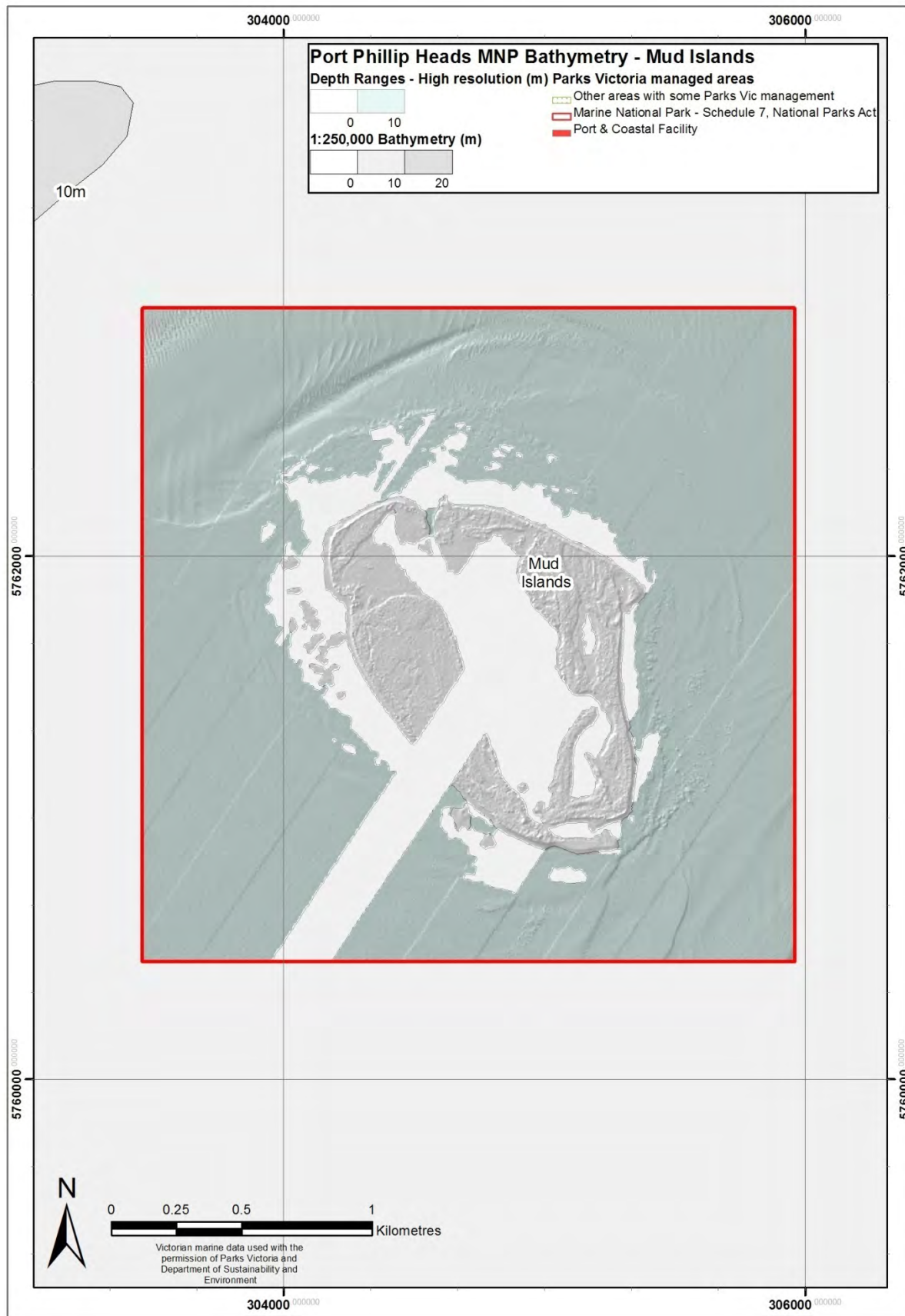


Figure 17. Location map of Mud Islands - Port Phillip Heads Marine National Park with bathymetry. The break in the high resolution bathymetry is an artifact and does not indicate a change in the bathymetry. There is no ongoing subtidal reef at Mud Islands and therefore no SRMP.

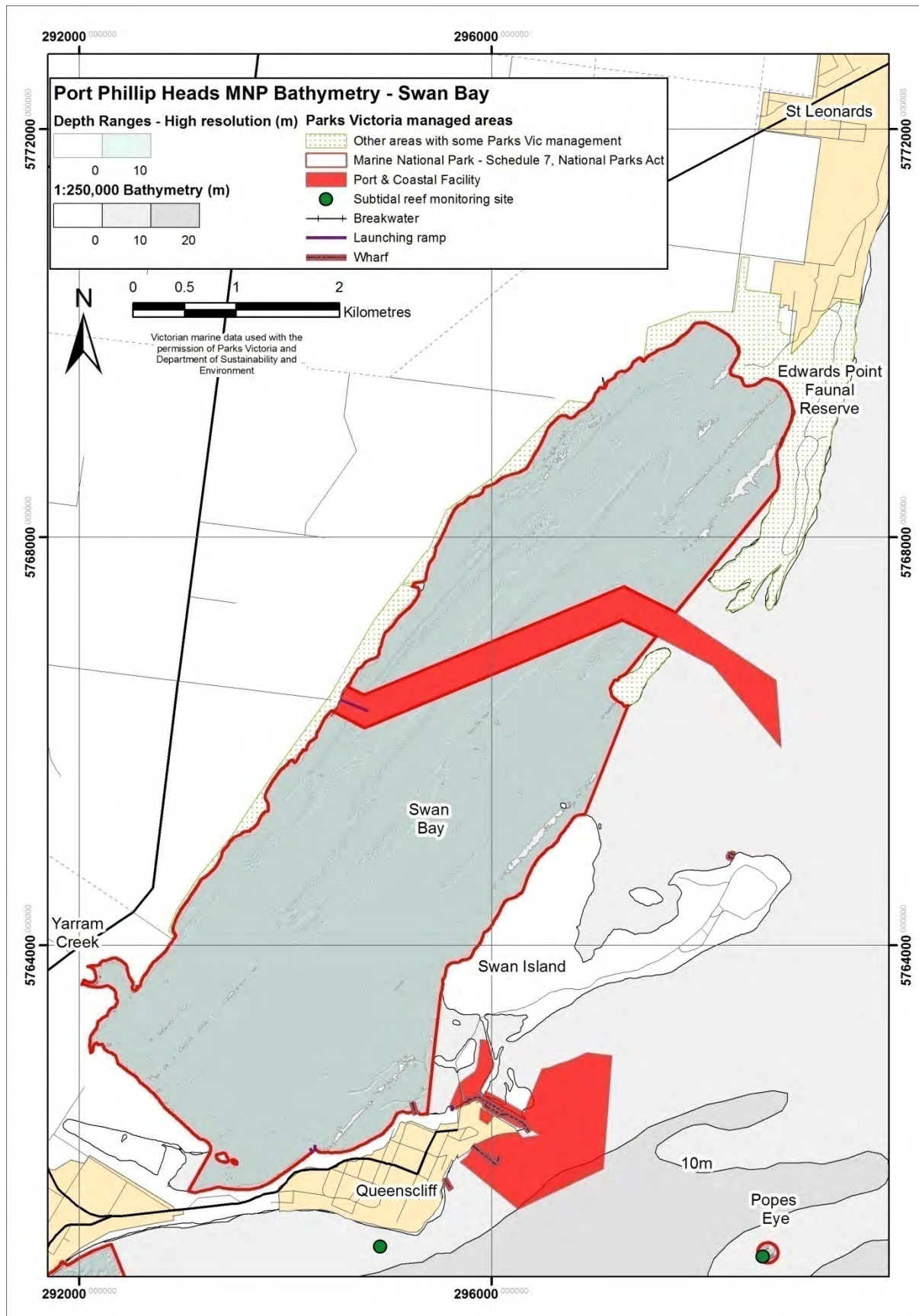


Figure 18. Location map of Swan Bay - Port Phillip Heads Marine National Park with bathymetry. Subtidal reef monitoring sites are shown.



Figure 19. Swan Bay, Port Phillip Heads Marine National Park. Photo by Mark Rodrigue.

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). Knowledge of the distribution and extent of habitats is required to more effectively target management activities effectively, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. High resolution bathymetry of the shallow (LiDAR) and deep waters of Port Phillip Heads MNP has been done. The substrate and biota of the shallow subtidal reef habitat in Point Lonsdale and Point Nepean in Port Phillip Heads MNP (Figure 22 & Figure 24) was mapped from aerial photography, and ground-truthed in 2004 and 2005 by site visits and underwater video (Ball and Blake 2007). The seagrass in Mud Islands and Swan Bay were mapped in 2001 and are part of an ongoing monitoring program (Blake and Ball 2001; PoMC 2009). The deep subtidal reef at Lonsdale Wall in the east of Point Lonsdale and at Portsea Hole have been surveyed as part of the assessment of the Port Phillip Bay Deepening Project (Edmunds *et al.* 2009a; Edmunds *et al.* 2009c).

There is a wide diversity of different habitat types in Port Phillip Heads MNP. Point Lonsdale, Point Nepean, Mud Island and Swan Bay have intertidal soft sediment that can be exposed or semi exposed beaches, or sheltered sand flats. The sand flats in Mud Island and Swan Bay can be unvegetated or vegetated with saltmarsh and seagrass. Mud Islands also has sand dunes. Intertidal reef platforms with their associated tide pools are calcarenite in Point Lonsdale and Point Nepean. In Popes Eye the intertidal reef is an artificial basalt structure. Subtidal soft sediments occur in all six sections of Port Phillip Heads MNP. This habitat can be unvegetated or support extensive beds of seagrass like in Mud Islands and Swan Bay. Shallow subtidal reef is an important habitat in Point Lonsdale, Point Nepean and Popes Eye. The calcarenite subtidal reef of Point Lonsdale and Point Nepean can be high or low profile, solid or patchy with rubble, gutters, ledges and overhangs, and inundated by sand. The reef can also be dominated by large canopy forming brown algae, or as in parts of Point Nepean, extensive beds of seagrass *Amphibolis antarctica*. The kelp *Ecklonia radiata* grows on moderate depth reefs in Point Lonsdale, Point Nepean, Popes Eye and Portsea Hole. Deep subtidal reef is found in Point Lonsdale, Point Nepean and Portsea Hole, and is dominated by sessile invertebrates, predominately sponges.



Figure 20. Beach and intertidal reef outside the Heads at Point Lonsdale in Port Phillip Bay Marine National Park. Photo by Don Love.



Figure 21. Aerial view of Point Lonsdale – Port Phillip Heads Marine National Park 2004 aerial photography (QASCO 28/3/04). From Ball and Blake 2007.

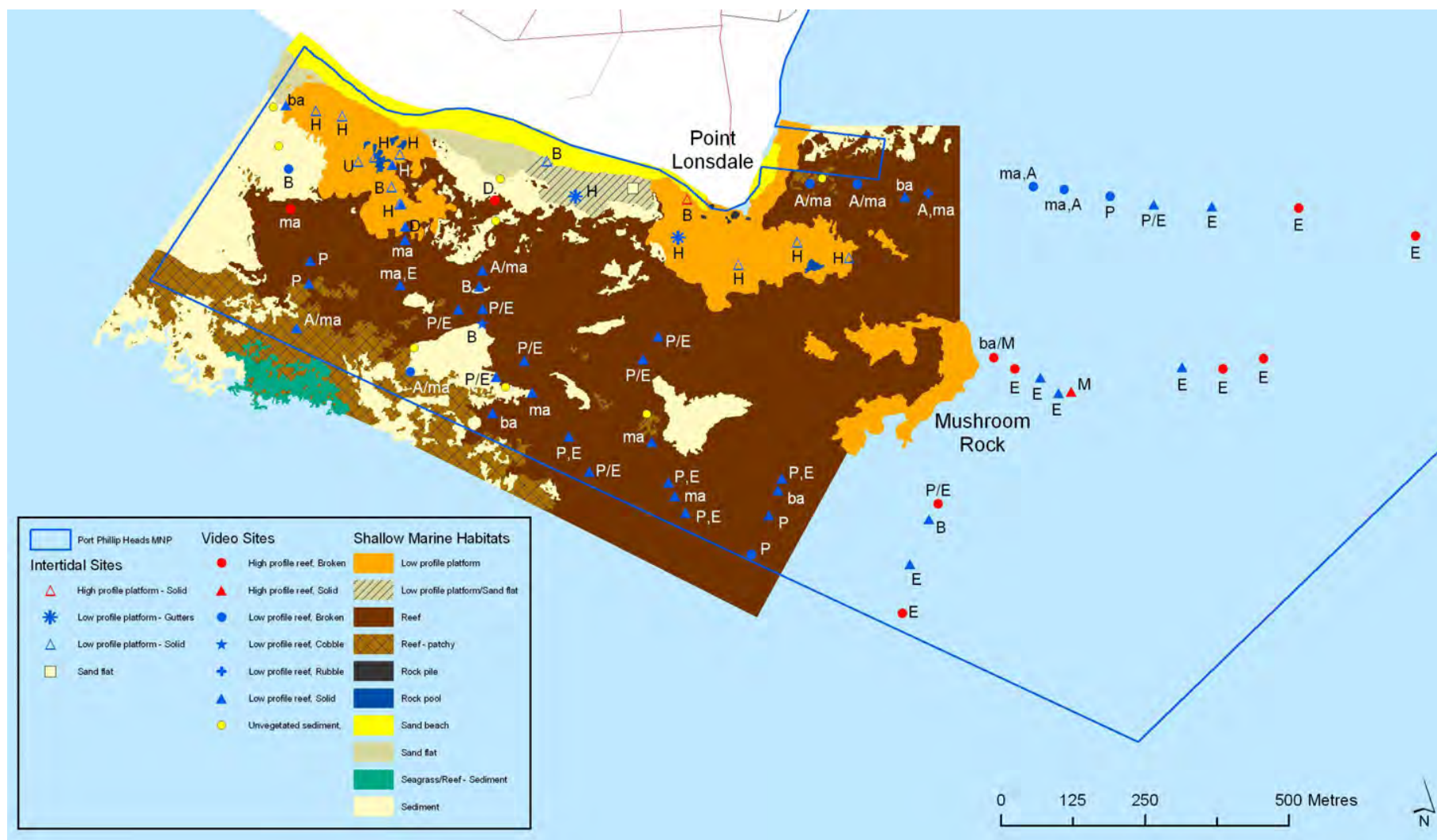


Figure 22. Detailed substrate and biota mapping of Point Lonsdale - Port Phillip Heads Marine National Park from Ball and Blake 2007. Dominant biota categories on the map A = *Amphibolis antarctica* B = bare reef or sediment, ba = mixed brown algae, D = *Durvillaea potatorum*, E = *Ecklonia radiata* H = *Hormosira banksii*, M = *Macrocystis pyrifera*, ma = mixed algae, P = *Phyllospora comosa*, U = *Ulva* spp.



Figure 23. Aerial view of Point Nepean - Port Phillip Heads Marine National Park 2003 aerial photography (Hydro Tasmania 21/07/2003). From Ball and Blake 2007.

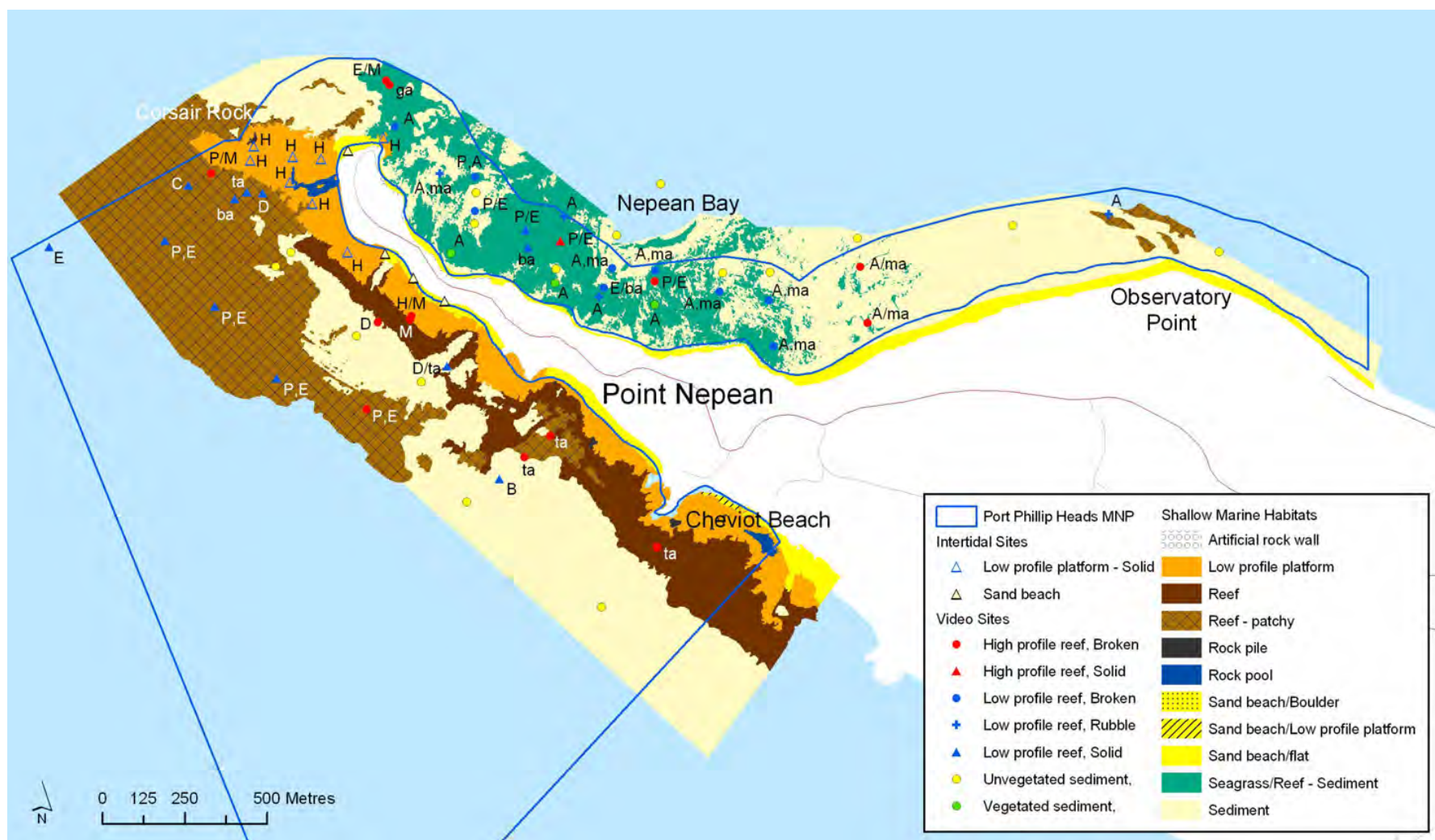


Figure 24. Detailed substrate and biota mapping of Point Nepean - Port Phillip Heads Marine National Park from Ball and Blake 2007. Dominant biota categories on the map A = *Amphibolis antarctica* B = bare reef or sediment, ba = mixed brown algae, C = *Cystophora* spp., D = *Durvillaea potatorum*, E = *Ecklonia radiata*, ga = mixed green algae, H = *Hormosira banksii*, M = *Macrocystis pyrifera*, P = *Phyllospora comosa* and ta = turfing algae.

The beaches outside the Heads at both Point Lonsdale (Figure 21 & Figure 22) and Point Nepean (Figure 23 & Figure 24) are medium energy reflective beaches and fronted by reef. Inside the Heads the beaches are low energy, low tide terraces (Short 1996). The Point Nepean coast inside the heads has limited intertidal reef and is mostly sand beach with strong tidal currents. The beach becomes wider with distance from the Heads (Ball and Blake 2007). Artificial walls, boulder ramparts and groins have been built along Lonsdale Bay to try and stop beach erosion (Bird 1993). In Point Nepean, inside the Heads, an artificial rock wall has been constructed at the base of the cliff to protect the shore from erosion (Ball and Blake 2007).

The nearshore region at both Point Lonsdale and Point Nepean is highly dynamic and has a large amount of sand movement (Ball and Blake 2007). Intertidal reef at the Heads, in Point Lonsdale and Point Nepean, joins subtidal reef platform. In approximately 17 m this reef becomes a very deep, steep sided canyon meandering north between the Heads for approximately 1.6 km (Edmunds *et al.* 2010c). The intertidal platforms in Point Lonsdale and Point Nepean have strong weathering features (Bird 1993). Point Lonsdale has two distinct rock platforms separated by a sand beach (Ball and Blake 2007). The eastern rock intertidal platform extends from the base of Point Lonsdale and is characterised by flat reef (Ball and Blake 2007). The western low profile rock platform emerges from a sand beach fronting high sand dunes and features a number of deep rock pools (Ball and Blake 2007). Inside the Heads the intertidal reef is patchy along a sandy beach. The intertidal habitat in Point Nepean can be clearly divided into two regions, outside the Heads exposed to Bass Strait, and inside the Heads that is mostly beach protected from the ocean swell (Ball and Blake 2007). The intertidal environment outside the Heads is characterised by a wide expanse of low profile platform, backed by steep cliffs (Ball and Blake 2007). Inside the Heads it is mostly sand beach (Ball and Blake 2007). Both Point Lonsdale and Point Nepean intertidal rock platforms are dominated by the brown algae *Hormosira banksii* (Ball and Blake 2007). The gutters and rockpools on the edge of the intertidal platform in Point Lonsdale have seagrass *Amphibolis antarctica* and brown algae (Ball and Blake 2007). Point Nepean's intertidal rock pools have *A. antarctica*, green algae *Caulerpa* spp., crayweed *Phyllospora comosa* and mixed brown algae. The seaward edge of the intertidal platform in both Point Lonsdale and Point Nepean is bordered by bull kelp *Durvillaea potatorum* (Ball and Blake 2007).

In the MNP, Point Lonsdale's shallow subtidal reef (Figure 22) outside the Heads is low profile and becomes higher profile with depth (Ball and Blake 2007). Inside the Heads Lonsdale Bay subtidal reef is deeper (4 - 8 m, Figure 9) than in Nepean Bay (2 - 4 m, Figure 10) but has a similar, moderate level of exposure (Ball and Blake 2007; Edmunds *et al.* 2010c). Other habitats in Nepean Bay are < 7 m, except offshore from Observatory Point where it drops to 20 m (Ball and Blake 2007). Outside the Heads in the MNP, Point Lonsdale extends to depths < 10 m but Point Nepean extends to depths of up to approximately 20 m 1 – 2 km offshore (Ball and Blake 2007).

The subtidal reefs in Point Lonsdale have deep undercuts, highly eroded rock faces and unusual formations that have been shaped by the powerful movement of water through the narrow opening (Bird 1993; Edmunds *et al.* 2010c). Point Nepean has a complex mosaic of habitats (Figure 24), with considerable variation between the relatively sheltered Nepean Bay and the reef exposed to swell from Bass Strait outside the Heads (Ball and Blake 2007). Extensive areas of patchy broken reef and sand, with *A. antarctica* dominate the west of Nepean Bay (Ball and Blake 2007). The subtidal reef is predominantly low profile, but with some areas of high profile reef (Ball and Blake 2007). In the east, Nepean Bay is predominantly bare sediment, with a large area of patchy rubble offshore from Observatory Point (Ball and Blake 2007). In Nepean Bay on the seaward edge of the MNP and around the Point, the reef is high profile (Ball and Blake 2007). Outside the Heads the inshore reef off the intertidal platform is high profile and broken, with some low profile reef (Ball and Blake

2007). Further offshore in Point Nepean the reef is generally solid low profile with scattered patchy areas of broken high profile reef amongst sand (Ball and Blake 2007). Wide bands of sand running parallel to the shore can separate the inshore and offshore reef (Ball and Blake 2007). The reef is subject to periodic burial and exposure by sediment movement (Ball and Blake 2007). To the east there is high profile reef which becomes lower in profile with distance from shore before being replaced by an expanse of bare sandy sediment at depths of approximately 7 m (Ball and Blake 2007).

Point Lonsdale shallow subtidal reef (Figure 22) is dominated by a mixture of *P. comosa* and *Ecklonia radiata*, with *E. radiata* becoming more dominant with depth and on higher profile reef (Ball and Blake 2007). Stands of giant kelp *Macrocystis pyrifera* grow near Mushroom Rock (Ball and Blake 2007). Beds of *A. antarctica* and mixed algae grow down to 8 m in the exposed west of the MNP, but are more common in the shallow more sheltered areas inside the Heads in Lonsdale Bay (Ball and Blake 2007; Edmunds *et al.* 2010c). Inside the Heads in Nepean Bay (Figure 24) is dominated by monospecific beds of *A. antarctica* (Ball and Blake 2007). Extensive areas of *P. comosa* and *E. radiata* with mixed brown algae grow on the higher profile reef (Ball and Blake 2007). At the entrance to Port Phillip Bay the high profile reef is dominated by mixed brown and green algae. Outside the Heads the reef is dominated by brown algae including *D. potatorum*, *P. comosa* and *E. radiata* (Ball and Blake 2007). Small stands of *M. pyrifera* grow amongst high profile reef off the Point (Ball and Blake 2007). Offshore the reef has a mixture of red and brown algae (Ball and Blake 2007). Extensive *P. comosa* beds begin at a depth of approximately 5 m, with *E. radiata* also present amongst the *P. comosa* around 8 m (Ball and Blake 2007). At around 13 m, sparse *E. radiata* becomes the dominant biota type (Ball and Blake 2007). The east shallow subtidal reef is dominated by turf algae inshore (Ball and Blake 2007).

The moderately deep (14 - 17 m) subtidal reefs in the Point Nepean and Point Lonsdale sections of the MNP extend out from both Points either side of a deep vertically walled channel (Edmunds *et al.* 2009c). Lonsdale Wall (Figure 9), in the Point Lonsdale section of the MNP, is part of this channel and drops from 27 m to over 70 m (Edmunds *et al.* 2009a). Lonsdale Wall's southern reef is highly irregular, sloping and stepped down to 37 m in the form of vertical drop offs and steep slopes (Edmunds *et al.* 2004a; Edmunds *et al.* 2009c). The shallower (19 - 27 m) habitat of the northern Lonsdale Wall has not been surveyed (Edmunds *et al.* 2009c). The deeper reefs of Lonsdale Wall consist of ledges and steps 1 - 10 m high with rocky outcrops on the shelves interspersed by sand (Edmunds *et al.* 2009c). The toe of the slope is between 57 - 67 m, dominated by sediment, rubble and some sparse low rocky outcrops (Edmunds *et al.* 2009c). Lonsdale Wall's southern reef has a well developed kelp *E. radiata* community at 19 m, the deeper reef is dominated by sessile invertebrates predominately sponges (Edmunds *et al.* 2009c).

The Point Lonsdale section of the Port Phillip Heads MNP also includes part of the Port Phillip Bay entrance deep canyon marine community listed under the *FFG Act 1988*. This is one of only two FFG listed marine communities in Victoria and is dominated by sessile invertebrates, predominantly sponges, with ascidians, bryozoans, hydroids and corals. The biota is diverse in terms of the variety of sponges and other invertebrate forms present. The community occurs within a 100 metre deep submarine canyon at the entrance to Port Phillip Bay, in an unusual and spectacular physical setting. The deep canyon community is characterised and differentiated from other communities by its species composition and their relative abundance. The community has a relatively high cover of sponges (65 per cent on average), erect hydroids (*Nemertesia procumbens*, *Halopteris glutinosa*, *Halicornopsis elegans*), but relatively few gorgonian corals (*Pteronisis* spp.), and no thallose seaweeds and coralline algae or the sea whip coral *Primnoella australasiae* (SAC 2009).

Popes Eye (Figure 13 and 25) is a natural sand shoal formation of the Great Sands with a semicircular ring of large basalt blocks on top creating an artificial reef. The reef is approximately 200 m long by 15 m wide, dropping steeply to sand (Edmunds *et al.* 2010c). The reef does not have high relief in terms of structural complexity, such as large caves, ledges and bombies, but does have a lot of interstitial space, providing important habitat for the feather star *Comanthus trichoptera* and hulafish *Trachinops caudimaculatus* (Edmunds *et al.* 2010c). The reef is dominated by the kelp *E. radiata* and has a high predominance of the green algae *Cladophora prolifera* and *Caulerpa* species (Edmunds *et al.* 2010c).



Figure 25. Australian gannets *Morus serrator* roosting on the artificial basalt structure, the Annulus, at Popes Eye in Port Phillip Heads Marine National Park. Photo by Jonathon Stevenson, Parks Victoria.

Portsea Hole (Figure 14) is a remnant section of the Yarra River with calcarenite vertical reef (Bird 1993). Its moderately exposed, vertical and sloping reef is orientated east in a natural amphitheatre (Edmunds *et al.* 2004a). It consists of rocky ledges and outcrops on the western side of a sandy bowl or hole. At the top of the hole there is a largely flat area with very low steps (0.5 m) and a few rock bombies (Edmunds *et al.* 2009c). This area is covered by patches of sand and algae (Edmunds *et al.* 2009c). In the hole there is a narrow strip of vertical reef wall and ledges at 22 m depth, approximately 2 m high and 20 m long, which supports mostly sessile invertebrates (Edmunds *et al.* 2009c). There is also a small area of rocky outcrop at 27 m depth interspersed with sand (Edmunds *et al.* 2009c). On the wall algae grows on horizontal reef surfaces, and is limited by low light from the overhanging ledges (Edmunds *et al.* 2009c).

Mud Islands (Figure 17 and 26) are a low < 3 m high, dynamic formation of two, which were once three, sandy islands encircling a lagoon. They are a series of low, concentric sand dunes formed on an extensive sand shoal of the Great Sands and anchored by outcroppings of cemented shell beds (Menkhorst and Kerry 1988; Bird 1993). These islands are constantly under the effect of tidal and weather influences, having undergone changes in their position, size and orientation since the earliest historical survey in 1836 (Bird 1993).

The lagoon opens to PPB via two narrow entrances between the two islands (Ball *et al.* 2009). The surrounding waters of Mud Islands are shallow and at low tide extensive sand spits extend from the south and north-west shores (Menkhorst and Kerry 1988). Guano, largely from Australian pelican *Pelecanus conspicillatus* colonies, was mined between 1860 and about 1903 from the island (Menkhorst and Kerry 1988). The changes in coastal topography have influenced the location and size of seagrass *Heterozostera nigricaulis* habitat (Ball *et al.* 2009). Since 1984 this habitat has predominantly been located on the northern and eastern sides of the eastern island, and its inner lagoon, with seagrass *H. nigricaulis* cover being relatively stable at 41 - 54 % (Ball *et al.* 2009).

Swan Bay (Figure 18) is a shallow lagoon (< 3 m) with two constricted connections to PPB. 'The Cut' is a constructed channel that separates Queenscliff Harbour from Swan Island. Between Swan Island and Edward Point is a natural channel. Swan Bay's subtidal soft sediment is dark silty sand and clay, with shell grit and shell fragments (Ball *et al.* 2009; Yee and Roberts 2009). Beds of seagrass are extensive over the intertidal and subtidal flats with little bare sediment (Jenkins and Black 1994; Blake and Ball 2001; Ball and Heislars 2008; Hirst *et al.* 2009; Yee and Roberts 2009). The seagrass species in Swan Bay include *Heterozostera nigricaulis*, *Zostera muelleri*, *Halophila australis*, *Ruppia maritima*, *R. tuberosa*, *R. Polycarpa*, *Lepilaena marina*, and *L. cylindrocarpa* (Blake and Ball 2001; Ball *et al.* 2009). *H. australis* is found in deeper water around the Swan Bay Jetty area (Blake and Ball 2001). Seagrass cover in Swan Bay has remained stable at 94-100 % over the last dry decade (Ball *et al.* 2009). A decline to 77 % in the 1990s is thought to be related to climate and the effect of very wet years (Ball *et al.* 2009). The southern deeper end of Swan Bay and near the centre (Figure 18) tend to be more dominated by algae such as *Caulerpa* spp. and filamentous algae than seagrass (Blake and Ball 2001).



Figure 26. Mud Islands in Port Phillip Heads Marine National Park. Saltmarsh is visible fringing the lagoon. Photo by Mark Rodrigue, Parks Victoria.

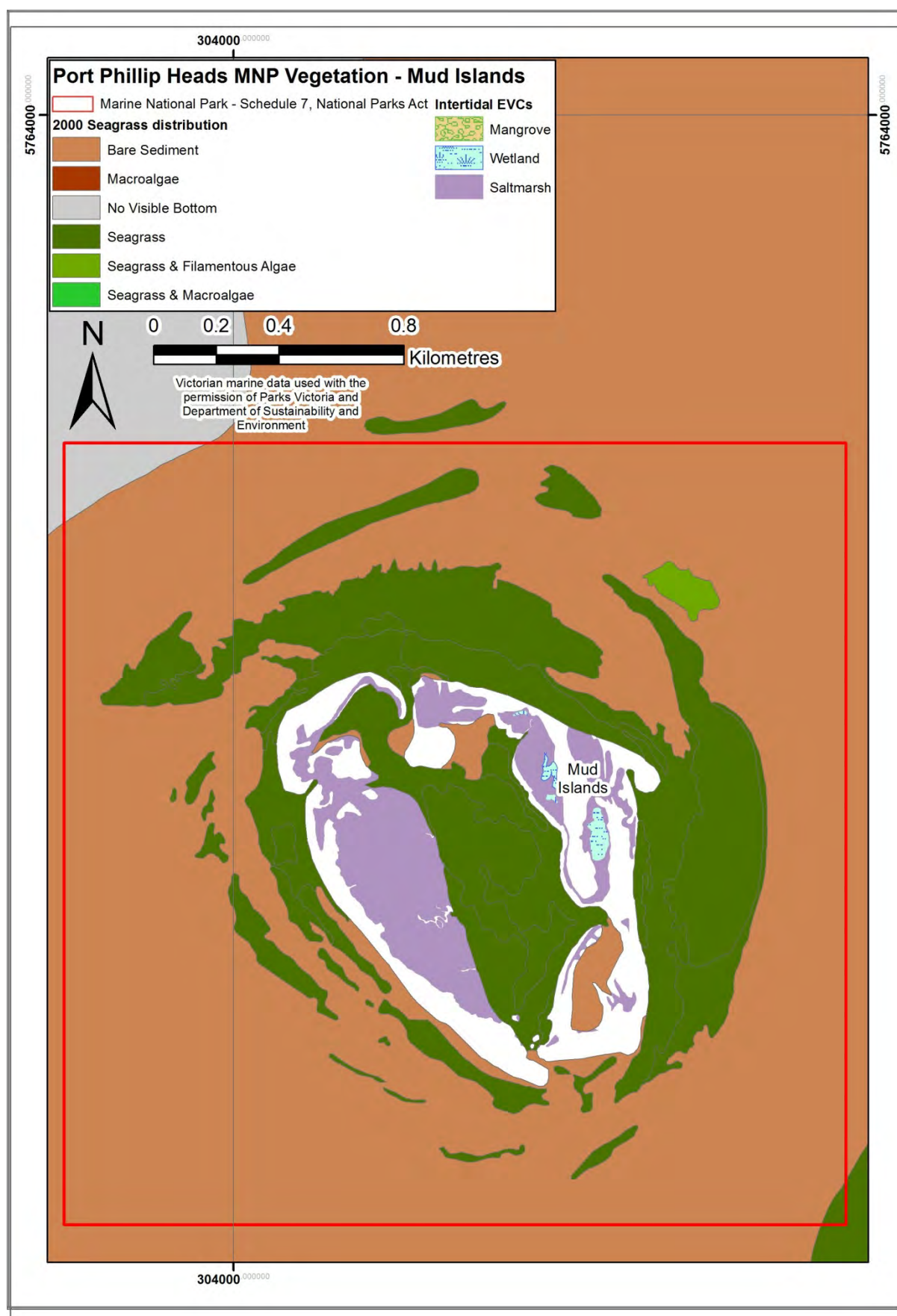


Figure 27. Vegetation map of Mud Islands - Port Phillip Heads Marine National Park.

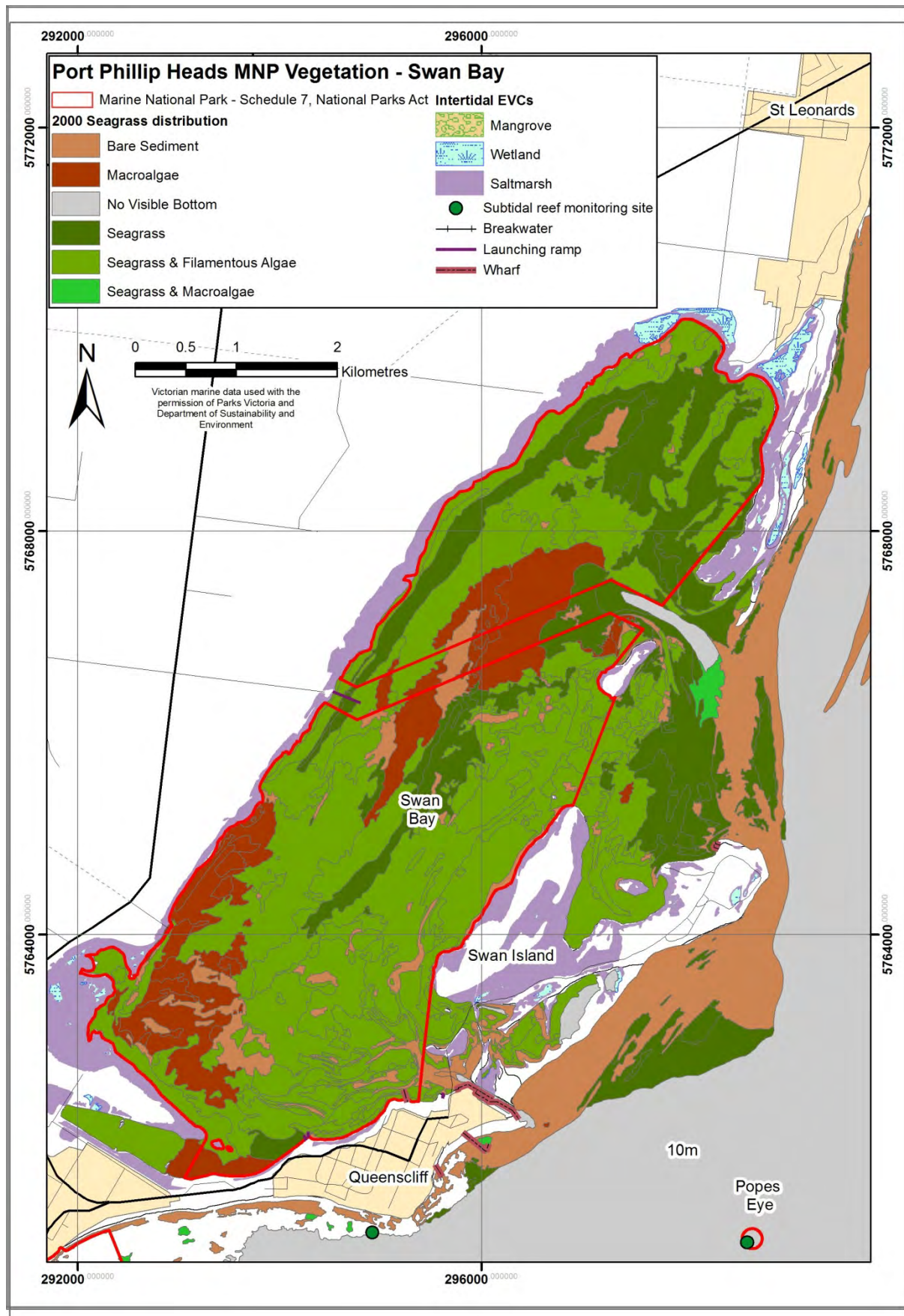


Figure 28. Vegetation map of Swan Bay - Port Phillip Heads Marine National Park.

2.1.3 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 Port Phillip Heads MNP. These include detailed bathymetric mapping of the MNP, and habitat mapping of Point Lonsdale and Point Nepean (Ball and Blake 2007). There have been more than six intertidal reef monitoring program (IRMP) surveys of the intertidal reef biota of Point Lonsdale, and thirteen subtidal reef monitoring program (SRMP) surveys of the subtidal reef biota of Point Lonsdale, Point Nepean and Popes Eye. DPI has been monitoring the seagrass beds in Mud Islands and Swan Bay (PoMC 2009). Saltmarsh and mangroves have been mapped statewide (Victorian Saltmarsh Study 2011). Red algae dominate the diversity of macrophytes, gastropods the invertebrates and birds the vertebrates in species recorded in Port Phillip Heads MNP (Table 3, Appendix 1). There have been no new surveys of the biota of subtidal bare soft sediments, or the pelagic habitats.

Table 3. Summary of the number of species in major biotic groups found in individual sections in Port Phillip Heads Marine National Park. Not specified indicates biota was recorded in the park but the individual section of the park wasn't specified.

Biotic group	Sections				Total
	Point Lonsdale	Point Nepean	Popes Eye	not specified	
Macrophytes	168	100	74	98	258
blue-green algae	1			1	2
green algae	23	19	13	14	36
brown algae	56	43	19	25	76
red algae	86	36	42	57	142
seagrasses	2	2		1	2
Invertebrates	26	0	0	60	68
cnidarians	2			3	4
polychaetes	1			1	1
barnacles				4	4
decapod crustaceans	1			4	5
chitons	0			7	7
gastropods	19			33	38
bivalves	2			4	4
sea slugs	1				1
echinoderms				3	3
ascidians				1	1
Vertebrates	50	54	47	125	199
fish	50	54	47	15	89
birds				100	100
reptiles				1	1
mammals				9	9

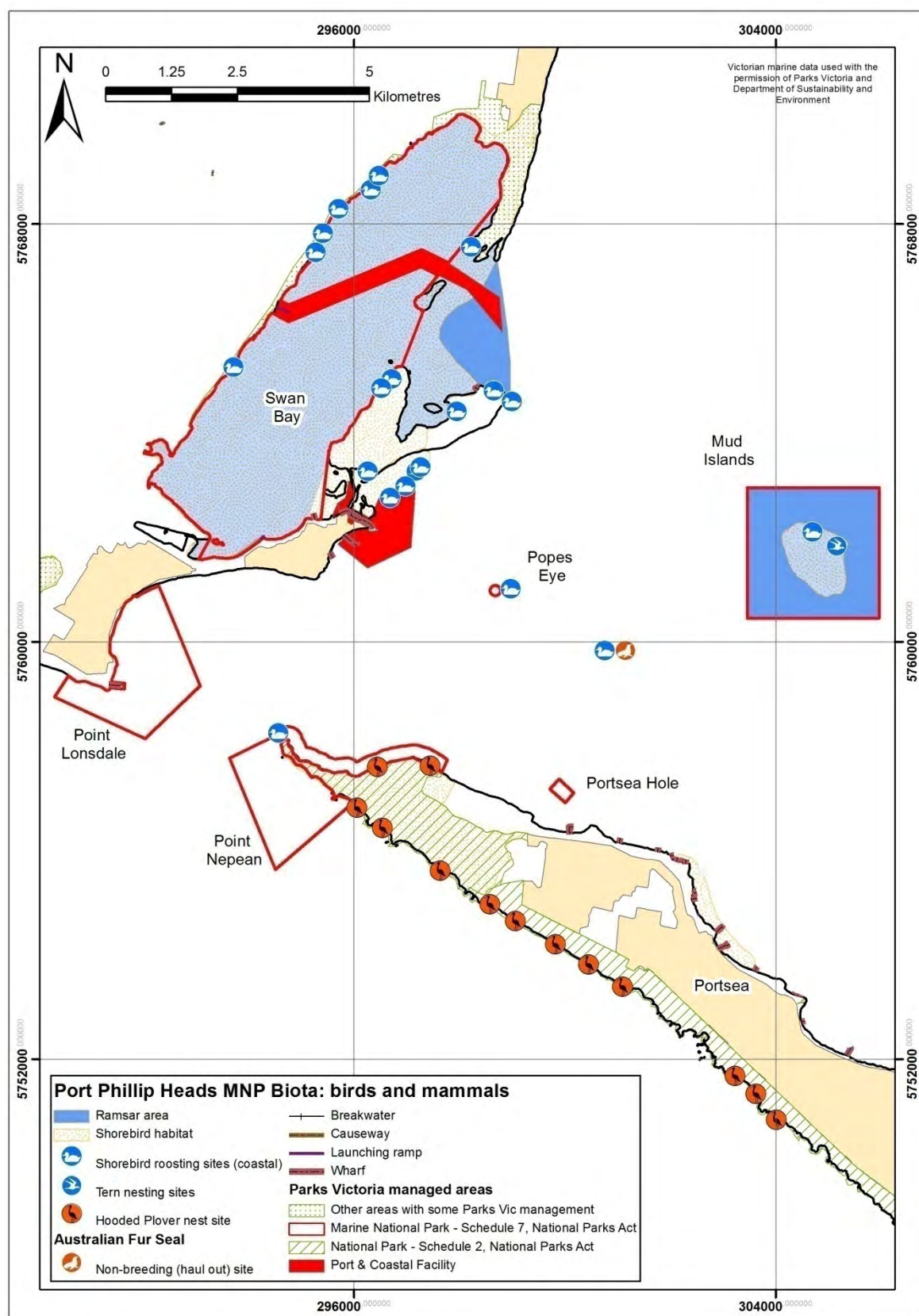


Figure 29. Sites of biotic significance in Port Phillip Heads Marine National Park and surrounds.

There are thirteen sites of biotic significance in Port Phillip Heads MNP, seven of which are in Swan Bay (Figure 29). There are two hooded plover *Thinornis rubricollis* nesting sites inside the Heads on the beaches at Nepean Bay and Observatory Point in Point Nepean (Figure 29). Outside the Heads and outside the MNP there are eleven nesting sites along the back beach of Point Nepean. Just outside the MNP off the tip of Point Nepean Corsair Rock is a minor bird roost. Popes Eye (Figure 29) is also a minor roost for cormorants and a breeding colony for Australian gannets *Morus serrator* (Green *et al.* 2009). Nearby Popes Eye and outside the MNP, Chinamans Hat is also a minor roosting site for cormorants and other diving birds.

Mud Islands has two sites of biotic significance, it is the second largest crested tern *Sterna bergii* nesting colony in Victoria (Figure 29). It is also a major roost site, the largest in PPB for waders with up to 5000 birds in summer and it is also used by Australian pelicans *Pelecanus conspicillatus*. Swan Bay has seven significant minor roosting sites for wader birds inside the MNP. There are six sites on the sandy shores of western Swan Bay and two on the eastern shore on Swan Island. Numbers of wading birds using these roosts peaks in summer. Nearby, outside the MNP there are seven significant roosting sites on the shore and surrounds of Swan Island and one off Edwards Point. The Point Lonsdale section of the MNP includes the Port Phillip Bay entrance deep canyon marine community, which is one of only two marine communities listed under the *FFG Act 1988*. The community is dominated by sessile invertebrates, predominantly sponges, with ascidians, bryozoans, hydroids and corals. The community is characterised and differentiated from other communities by its species composition and their relative abundance. There are no recognised sites of biotic significance in the Portsea Hole section of the MNP.

Intertidal

Soft sediment

Flora on intertidal sandy beaches is restricted to macroalgae drift and epiphytes. Beach-washed materials, or wrack, on sandy beaches 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. Intertidal mudflats are also an important soft-sediment habitat as feeding grounds for migratory shore birds and many fish species, and are also important for nutrient cycling because of the invertebrates that inhabit them. Intertidal seagrass filters and retains nutrients, stabilises sediments and baffles wave energy, protecting adjacent coastal shorelines from erosion. The fauna of the intertidal beach soft sediment habitat in Port Phillip Heads MNP has not been surveyed (Plummer *et al.* 2003).

Vegetation on the low-lying Mud Islands consists of saltmarsh and dune shrub land (Plummer *et al.* 2003). A total of 112 plant species have been recorded from the saltmarsh and surrounding dune systems (Plummer *et al.* 2003). Three dominant saltmarsh communities have been identified on Mud Islands: Wet Saltmarsh Scrubland (18 ha); Wet Saltmarsh Herbland (16 ha); and Coastal Tussock Saltmarsh (<1 ha) (Victorian Saltmarsh Study 2011). Within these communities a number of species are considered rare or threatened in Victoria (Plummer *et al.* 2003). Saltmarsh in Swan Bay is predominately outside the MS boundaries but contains communities of Wet Saltmarsh Scrubland; Wet Saltmarsh Herbland; Coastal Tussock Saltmarsh; Coastal Hypersaline Shrubland; Coastal Saltmarsh; and Estuarine Wetlands (Victorian Saltmarsh Study 2011). Species found within the MS include beaded glasswort *Sarcocornia quinqueflora*, creeping brookweed *Samolus repens* *Hemichroa pentandra* and grey glasswort *Halosarcia halocnemoides* (Plummer *et al.* 2003).

Intertidal seagrass, usually *Zostera muelleri*, is an important habitat in Port Phillip Heads MNP, particularly in Swan Bay and Mud Islands (Blake and Ball 2001; Hirst *et al.* 2009). In Swan Bay beds of seagrass are extensive over the intertidal flats (Jenkins and Black 1994;

Blake and Ball 2001; Ball and Heislars 2008; Hirst *et al.* 2009; Yee and Roberts 2009). The aquatic macrophyte *Lepilaena marina* is also present in the intertidal areas in Swan Bay and Mud Islands (Blake and Ball 2001; Hirst *et al.* 2009). Intertidal seagrass is usually shorter and has less epiphytic algae than the same species subtidally (Hirst *et al.* 2009). Wrack on the shore in Swan Bay can be considerable and cover the inshore seagrass beds (Hirst *et al.* 2009). The upper extent of intertidal seagrass moves over time, at Mud Islands it moved predominantly landward by up to seven metres between spring 2008 and summer 2009 (Hirst *et al.* 2009).

There have been very few surveys of the invertebrate fauna of unvegetated intertidal soft sediments in Swan Bay (Plummer *et al.* 2003; Figure 30). The communities are dominated by a few taxa of oligochaete and polychaete worms *Capitella* sp., bivalve *Mysella donaciformis*, gastropod *Salinator fragilis* and crane flies Tipulidae (Morris and Keough 2003). Infauna associated with intertidal seagrass beds in Swan Bay is also dominated by large numbers of relatively few species (Plummer *et al.* 2003). Corophiid amphipods and the amphipod *Allorchestes compressa* are the dominant crustacea, and the polychaete fauna is dominated by capitellids, the nereid *Ceratonereis pseudoerythraeensis* and the orbinid *Scoloplos cylindrifer* (Plummer *et al.* 2003). In the seagrass beds gastropod and bivalve molluscs, tanaids and epibenthic harpacticoids dominate the macrofauna (Plummer *et al.* 2003).



Figure 30. Seagrass beds exposed at low tide in Swan Bay, Port Phillip Heads Marine National Park. Photo by Don Love.

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, 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

One species of seagrass *Amphibolis antarctica*, and 29 species of algae, including 14 species of brown algae, are commonly found on the intertidal reefs of Port Phillip Heads MNP (Costa *et al.* 2010; O'Hara *et al.* 2010). Intensive surveys have found up to 118 species of algae on the intertidal reef (Plummer *et al.* 2003). The macroalgal community is dominated by the brown algae Neptune's necklace *Hormosira banksii* (Edmunds *et al.* 2010d; Figure 31). Other algae growing on the intertidal reef includes *Notheia anomala*, *Echinothamnion* sp., *Corallina officinalis*, algal turf, filamentous greens and *Sargassum* spp (Edmunds *et al.* 2010d). The ephemeral green algae *Ulva* spp. and *Enteromorpha* spp. occur as small patchily distributed tufts (Edmunds *et al.* 2010d).

Habitat forming sessile invertebrates include the tube worm *Galeolaria caespitosa* and two species of mussels, the beaked *Austromytilus rostratus* and the flea *Limnoperna pulex*, occur in low abundances on the intertidal reef (Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). Other sessile invertebrates include four species of barnacles *Chamaesipho tasmanica*, *Chthamalus antennatus*, *Tesseropora rosea* and *Tetraclitella purpurascens*, the ascidian *Pyura stolonifera*, and three anemones *Aulactinia veratra*, *Actinia tenebrosa* and *Oulactis muscosa* (Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010).



Figure 31. Intertidal reef dominated by Neptune's necklace *Hormosira banksii* at Point Lonsdale in Port Phillip Heads Marine National Park. Photo by Don Love.

Mobile invertebrates

Thirty species of mobile invertebrates (Figure 49), including 29 species of molluscs, have been found on the intertidal reefs of Port Phillip Heads MNP (Costa *et al.* 2010; O'Hara *et al.* 2010). Point Lonsdale intertidal reefs have moderate levels of invertebrate species richness compared to other central Victorian reefs and relatively high levels of species diversity (Edmunds *et al.* 2010d). The slit limpet *Clypidina rugosa* is the most common species although its abundance is variable (Edmunds *et al.* 2010d). The variegated limpet *Cellana tramoserica* is also relatively common, as is the striped conniwink *Bembicium nanum* (Edmunds *et al.* 2010d). Other common molluscs include the false limpet *Siphonaria* spp, ribbed top shell *Austrocochlea constricta*, tall ribbed limpet *Patelloida alticostata* and warrener *Turbo undulatus* (Edmunds *et al.* 2010d). Less common species include the carnivorous gastropods the wine-mouthed lepsiella *Lepsiella vinosa* and lineated cominella *Cominella lineolata* (Edmunds *et al.* 2010d). The small black periwinkle *Nodilittorina acutispira* can be very abundant on the intertidal reef, but its abundance varies immensely (Edmunds *et al.* 2010d). There is a distinct pattern of recruitment of gastropods in PPB, with a separation of the populations in the south and north of PPB (Bathgate 2010). The gastropods with a short planktonic period do not have a large dispersal distance and tend to recruit locally (Bathgate 2010).

Fish

Fish have been described as abundant in the rockpools outside the Heads in Point Nepean and include blennies, gobies, juvenile wrasse, leatherjackets and old wives (Plummer *et al.* 2003).

Subtidal

Soft sediment

Seagrasses are highly productive ecosystems, providing food and shelter for diverse faunal communities, many of commercial importance. Seagrass plants filter and retain nutrients, stabilise sediments and baffle wave energy, protecting adjacent coastal shorelines from erosion. Seagrass meadows provide food for benthic fauna and scavenger communities living in the mudflats and these in turn provide food for fish, crustaceans and birds. Some animals feed directly on the seagrass, such as black swans *Cygnus atratus*, while others graze on epiphytes or seagrass detritus. Seagrass meadows provide habitat for fish, and they can play an important role as nursery areas for the juvenile stages of certain species. The larval stages of some fish species settle directly into subtidal *Heterozostera nigricaulis* beds (Blake and Ball 2001). The biomass and abundance of fish can be greater in subtidal seagrass habitats than in unvegetated subtidal habitats (Blake and Ball 2001).

Seagrass is an important habitat in Port Phillip Heads MNP, particularly on the soft subtidal sediments in Mud Islands and Swan Bay. In Mud Islands *H. nigricaulis* (Figure 32) grows in the lagoon and on the seaward edges of the islands in waters up to 8 m deep (Hutchinson *et al.* 2011). The seagrass beds around Mud Islands are very large and persistent through time compared with elsewhere in the southern region of PPB (Hutchinson *et al.* 2011). Epiphyte coverage can be quite high on the seagrass in Mud Islands (Hirst *et al.* 2009). Turfing algae can cover > 40 % of leaf area at Mud Islands, encrusting algae epiphytes can cover > 20 % in shallow beds and > 30 % in deeper waters (Hirst *et al.* 2009). In Swan Bay beds of seagrass are extensive over the subtidal flats (Jenkins and Black 1994; Blake and Ball 2001; Ball and Heislars 2008; Hirst *et al.* 2009; Yee and Roberts 2009). The seagrass species in Swan Bay include *H. nigricaulis*, *Zostera muelleri*, *Halophila australis*, *Ruppia maritima*, *R. tuberosa*, *R. polycarpa* *Lepilaena marina*, and *L. cylindrocarpa* (Blake and Ball 2001; Edmunds *et al.* 2004a; Ball *et al.* 2009; Hirst *et al.* 2009). *H. australis* is found in deeper water around the Swan Bay Jetty area (Blake and Ball 2001). The southern deeper end of Swan Bay and near the centre tend to be more dominated by algae such as *Caulerpa* spp. and filamentous algae than seagrass (Blake and Ball 2001). Encrusting algal epiphytes are less abundant (> 5 %) in Swan Bay subtidal seagrass beds (Hirst *et al.* 2009). Epiphytic

macroalgal cover in the shallow subtidal seagrass beds can be up to > 70 % in Swan Bay but < 5 % of the bed at Mud Islands (Hirst *et al.* 2009).

The *H. nigricaulis* habitat in Mud Islands supports at least twenty-seven species of finfish and one species of squid (Hutchinson *et al.* 2011). Fish are generally more abundant in the shallow (< 1 m) seagrass beds than in the deeper (2 - 8 m) beds (Hutchinson *et al.* 2011). In the shallow beds, smallmouth hardyheads *Atherinosoma microstoma* and hardyhead recruits *Atherinidae* spp. are the most abundant fish species (Hutchinson *et al.* 2011). Also abundant are the wide-body pipefish *Stimatorpora nigra*, bridled leatherjacket *Acanthaluteres spilomelanurus*, little rock whiting *Neoodax balteatus*, blue sprat *Sparatelloides robustus* and spotted pipefish *S. argus*. In the deeper seagrass beds the most abundant fish is the wide-body pipefish *S. nigra*. Also abundant are leatherjackets, including the bridled *A. spilomelanurus*, toothbrush *A. vittiger* and pygmy *Brachaluteres jacksonianus* along with the little rock whiting *Neoodax balteatus* (Hutchinson *et al.* 2011). The Australian giant cuttlefish *Sepia apama* has been found in the deeper beds of *H. nigricaulis* (Hutchinson *et al.* 2011). Red mullet *Upeneichthys vlamingii*, little gurnard perch *Maxillcosta scabriceps* and yank flathead *Platycephalus speculator* are also found in the deeper beds (Hutchinson *et al.* 2011). The seagrass assemblages in Swan Bay tend to be dominated by large numbers of the spotted pipefish *Stigmatopora argus* with other species of pipefish such as *Vanacampus phillipi* also well represented. Other dominant species include the hardyhead *Leptatherina presbyteroides*, the bridled leather jacket *Acanthaluteres spilomelanurus*, the spot-shoulder weed fish *Heteroclinus perspicillatus* and the cobbler *Gymnapistes marmoratus* (Plummer *et al.* 2003). A number of commercially important species, rough leatherjacket *Scobinichthys granulatus*, six-spined leatherjacket *Meuschenia freycineti*, and King George whiting *Sillaginodes punctatus*, settle directly into subtidal *H. nigricaulis* beds (Blake and Ball 2001; Plummer *et al.* 2003).

Skates, rays and stingarees are particularly common on the sand beds in the MNP (Edmunds *et al.* 2009b). Species found include the eagle ray *Myliobatis australis*, smooth stingray *Dasyatis brevicaudata*, banjo ray *Trygonorrhina fasciata*, southern fiddler ray *T. guaneria*, sparsely spotted stingaree *Urolophus paucimaculatus* and spotted stingaree *U. gigas* (Edmunds *et al.* 2009b).



Figure 32. Seagrass *Heterozostera nigricaulis* beds at Mud Islands in Port Phillip Bay 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 (Figure 35) and sessile invertebrates can form habitat and food sources for invertebrates and fish. Shallow subtidal reefs are known for their high biological complexity, such as species diversity and productivity; and 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 relatively sheltered reef at Popes Eye is dominated by the kelp *E. radiata* (Figure 33) and has a high predominance of the green algae *C. prolifera* and *Caulerpa* species (Edmunds *et al.* 2010c). *E. radiata* is particularly abundant and can cover around 60 % of the reef (Edmunds *et al.* 2009b). The reef has open patches of turfing red algae that are maintained by the scalyfin *Parma victoriae* and used as important feeding areas for other fish (Edmunds *et al.* 2009b). *P. comosa* (Figure 34), which dominates the more exposed Point Lonsdale and Point Nepean reefs is not recorded at Popes Eye (Edmunds *et al.* 2009b). Likewise, the brown algae *C. moniliformis* that grows on the more sheltered reefs inside the Heads at Point Lonsdale and Point Franklin is not recorded at Popes Eye (Edmunds *et al.* 2009b). Popes Eye has a moderate abundance of red algal species (Edmunds *et al.* 2010c). The abundance of the brown algae *E. radiata* has remained relatively steady in Popes Eye but has decreased in comparable habitat at South Channel fort (Keough and Carnell 2009; Edmunds *et al.* 2010c).

Giant kelp *Macrocystis pyrifera* was once present in relatively high abundance in the Port Phillip Heads region, particularly off Lonsdale Point and in Lonsdale Bay, where it covered most of the middle reef (Edmunds *et al.* 2009b; Keough and Carnell 2009). *M. pyrifera* has previously formed small stands at Popes Eye, although it is currently present in very low abundance (Edmunds *et al.* 2010c). Abundances of *M. pyrifera* in Victoria have decreased considerably for much of the past two decades (Edmunds *et al.* 2009b).

The tops of the rocky banks of Lonsdale Wall, are covered by an *E. radiata* kelp bed (Edmunds 2007). These intermediate depth (19 m) kelp beds are different in community composition to shallower *Ecklonia* kelp beds in the region, having lower abundances of understory algae (Edmunds 2007). The kelp beds generally extend to the edge of the canyon (Edmunds 2007). There are small isolated stands of kelp on horizontal shelves of reef to depths of approximately 27 m (Edmunds 2007). The rocky top of Nepean Banks in the MNP is also covered by a bed of kelp *E. radiata* (Edmunds 2007).



Figure 33. Subtidal reef dominated by kelp *Ecklonia radiata* at Point Nepean in Port Phillip Heads Marine National Park.

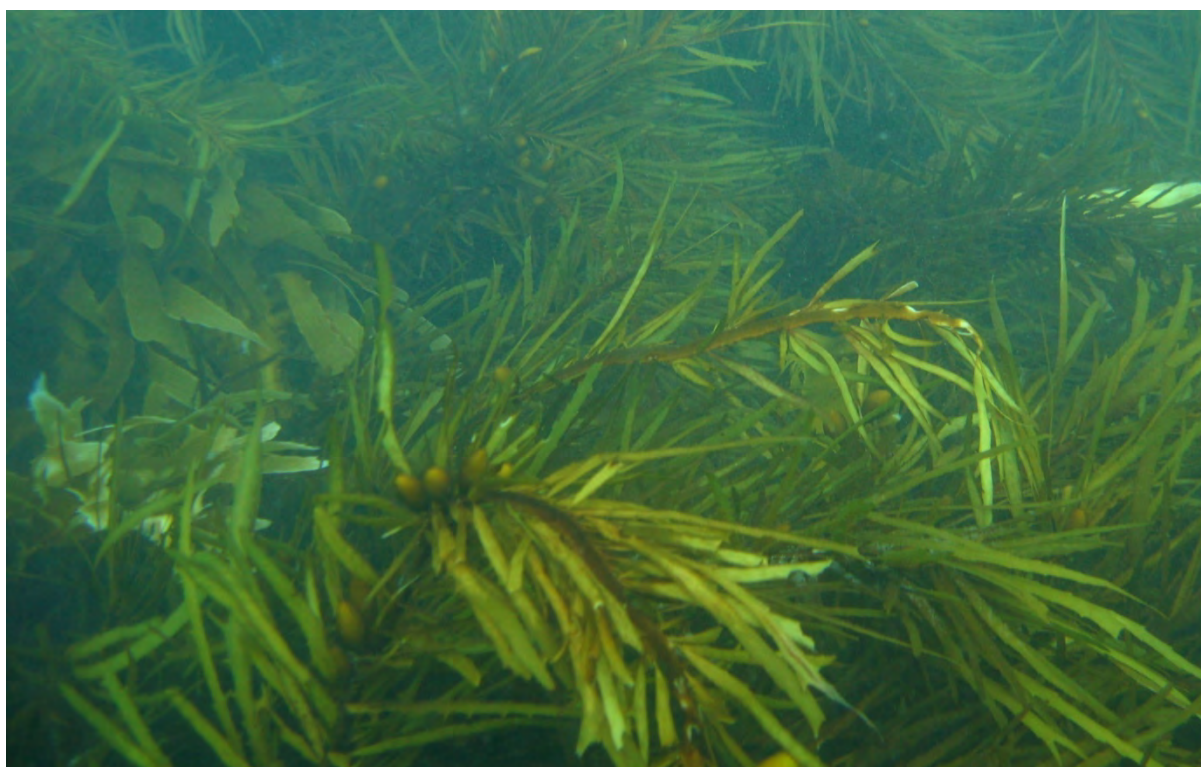


Figure 34. Subtidal reef dominated by crayweed *Phyllospora comosa* in Port Phillip Heads Marine National Park. Photo by AME.

Seaweeds provide important habitat structure for other organisms on shallow subtidal reefs. This habitat structure varies considerably, depending on the type of seaweed species present. Around 20 - 50 species of macroalgae are found on the shallow subtidal reefs of Port Phillip Heads MNP (Edmunds *et al.* 2010c). Point Nepean reefs (Table 7) provide habitat for some rare species of algae (Edmunds *et al.* 2009b).

There are four general groups of subtidal reef macroalgal communities corresponding with four subtidal reef groupings in Port Phillip Heads MNP: outside the Heads; inside the Heads at Point Lonsdale in Lonsdale Bay; inside the Heads in Point Nepean in Nepean Bay; and well inside the Heads at Popes Eye (Edmunds *et al.* 2010c). These groupings correspond with differences in wave exposure and depth (Edmunds *et al.* 2010c). The exposed reefs outside the Heads and the relatively sheltered reefs at Popes Eye have very different macroalgal communities, with intermediate communities inside the Heads at Point Lonsdale and Point Nepean (Edmunds *et al.* 2010c). The community structure on the reefs outside the Heads is fairly stable temporally and spatially, and there is greater variation between reefs in Lonsdale Bay compared to Nepean Bay (Edmunds *et al.* 2010c).

Outside the Heads in Point Lonsdale, the reefs have a *Phyllospora comosa* dominated canopy (Ball and Blake 2007; Edmunds *et al.* 2010c). Understorey species include *Haliptilon roseum*, *Phacelocarpus peperocarpus*, *Pterocladia lucida*, *Ballia callitricha* and *Areschougia congesta*. In the MNP red algae are relatively low in abundance compared to the larger green *Caulerpa* species and brown algae, and have considerably greater temporal variation (Edmunds *et al.* 2009b). Red algae is more persistent on reefs outside the Heads than inside (Edmunds *et al.* 2009b). A small patch of *A. antarctica* grows offshore from the Surf Life Saving Club (Ball and Blake 2007; Edmunds *et al.* 2010c). The green algae *Cladophora prolifera* is not recorded at any of the exposed reefs outside of the Heads (Edmunds *et al.* 2009b). Outside of the Heads on the low relief reef of Point Nepean *E. radiata* stands form dense canopy interspersed by smaller thallose algae, including *Caulerpa flexilis*, *Plocamium angustum*, *Melanthalia obtusata* and *P. peperocarpus* (Edmunds *et al.* 2004a; Ball and Blake 2007).

Inside the Heads in Point Lonsdale, the predominant cover on the inshore reef at Victory Shoal is *E. radiata* (Edmunds *et al.* 2010c). Other dominant species include *C. prolifera*, *Cystophora moniliformis*, *Seirococcus axillaris* and *P. comosa*. *A. antarctica* forms substantial beds further offshore in the middle of Lonsdale Bay (Edmunds *et al.* 2010c). The algal communities on the reef at the more southern sites in Lonsdale Bay are dominated by *P. comosa*, with *E. radiata* also contributing a considerable portion of the canopy (Ball and Blake 2007; Edmunds *et al.* 2010c). These reefs have a relatively low cover of red algal understorey species, which includes *B. callitricha*, *A. congesta*, *P. peperocarpus* and *Plocamium* spp (Edmunds *et al.* 2010c). In Lonsdale Bay *C. prolifera* is usually present, but its abundance is highly variable through time (Edmunds *et al.* 2009b). The common kelp *E. radiata* abundance appears to be seasonally variable on the deeper reef in Lonsdale Bay (Edmunds *et al.* 2009b). Small patches of *E. radiata* dieback, a disease that causes necrosis of the blade and laterals fronds back to the stipe, has been observed in recent years on these reefs in the MNP (Edmunds *et al.* 2009b). Large areas of *E. radiata* dieback have been observed off Point Franklin north-east of the MNP (Edmunds *et al.* 2009b).

Inside the Heads in Point Nepean the reef of Nepean Bay is dominated by large monospecific stands of the seagrass *A. antarctica* and patches of mixed brown algal species (Edmunds *et al.* 2010c). Beds of *A. antarctica* are not just restricted to low reef flats but grow well up the sides of reef slopes. The brown algae generally includes *E. radiata*, *P. comosa*, *Cystophora moniliformis* and *Cystophora retorta* (Edmunds *et al.* 2010c). The green alga *Cladophora prolifera* is usually present in Nepean Bay, but in low abundances (Edmunds *et al.* 2009b).



Figure 35. Macroalgae commonly observed on the subtidal reefs in Port Phillip Heads Marine National Park: a) *Haliptilon roseum*; b) *Seirococcus axillaris*; c) *Melanthalia obtusata*; d) *Caulerpa flexilis*; e) *Plocamium preissianum*; and f) *Cystophora retorta*. Photos by AME.



Figure 36. The biscuit star *Tosia australis* is one of the most abundant seastars on subtidal reefs in Port Phillip Heads Marine National Park. Photo by AME.

Invertebrate fauna

There are substantial differences in shallow subtidal reef invertebrate fauna (Figure 37) community structure between locations within the Heads, as species and communities appear to be dependent, to some degree, on particular environmental conditions and habitats (Edmunds 2007). Over 150 species of opisthobranch molluscs (colourful sea slugs) have been observed within Point Lonsdale and this area is a type locality for many marine species (Edmunds *et al.* 2009b). Point Nepean provides habitat for some rare species of molluscs (Edmunds *et al.* 2009b). Mobile invertebrate species numbers range from 5 - 15 species on the subtidal reefs of Port Phillip Heads MNP (Edmunds *et al.* 2010c).

As observed with macroalgae communities, there are four general groups of invertebrate communities, corresponding to the four site groupings: outside the Heads; inside the Heads at Point Lonsdale in Lonsdale Bay; inside the Heads in Nepean Bay; and well inside the Heads at Popes Eye (Edmunds *et al.* 2010c). The invertebrate community can be very variable through time especially inside the Heads in Point Lonsdale and Point Nepean (Edmunds *et al.* 2010c). The biscuit star *Tosia australis* (Figure 36) is the most abundant seastar on all the reefs in Port Phillip Heads, although its numbers can be very variable (Edmunds *et al.* 2010c).

Blacklip abalone *Haliotis rubra* are abundant on the exposed reef of Point Lonsdale outside the Heads and Merlan Reef in Lonsdale Bay (Edmunds *et al.* 2009b). They are less abundant on the more protected reef inside the Heads in Lonsdale Bay (Edmunds *et al.* 2009b). Greenlip abalone *H. laevis* are not as common as blacklip abalone *H. rubra* and are found on the inshore shallow reefs of Lonsdale Bay (Edmunds *et al.* 2009b). Inside the Heads in Point Lonsdale the warrener *Turbo undulatus* and the seastar *Nectria ocellata* are common (Edmunds *et al.* 2010c). Reefs both outside and inside the Heads at Point Lonsdale have low abundances of purple sea urchin *Heliocidaris erythrogramma* and feather star *Comanthus trichoptera* (Edmunds *et al.* 2009b).



Figure 37. Invertebrate fauna on the subtidal reefs of Port Phillip Heads Marine National Park: a) *Haliotis rubra* b) *Haliotis laevigata* c) *Nectria ocellata* and d) *Uniophora granifera*; e) *Heliocidaris erythrogamma*; and f) *Comanthus trichoptera*. Photos by AME.

Inside the Heads in Nepean Bay, the shallow subtidal reefs are characterised by having moderate abundances of both blacklip *H. rubra* and greenlip abalone *H. laevigata* (Edmunds *et al.* 2010c). The molluscs, warrener *T. undulatus* and cartrut shell *Dicathais orbita*, and feather star *C. trichoptera* are abundant along with moderate abundances of the purple sea urchin *H. erythrogramma* (Edmunds *et al.* 2010c). The biscuit star *T. australis* is not common on the inshore reefs in west Nepean Bay (Edmunds *et al.* 2009b).

Popes Eye has high abundances of the featherstar *C. trichoptera*, low abundances of blacklip abalone *H. rubra*, and moderate to high abundances of the purple sea urchin *H. erythrogramma* (Edmunds *et al.* 2010c). The biscuit star *T. australis* is also common (Edmunds *et al.* 2009b). The spaces in the basalt blocks of the reef provide important habitat for feather star *C. trichoptera* and *Trachinops* sp. (Edmunds *et al.* 2010c). Blacklip abalone *H. rubra* abundance is increasing at Popes Eye (Keough and Carnell 2009; Edmunds *et al.* 2010c). No greenlip abalone *H. laevigata* have been recorded at Popes Eye (Edmunds *et al.* 2009b). The warrener *T. undulatus*, which is common in Point Lonsdale and Point Nepean, has not been recorded in Popes Eye (Edmunds *et al.* 2009b).

The deep subtidal sessile invertebrate reef community of north Lonsdale Wall northern has one of the greatest species diversity in the Heads (Edmunds 2007). The intermediate depth (19 m) kelp *E. radiata* beds at Lonsdale Wall are different in community composition to shallower *E. radiata* kelp beds in the region, having a much lower abundance and diversity of mobile invertebrates, particularly seastars (Edmunds 2007). Lonsdale Wall's vertical reef has a high abundance and diversity of sessile invertebrates, especially arborescent, encrusting and flabellate sponges, and gorgonian corals (Edmunds *et al.* 2004a; Edmunds 2007). There have been over 271 species of sponges collected from the Heads, which is a substantial proportion of the known species from Victoria and Australia (Edmunds 2007). At least 115 of the sponge species are endemic to the Heads (Edmunds 2007). PPB is also considered to be a place of high bryozoan diversity and is particularly rich in hydroid fauna (Edmunds 2007; Figure 50). The Heads are the type locality for three ascidian species, one of which is endemic (Edmunds 2007). The deep subtidal reef sessile invertebrate communities at the Heads include a suite of species that commonly occur throughout southern Australia (Edmunds 2007). These include distinctive species such as the hydroids *Solanderia fusca*, *Nemertesia procumbens* and *Gymnangium superbum*, jewel anemone *Corynactis australis* and the bryozoan *Orthoscuticella ventricosa* (Edmunds 2007).

The sessile invertebrate communities (Figure 38) of the Heads are quite distinct from comparable deep water reefs in Point Addis and Wilsons Promontory (Edmunds 2007). The most abundant hydroids at the Heads, *N. procumbens* and the feathery red hydroid *Halopteris glutinosa* are not found in comparable habitat in Wilson Promontory (Edmunds 2007). The Heads have less algae and lower abundance of gorgonian coral fans *Pteronisia* sp, and no sea whips *Primnoella australasiae* compared to Wilsons Promontory (Edmunds 2007). Sponge (Figures 39 and 40) coverage is 65 % at the Heads, compared to 10 % at Wilsons Promontory and 15 - 26 % at Point Addis (Edmunds 2007). The bryozoan colonies in the Heads are typically bushy arborescent species compared to a dominance of erect crustose species in Point Addis Heads (Edmunds 2007). Deep reef surveys at The Arches MS and Twelve Apostles MNP found new types of deep subtidal reef communities, which had some affinities to those at Point Addis but none with those in the Heads (Edmunds *et al.* 2010b).

Vertical sections of the Portsea Hole support a high abundance and diversity of sessile invertebrates, including sixteen different types of sponges such as arborescent, flabellate, encrusting and massive sponges (Edmunds *et al.* 2004a). Massive ruffled sponges can be particularly abundant on the reef (Edmunds *et al.* 2009c). Over four years it was observed that the relative dominance of sponges can change over time with a decrease in reticulated sponge *Holopsamma laminaefavosa*, and a corresponding increase in thallose red algae,

kelp *Ecklonia radiata*, encrusting ruffled grey sponge, and other ruffled sponges (Edmunds *et al.* 2009c). Other sessile invertebrate fauna includes bryozoans such as *O. ventricosa*, and ascidians *Herdmania momus* and *Ritterella pedunculata* (Edmunds *et al.* 2009c).



Figure 38. Sessile invertebrate fauna of the deep subtidal reefs in Port Phillip Heads Marine National Park: a) *Gymnangium superbum*; b) *Herdmania grandis*; c) *Orthoscuticella ventricosa*; d) *Ritterella pedunculata*; e) *Reteporella granulata*; and f) *Carijoa* sp. Photos by AME.



Figure 39. Sponges on subtidal reef at Popes Eye in Port Phillip Heads Marine National Park. Photos by AME.



Figure 40. Reticulated sponge *Holopsamma laminaefavosa* in Port Phillip Heads Marine National Park. Photo by AME.

Fish

Over 71 species of fish are found on the shallow subtidal reefs of Port Phillip Heads MNP (Edmunds *et al.* 2009b; *e.g.* Figures 41, 42, 46, 47 and 48). There is a less distinct grouping of shallow subtidal reef fish communities than for both the macroalgae and invertebrate communities in Port Phillip Heads MNP (Edmunds *et al.* 2009b). Inside the Heads both Lonsdale Bay and Nepean Bay have a relatively low abundance of fishes and the community structure is very variable over time (Edmunds *et al.* 2009b; Keough and Carnell 2009). Outside the Heads the fish communities of these exposed sites are less variable (Edmunds *et al.* 2009b).

Outside the Heads in Point Lonsdale, shallow subtidal reefs have abundant scalyfin *Parma victoriae* and senator wrasse *Pictilabrus laticlavius*. Also on the reef are herring cale *Odax cyanomelas*, blue-throated wrasse *Notolabrus tetricus* and the horseshoe leatherjacket *Meuschenia hippocrepis* (Edmunds *et al.* 2009b). The fish communities inside the Heads in Point Lonsdale and Point Nepean are similar, except for a lower abundance of scalyfin *P. victoriae* and senator wrasse *P. laticlavius*. Point Lonsdale also has a higher abundance of zebra fish *Girella zebra* and magpie perch *Cheilodactylus nigripes* than Point Nepean (Edmunds *et al.* 2009b).

Popes Eye has a fish community that is distinct from elsewhere in the MNP (Edmunds *et al.* 2009b). Fishing has been banned from Popes Eye since 1976 and the reef has higher species richness, as well as abundance of fish including larger fish than elsewhere in southern PPB (Edmunds *et al.* 2009b; Keough and Carnell 2009). It has a distinct community of fishes that shows little temporal variation (Edmunds *et al.* 2009b; Keough and

Carnell 2009). Blue-throated wrasse *N. tetricus*, scalyfin *P. victoriae*, purple wrasse *N. fucicola*, magpie perch *C. nigripes*, horseshoe leatherjacket *M. hippocrepis* and herring cale *O. cyanomelas* are abundant in Popes Eye (Edmunds *et al.* 2009b). Several species, including sea sweep *Scorpius aequipinnis* and rosy wrasse *Pseudolabrus psittaculus* are rarely observed elsewhere in the MNP other than at Popes Eye (Edmunds *et al.* 2009b). Barber perch *Caesioperca razor* and southern hulafish *Trachinops caudimaculatus* are common at Popes Eye, but not common elsewhere in the MNP (Edmunds *et al.* 2009b). The interstitial spaces in the basalt blocks of the reef, provide important habitat for *T. caudimaculatus* (Edmunds *et al.* 2010c). Scalyfin *P. victoriae* maintains open turfing red algal patches that are used as important feeding areas for magpie perch *C. nigripes*, banded morwong *Cheilodactylus spectabilis* and marblefish *Aplodactylus arctidens* (Edmunds *et al.* 2009b; Figure 43). Blue-throated wrasse *N. tetricus* at Popes Eye is more abundant and has a higher proportion of large fish than elsewhere in the MNP (Edmunds *et al.* 2009b). The large fish are males, as *N. tetricus* is a protogynous hermaphrodite, with all juveniles and smaller adults being females. A few larger, dominant females change sex to males, and guard their harem of females against intrusion by other males (Edmunds *et al.* 2009b). Popes Eye diversity is dominated by a high abundance of a few species, particularly hula fish *T. caudimaculatus*, scalyfin *P. victoriae* and blue-throated wrasse *N. tetricus* (Edmunds *et al.* 2009b).

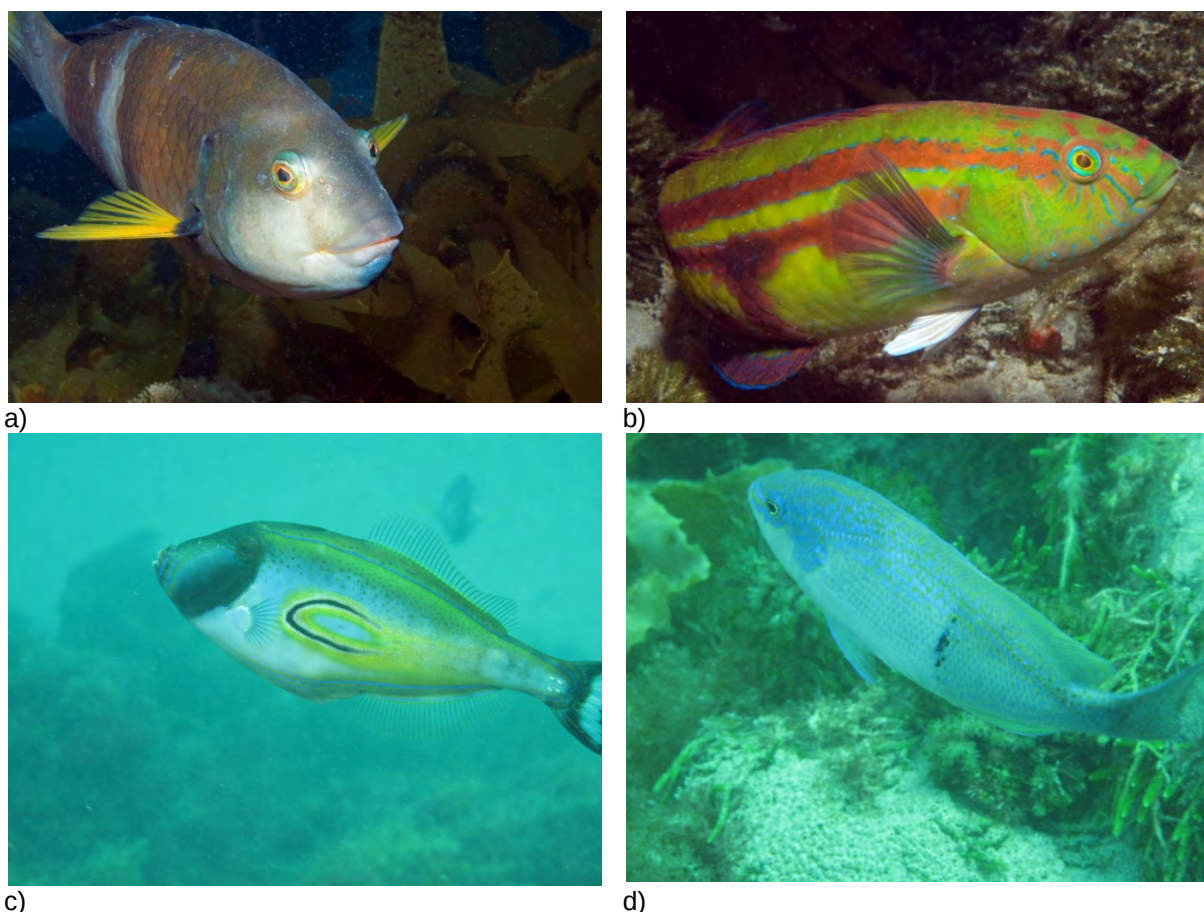


Figure 41. Subtidal reef fish at Popes Eye: a) *Notolabrus tetricus*; b) *Pictilabrus laticlavius*; c) *Meuschenia hippocrepis*; and d) *Caesioperca razor*. Photos a & b by Julian Finn Museum of Victoria, c & d by AME.

Deep subtidal reef in Lonsdale Wall has a diverse fish community dominated by barber perch *C. razor*, southern hulafish *T. caudimaculatus* and rosy wrasse *P. psittaculus* (Edmunds *et al.* 2004a). The intermediate depth (19 m) kelp beds at the top of Lonsdale Wall have a different fish community to shallower *Ecklonia* kelp beds in the region (Edmunds 2007). Portsea Hole has a high abundance and diversity of fish species including barber perch *C. razor*, southern hulafish *T. caudimaculatus*, silver sweep *Scorpiis lineolata* and Australian mado *Atypichthys strigatus* (Edmunds *et al.* 2004a). Other commonly seen fish species include the blue devil fish *Paraplesiops meleagris*, butterfly perch *Caesioperca lepidoptera*, jackass morwong *Nemadactylus macropterus*, gurnards Triglidae and goat fish Mullidae (Plummer *et al.* 2003).



Figure 42. Old wife *Enoplosus armatus* over subtidal reef in Port Phillip Heads Marine National Park. Photo by Julian Finn, Museum Victoria.

Water column

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

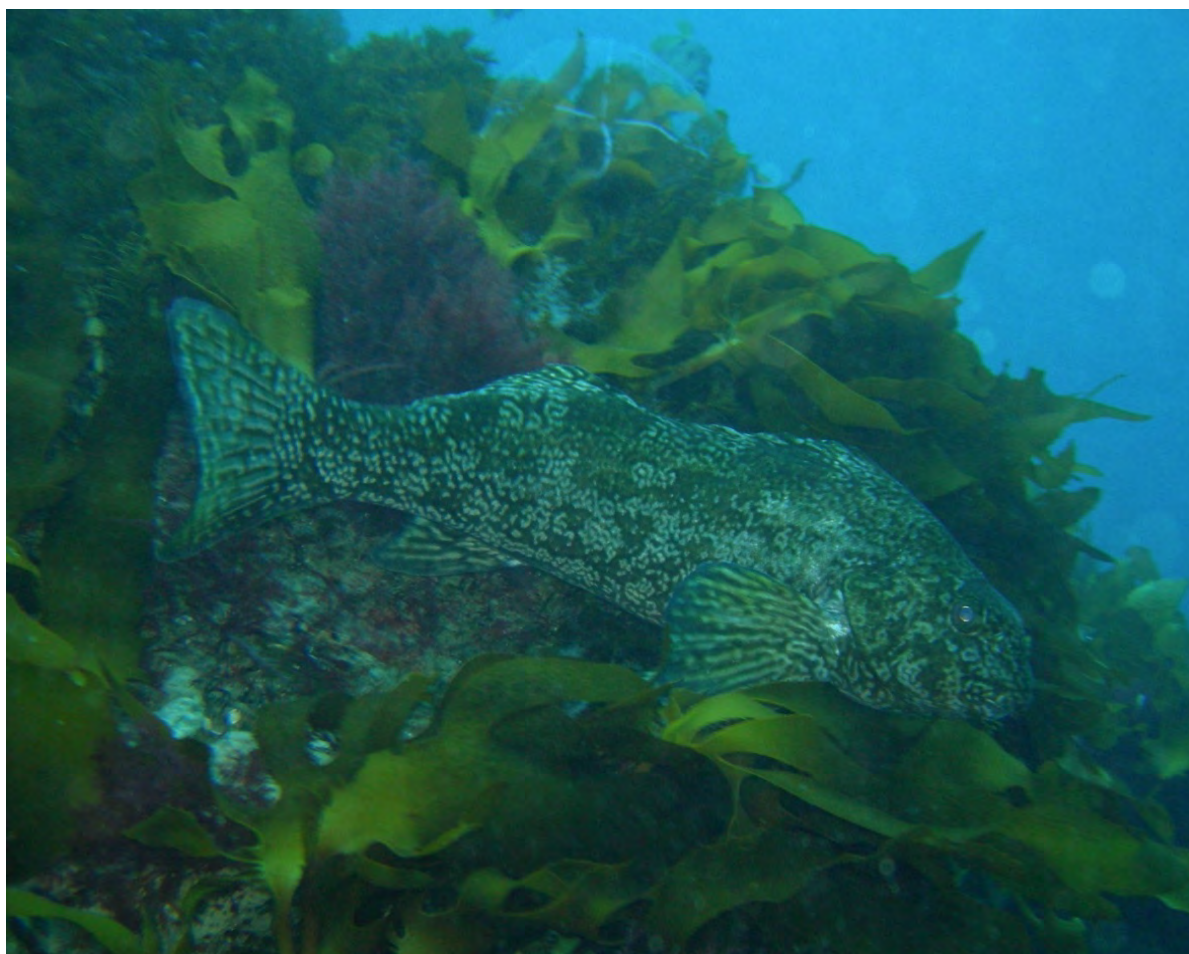


Figure 43. Marble fish *Aplodactylus arctidens* on subtidal reef in Port Phillip Heads Marine National Park. Photo by AME.

2.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora

No conservation listed marine flora has been recorded in Port Phillip Heads MNP (Parks Victoria 2007b).

Invertebrates

The shrimp *Eucalliax tooradin* and the chiton *Bassethullia glypta* are endemic to Port Phillip Heads MNP and both are listed under the *FFG Act 1988*.

Fish

Under the Victorian *Fisheries Act 1995* all syngnathid species are listed as Protected Aquatic Biota. Nationally they are listed as threatened under the *EPBC Act 1999*. In the seagrass beds of Mud Islands the wide-body pipefish *Stimatorpora nigra*, spotted pipefish *S. argus*, half-banded pipefish *Mitotichthys semistriatus* and Port Phillip pipefish *Vanacampus phillipi* are found (Hutchinson *et al.* 2011). Both the spotted pipefish *S. argus* and Port Phillip pipefish *V. phillipi* are abundant in Swan Bay seagrass beds (Plummer *et al.* 2003). The weedy seadragon *Phyllopteryx taeniolatus* (Figure 44) has been recorded from the protected

shallow subtidal reefs within the MNP around Point Lonsdale (Edmunds *et al.* 2009b). Many other syngnathids occur in Port Phillip Heads MNP including the short-headed seahorse *Hippocampus breviceps*, big-bellied seahorse *H. abdominalis* and upside-down pipefish *Heraldia nocturnia*, which are found on subtidal reef. Many species of pipefish are also found in seagrass habitat (Edmunds *et al.* 2004a).



Figure 44. The weedy seadragon *Phyllopteryx taeniolatus* on subtidal reef in Port Phillip Heads Marine National Park. Photo by AME.

Birds

Fifty-eight conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Port Phillip Heads MNP (Table 4). Thirty-nine are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Two species, the grey-tailed tattler *Heteroscelus brevipes* and the orange-bellied parrot *Neophema chrysogaster* are regarded as critically endangered, the latter both in Victoria and nationally. Three birds are listed in Victoria as endangered, sixteen vulnerable and eighteen near threatened. Five birds are listed as vulnerable at both the state and national level, including the seabirds fairy prion *Pachyptila turtur*, northern giant-petrel *Macronectes halli*, and shy *Thalassarche cauta*, yellow-nosed *T. chlororhynchos* and black-browed albatross *T. melanophris*. Forty-three birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA).

There are two hooded plover *Thinornis rubricollis* nesting sites inside the Heads at Nepean Bay and Observatory Point in Point Nepean. Nests are located directly on the beach above high tide or on adjacent sand dunes. Nesting season is unpredictable but typically occurs between August and April. Popes Eye is biotically significant because it is a minor roost for cormorants and has a large breeding colony of Australian gannets *Morus serrator* (Green *et al.* 2009).

Mud Islands is the largest roost site for waders in PPB in summer. It has the largest colonies of breeding waterbirds and seabirds in PPB. It is the second largest crested tern *Sterna bergii* breeding colony in Victoria with over 2,000 pairs (DSE 2003). Its colony of 5,000 white-faced storm-petrels *Pelagodroma marina* is one of only three colonies in Victoria (DSE 2003). It is a significant breeding site for white ibis *Threskiornis molucca*, Caspian terns *Hydroprogne caspia*, crested terns *Sterna bergii*, and royal spoonbills *Platalea regia* (DSE 2003). Several hundred Australian pelicans *Pelecanus conspicillatus*, many thousands of straw-necked ibis *Threskiornis spinicollis* and a small colony of yellow-billed spoonbills *P. flavipes* breed on the islands (DSE 2003). It also has breeding colonies of pied cormorant *Phalacrocorax varius*, pied oystercatcher *Haematopus longirostris*, fairy tern *S. nereis* and silver gulls *Larus novaehollandiae* (Menkhorst and Kerry 1988; DSE 2003). Orange-bellied parrots *N. chrysogaster* winter on the islands (Menkhorst and Kerry 1988). Swan Bay has significant roosting sites for wader birds with numbers peaking in summer. The seagrass beds in Swan Bay are important for black swans *Cygnus atratus*. Swan Bay and Mud Islands are internationally significant shorebird habitats and form part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site listed under the RAMSAR convention and on the Register of the National Estate (DSE 2003; Parks Victoria 2006). A Special Protection Area overlay also applies in Swan Bay to protect seagrass beds and seabird and shorebird habitat (Parks Victoria 2006).

Table 4. Conservation listed shorebird and seabird records from Port Phillip Heads Marine National Park and surrounds.

Common name	Scientific name	Victorian listing		National listing EPBC	International treaty	
		FFG	VROTS		CAMBA	JAMBA
orange-bellied parrot	<i>Neophema chrysogaster</i>	L	CE	CE		
grey-tailed tattler	<i>Heteroscelus brevipes</i>	L	CE		C	J
great knot	<i>Calidris tenuirostris</i>	L	EN		C	J
fairy tern	<i>Sternula nereis</i>	L	EN			
little egret	<i>Egretta garzetta</i>	L	EN			
shy albatross	<i>Thalassarche cauta</i>	L	VU	VU		J
yellow-nosed albatross	<i>Thalassarche chlororhynchos</i>	L	VU	VU		J
black-browed albatross	<i>Thalassarche melanophris</i>		VU	VU		J
fairy prion	<i>Pachyptila turtur</i>		VU	VU		J
eastern great egret	<i>Ardea modesta</i>	L	VU		C	J
little tern	<i>Sternula albifrons</i>	L	VU		C	J
white-bellied sea-eagle	<i>Haliaeetus leucogaster</i>	L	VU		C	
hooded plover	<i>Thinornis rubricollis</i>	L	VU			
brolga	<i>Grus rubicunda</i>	L	VU			
common sandpiper	<i>Actitis hypoleucos</i>		VU		C	J
black-tailed godwit	<i>Limosa limosa</i>		VU		C	J
whimbrel	<i>Numenius phaeopus</i>		VU		C	J
lesser sand plover	<i>Charadrius mongolus</i>		VU		C	J
greater sand plover	<i>Charadrius leschenaultii</i>		VU		C	J
royal spoonbill	<i>Platalea regia</i>		VU			
white-faced storm-petrel	<i>Pelagodroma marina</i>		VU			
northern giant-petrel	<i>Macronectes halli</i>	L	NT	VU		J
Caspian tern	<i>Hydroprogne caspia</i>	L	NT		C	J
Latham's snipe	<i>Gallinago hardwickii</i>		NT		C	J
Pacific golden plover	<i>Pluvialis fulva</i>		NT		C	J
red knot	<i>Calidris canutus</i>		NT		C	J
grey plover	<i>Pluvialis squatarola</i>		NT		C	J
white-winged black tern	<i>Chlidonias leucopterus</i>		NT		C	J
eastern curlew	<i>Numenius madagascariensis</i>		NT		C	J
sanderling	<i>Calidris alba</i>		NT		C	J
pectoral sandpiper	<i>Calidris melanotos</i>		NT			J
Pacific gull	<i>Larus pacificus</i>		NT			
piebald cormorant	<i>Phalacrocorax varius</i>		NT			
common diving-petrel	<i>Pelecanoides urinatrix</i>		NT			
sooty oystercatcher	<i>Haematopus fuliginosus</i>		NT			
black-faced cormorant	<i>Phalacrocorax fuscescens</i>		NT			
white-fronted tern	<i>Sterna striata</i>		NT			
nankeen night heron	<i>Nycticorax caledonicus</i>		NT			
whiskered tern	<i>Chlidonias hybridus</i>		NT			
bar-tailed godwit	<i>Limosa lapponica</i>				C	J
common tern	<i>Sterna hirundo</i>				C	J
red-necked stint	<i>Calidris ruficollis</i>				C	J
sharp-tailed sandpiper	<i>Calidris acuminata</i>				C	J
sooty shearwater	<i>Ardenna grisea</i>				C	J

ruddy turnstone	<i>Arenaria interpres</i>				C	J
curlew sandpiper	<i>Calidris ferruginea</i>				C	J
common greenshank	<i>Tringa nebularia</i>				C	J
marsh sandpiper	<i>Tringa stagnatilis</i>				C	J
pomarine jaeger	<i>Stercorarius pomarinus</i>				C	J
Asian dowitcher	<i>Limnodromus semipalmatus</i>				C	J
broad-billed sandpiper	<i>Limicola falcinellus</i>				C	J
brown booby	<i>Sula leucogaster</i>				C	J
red-necked phalarope	<i>Phalaropus lobatus</i>				C	J
ringed plover	<i>Charadrius hiaticula</i>				C	J
short-tailed shearwater	<i>Ardenna tenuirostris</i>					J
Arctic jaeger	<i>Stercorarius parasiticus</i>					J
Wilson's storm-petrel	<i>Oceanites oceanicus</i>					J
wedge-tailed shearwater	<i>Ardenna pacifica</i>					J

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



Figure 45. Australian fur seal *Arctocephalus pusillus doriferus* at Popes Eye in Port Phillip Heads Marine National Park. Photo by AME.

Marine mammals and reptiles

Two Victorian conservation listed mammals, the southern right *Eubalaena australis* and humpback whale *Megaptera novaeangliae*, have been observed in Port Phillip Heads MNP (Table 5). The nationally listed southern elephant seal *Mirounga leonina* and loggerhead turtle *Caretta caretta* have also been recorded in the MNP. The southern right *E. australis* and humpback whales *M. novaeangliae*, and loggerhead turtle *C. caretta* are listed as migratory under the Bonn convention. A Sea Use Designation overlay applies in Ticonderoga Bay off inner Point Nepean as a Sanctuary Zone for bottlenose dolphin *Tursiops truncatus* protection (Parks Victoria 2006). The northwest corner of the Popes Eye

is a minor haul-out area for the *EPBC* listed Australian fur seal *Arctocephalus pusillus doriferus* (Edmunds *et al.* 2009b; Figure 45).

Table 5. Conservation listed marine mammal and reptile records from Port Phillip Heads Marine National Park and surrounds.

Common name	Scientific name	Victorian listing		National listing	International convention
		FFG	VROTS	EPBC	Bonn
southern right whale	<i>Eubalaena australis</i>	L	CE	EN	L
humpback whale	<i>Megaptera novaeangliae</i>	L	VU	VU	L
southern elephant seal	<i>Mirounga leonina</i>			VU	
Australian fur seal	<i>Arctocephalus pusillus doriferus</i>			L	
loggerhead turtle	<i>Caretta caretta</i>			EN	L

L = listed, VU = Vulnerable, EN = Endangered, CE = Critically Endangered

Outside of the Heads in Point Lonsdale and Point Nepean is a possible habitat for the *FFG Act 1988* listed threatened southern bluefin tuna *Thunnus maccoyii*, although it is predominantly a migratory species found further offshore. Likewise the open waters off the Heads could potentially be used by the grey nurse shark *Charcharias taurus* which is listed as threatened in Victoria (*FFG*) and critically endangered nationally (*EPBC*). Juveniles of the great white shark *Carcharodon carcharias* are known to enter PPB and could be found in the waters of Port Phillip Heads MNP. This species is regarded as threatened in Victoria (*FFG*) and vulnerable nationally (*EPBC*).

Marine Communities

The Port Phillip Bay entrance deep canyon marine community is one of two marine communities in Victoria listed under the *FFG Act 1988*. Part of the area occupied by the community falls within the boundary of the Point Lonsdale section of the Port Phillip Heads Marine National Park. The community is dominated by sessile invertebrates, predominantly sponges, with ascidians, bryozoans, hydroids and corals. The biota is diverse in terms of the variety of sponges and other invertebrate forms present. The community occurs within a 100 metre deep submarine canyon at the entrance to Port Phillip Bay, in an unusual and spectacular physical setting.

The deep canyon community is characterised and differentiated from other communities by its species composition and their relative abundance. The community is considered to be different from other known deep reef communities in south-eastern Australia (Point Addis, Wilsons Promontory, Twelve Apostles) due to the relatively high cover of sponges (65 per cent on average), the abundance of erect hydroids (*Nemertesia procumbens*, *Halopteris glutinosa*, *Halicornopsis elegans*), the scarcity of gorgonian coral (*Pteronisis* spp.), the absence of the sea whip coral *Primnoella australasiae*, and absence of thallose seaweeds and coralline algae (Edmunds *et al.* 2007).

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that Port Phillip Heads MNP (Table 6) has three known endemic invertebrates and two molluscs presumed to be endemic (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Table 6. Endemic fauna in Port Phillip Heads Marine National Park (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Phylum	Order	Family	Species
Crustacea	Thalassinidea	Callinassidae	<i>Eucalliax torradin</i> *
Mollusca	Polyplacophora	Acanthochitonidae	<i>Bassethullia glypta</i> *
Mollusca	Bivalvia	Veneridae	<i>Veneropsis obesa</i> *
Mollusca	Bivalvia	Galeommatidae	<i>Mysella dromanaensis</i>
Mollusca	Gastropoda	Eatoniellidae	<i>Eatoniella victoriae</i>

* Recorded endemic, others presumed endemic

One hundred and four biota (Table 7) have been recorded or are presumed to be at their distributional limit in Port Phillip Heads MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000; Plummer *et al.* 2003). Three fish have been recorded and one presumed to be at the northern limit of their distribution in the Port Phillip Heads MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). Six biota, including two species of red algae, two crustaceans and two fish have been recorded to be at their western limit of their distribution in the MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). Sixteen biota, including algae, molluscs, urchins and fish, are presumed to be at their western distributional limit. Thirteen algae, mostly red, with two green and two brown algae, are recorded as being at the easterly limit of their distribution in the MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). Sixty-three biota are presumed as being at the easterly limit of their distribution at Port Phillip Heads MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). Forty-eight species of algae are presumed to be at their eastern distributional limit in the MNP and includes thirty-eight species of red algae, seven brown and three green algae. Seven fish and eight invertebrates, including four chitons are also presumed to be at their eastern distribution limit. Many species were first collected or only known from Port Phillip Heads MNP. The chiton *Bassethullia glypta* occurs in Port Phillip Heads (type locality) along the shore from Sorrento to Portsea and at Shortland Bluff in Lonsdale Bay. It also occurs in Western Port Bay at West Head, Flinders and possibly near Stanley, northwest Tasmania (O'Hara and Barmby 2000). This chiton is considered very rare and restricted in distribution (O'Hara and Barmby 2000). The microscopic brown algae *Elachista claytoniae* is only known on *Sargassum* basal leaves from Port Phillip Heads but is probably wider spread. The distributional limits of the biota listed in Table 7 may reflect intensive collection effort in Port Phillip Heads MNP 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 7. Marine species at their distribution limits in Port Phillip Heads Marine National Park (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Family	Species	Common name	Category
Clinidae	<i>Heteroclinus mammoratus</i>	shorttassel weedfish	RN
Leptoscopidae	<i>Crapatalus munroi</i>	pink sandfish	RN
Tripterygiidae	<i>Apopterygion alta</i>	tassellated threefin	RN
Gobiidae	<i>Nesogobius hinsbyi</i>	orange spotted goby	PN
Cheilodactylidae	<i>Cheilodactylus fuscus</i>	red morwong	RW
Clinidae	<i>Heteroclinus nasutus</i>	large nose weedfish	RW
Galatheididae	<i>Munida subrugosa</i>	crab	RW
Callinassidae	<i>Eucalliax tooradin</i>	ghost shrimp	RW
Gracilariaceae	<i>Curdiea crassa</i>	red algae	RW
Phyllophoraceae	<i>Ahnfeltiopsis fastigiata</i>	red algae	RW
Ceramiales	<i>Macrothamnion pectenellum</i>	red algae	PW
Corallinales	<i>Lithothamnion indicum</i>	red algae	PW
Halymeniaceae	<i>Cryptonemia nitophylloides</i>	red algae	PW

Halymeniaceae	<i>Cryptonemia wilsoni</i>	red algae	PW
Brissidae	<i>Eupatagus valenciennesii</i>	sea urchin	PW
Anabathridae	<i>Pisinna nitida</i>	marine snail	PW
Eatoniellidae	<i>Eatoniella victoriae</i>	marine snail	PW
Fissurellidae	<i>Diodora lineata</i>	marine snail	PW
Naticidae	<i>Natica shorehami</i>	marine snail	PW
Trochidae	<i>Fossarina patula</i>	marine snail	PW
Trachichthyidae	<i>Optivus sp</i>	violet roughy	PW
Clinidae	<i>Heteroclinus sp</i>	longtail weedfish	PW
Gobiidae	<i>Nesogobius sp</i>	speckled goby	PW
Pentacerotidae	<i>Paristiopterus labiosus</i>	giant boarfish	PW
Serranidae	<i>Lepidoperca pulchellus</i>	eastern orange roughy	PW
Sporochnaceae	<i>Nereia lophocladia</i>	brown algae	PW
Caulerpaceae	<i>Caulerpa cliftonii</i>	green algae	RE
Bryopsidaceae	<i>Bryopsis macraildii</i>	green algae	RE
Cystoseiraceae	<i>Cystophora racemosa</i>	brown algae	RE
Seirococcaceae	<i>Scytothalia dorycarpa</i>	brown algae	RE
Ceramiaceae	<i>Acrothamnopsis eliseae</i>	red algae	RE
Ceramiaceae	<i>Elisiella dispar</i>	red algae	RE
Ceramiaceae	<i>Ptilocladia pulchra</i>	red algae	RE
Ceramiaceae	<i>Shepleya wattsii</i>	red algae	RE
Ceramiaceae	<i>Trithamnion eubryanii</i>	red algae	RE
Ceramiaceae	<i>Wollastoniella myriophylloides</i>	red algae	RE
Gelidiaceae	<i>Gelidiella mimima</i>	red algae	RE
Areschougiaceae	<i>Melanema dumosum</i>	red algae	RE
Nemastomataceae	<i>Adelophycus corneus</i>	red algae	RE
Udoteaceae	<i>Avrainvillea clavatiramea</i>	green algae	PE
Udoteaceae	<i>Callipsygma wilsonis</i>	green algae	PE
Codiaceae	<i>Codium perrinae</i>	green algae	PE
Chordariaceae	<i>Tinocladia australis</i>	brown algae	PE
Dictyotaceae	<i>Dilophus robustus</i>	brown algae	PE
Dictyotaceae	<i>Homoeostrichus canaliculatus</i>	brown algae	PE
Cystoseiraceae	<i>Cystophora cuspidata</i>	brown algae	PE
Cystoseiraceae	<i>Cystophora cymodoceae</i>	brown algae	PE
Sphacelariaceae	<i>Sphacelaria bracteata</i>	brown algae	PE
Sporochnaceae	<i>Sporochnus apodus</i>	brown algae	PE
Ceramiaceae	<i>Ballia ballioides</i>	red algae	PE
Ceramiaceae	<i>Callithamnion caulescens</i>	red algae	PE
Ceramiaceae	<i>Callithamnion pinnatum</i>	red algae	PE
Ceramiaceae	<i>Ceramium repens</i>	red algae	PE
Ceramiaceae	<i>Crouania mucosa</i>	red algae	PE
Ceramiaceae	<i>Dasythamniella dasyura</i>	red algae	PE
Ceramiaceae	<i>Dasythamniella wollastoniana</i>	red algae	PE
Ceramiaceae	<i>Diapse ptilota</i>	red algae	PE
Ceramiaceae	<i>Drewiana nitella</i>	red algae	PE
Ceramiaceae	<i>Elisiella arbuscula</i>	red algae	PE
Ceramiaceae	<i>Griffithsia pulvinata</i>	red algae	PE
Ceramiaceae	<i>Gymnothamnion nigrescens</i>	red algae	PE
Ceramiaceae	<i>Hirsutithallia angustata</i>	red algae	PE
Ceramiaceae	<i>Hirsutithallia formosa</i>	red algae	PE
Ceramiaceae	<i>Hirsutithallia laricina</i>	red algae	PE
Ceramiaceae	<i>Involucrana meredithiana</i>	red algae	PE

Ceramiaceae	<i>Macrothamnion acanthophorum</i>	red algae	PE
Ceramiaceae	<i>Macrothamnion pellucidum</i>	red algae	PE
Ceramiaceae	<i>Macrothamnion secundum</i>	red algae	PE
Ceramiaceae	<i>Perichelia glomulifera</i>	red algae	PE
Ceramiaceae	<i>Rhodocallis elegans</i>	red algae	PE
Dasyaceae	<i>Heterosiphonia Lawrenciana</i>	red algae	PE
Acrotylaceae	<i>Amphiplexia hymenocladoides</i>	red algae	PE
Cystocloniaceae	<i>Erythranaena ceramoides</i>	red algae	PE
Gigartinaceae	<i>Gigartina muelleriana</i>	red algae	PE
Gigartinaceae	<i>Gigartina pinnata</i>	red algae	PE
Gigartinaceae	<i>Gigartina wahliae</i>	red algae	PE
Halymeniaceae	<i>Cryptonemia digitata</i>	red algae	PE
Kallymeniaceae	<i>Cirrularia nanus</i>	red algae	PE
Kallymeniaceae	<i>Hormophora australasica</i>	red algae	PE
Nizymeniaceae	<i>Stenocladia australis</i>	red algae	PE
Nizymeniaceae	<i>Stenocladia furcata</i>	red algae	PE
Phacelocarpaceae	<i>Phacelocarpus complanatus</i>	red algae	PE
Sarcodiaceae	<i>Sarcoidia marginata</i>	red algae	PE
Liagoraceae	<i>Liagora codii</i>	red algae	PE
Rhodymeniaceae	<i>Erythrymenia minuta</i>	red algae	PE
Rhodymeniaceae	<i>Faucheopsis cronata</i>	red algae	PE
Rhodymeniaceae	<i>Webervanbossea splachnoides</i>	red algae	PE
Comasteridae	<i>Comatulella brachiolata</i>	feather star	PE
Phyllophoridae	<i>Thyone nigra</i>	sea cucumber	PE
Costellariidae	<i>Vexillum (Costellaria) pellucidum</i>	marine snail	PE
Acanthochitonidae	<i>Leptoplax wilsoni</i>	chiton	PE
Ischnochitonidae	<i>Ischnochiton contractus</i>	chiton	PE
Ischnochitonidae	<i>Ischnochiton torri</i>	chiton	PE
Ischnochitonidae	<i>Ischnochiton wilsoni</i>	chiton	PE
Rhynchocinetidae	<i>Rhynchocinetes kuiteri</i>	shrimp	PE
Berycidae	<i>Centroberyx gerrardi</i>	red snapper	PE
Clinidae	<i>Heteroclinus sp</i>	milwards weedfish	PE
Gobiidae	<i>Nesogobius sp</i>	sicklefin goby	PE
Gobiidae	<i>Nesogobius sp</i>	threadfin sandgoby	PE
Labridae	<i>Notolabrus parilus</i>	orange spotted wrasse	PE
Pentacerotidae	<i>Parazanclistus hutchinsi</i>	short boarfish	PE
Serranidae	<i>Othos dentex</i>	harlequin fish	PE
Acanthochitonidae	<i>Bassethullia glypta</i>	chiton	PB
Elachistaceae	<i>Elachista claytoniae</i>	brown algae	P

PN = presumed northern limit, RE = recorded eastern limit, RW = recorded western limit, PE = presumed eastern limit, PW = presumed western limit, PB = presumed to be restricted to PPB & WPB

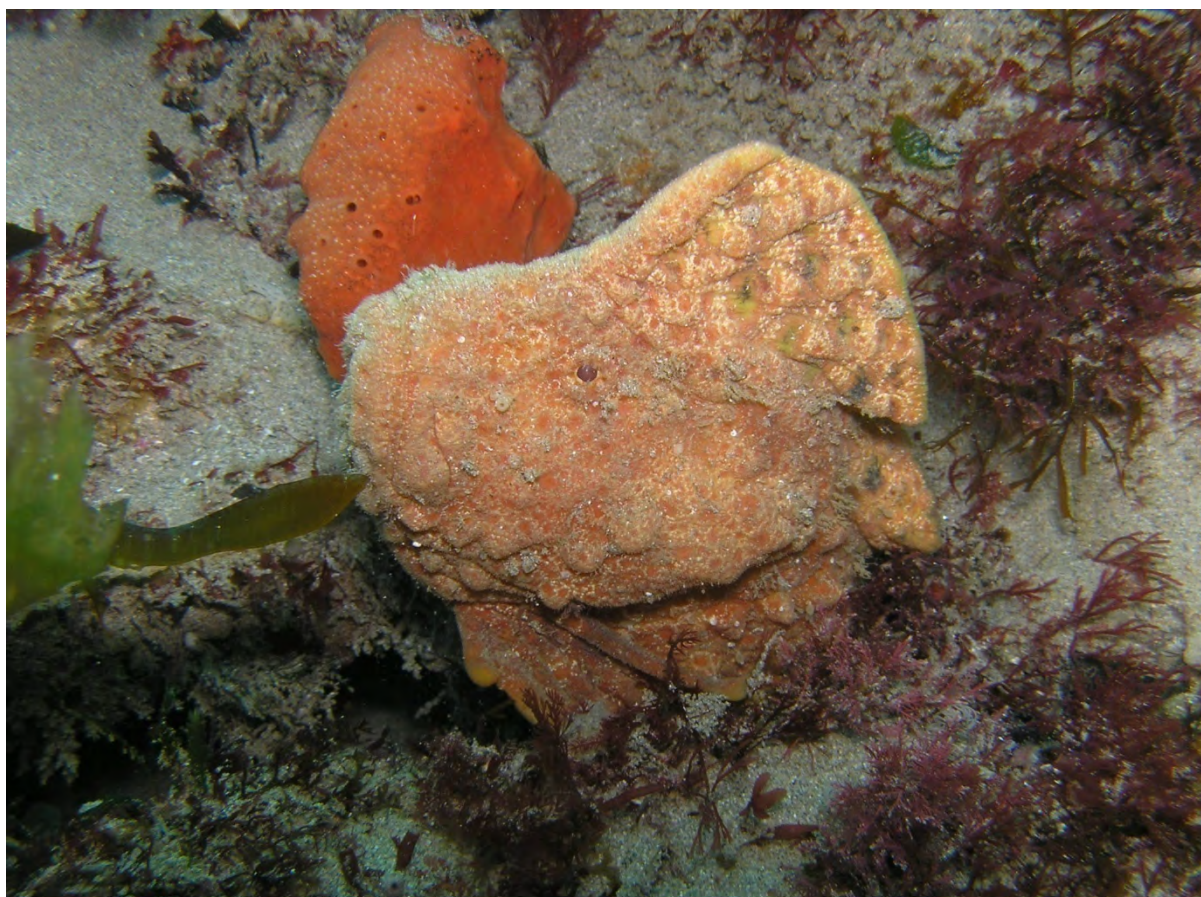


Figure 46. Warty prowfish *Aetapcus maculatus* on subtidal reef at Popes Eye in Port Phillip Heads Marine National Park. Photo by Don Love.

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 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). Eight 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. Exotic species displacing existing local species and precipitating large ecological change (all of MNP);
2. Sediment load from dredging resulting in decreased park visitation. (*i.e.* poorer visibility leading to fewer divers) (all of MNP);
3. Failure to document ecological change – lack of baseline and monitoring data (all of MNP);
4. Dumping of dredged spoil 10 km north of Mud Is in water more than 15 m deep, affecting seagrass and benthic fauna, and therefore wetland birds (Mud Island);
5. Effects of sand movement from dredging on benthic biota (all of MNP);
6. Planning decisions leading to changed hydrology and thus changed ecological values (all of MNP);
7. Sediment loads from dredging resulting in loss of seagrass and thus loss of fauna (all of MNP); and
8. Ship grounding resulting in a major oil spill (all of MNP).

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). Port Phillip Bay has the most marine pests in Victorian waters (Parks Victoria 2003; Hewitt *et al.* 2004). Surveys in late 2008/early 2009 confirmed that the northern Pacific seastar *Asterias amurensis* and green algae dead man's fingers *Codium fragile* (*subsp. fragile*) are established in both Swan Bay and Mud Islands. The European fan worm *Sabella spallanzanii* is also established in Swan Bay, and in 2000 was observed in the southern part of Port Phillip Bay but not inside the MNP (Parks Victoria 2006; Edmunds *et al.* 2009b). Like *A. amurensis*, *S. spallanzanii* generally prefers sheltered silty estuarine/bay habitats. The introduced green shore crab *Carcinus maenas* is confirmed from Mud Islands but is thought to be present in the intertidal zone throughout the MNP. Japanese kelp *Undaria pinnatifida* is established in the north of Port Phillip Bay and is gradually colonising subtidal habitats southwards along the eastern side of the Bay (Edmunds *et al.* 2010c). It is not known to be in the MNP (Parry and Cohen 2001; Edmunds *et al.* 2010c). Another species of particular concern is the New Zealand screw shell *Maoricolpus roseus* which is established in eastern Bass Strait (Parks Victoria 2003).

Terrestrial plant pest species are a problem in parts of Mud Islands within the park. Invasive species can pose a threat to the islands' bird populations, ecology and landscape values (Parks Victoria 2006). The Friends of Mud Islands regularly undertake pest plant removal activities on their monthly visits to the islands (Parks Victoria 2006).

A virus affecting abalone called abalone viral ganglioneuritis 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 Port Phillip Heads MNP but its spread into the park could have serious long term ecological consequences for rocky reef communities (DPI 2009).

Abundances of giant kelp *Macrocystis pyrifera* have been reduced considerably over the past two decades (Edmunds *et al.* 2009b). The decline of *M. pyrifera* abundance in Port Phillip Heads is strikingly apparent, with few plants observed since 2005 (Edmunds *et al.* 2009b). These results correspond with observations at other subtidal reef monitoring sites across Victoria, where *M. pyrifera* has also substantially declined in abundance (Edmunds *et al.* 2009b). 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 nutrient inputs in Port Phillip Bay (Edmunds *et al.* 2009b).

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 northern, eastern or western limit of their distributional range in Port Phillip Heads MNP and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in 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 Port Phillip Heads MNP (Parks Victoria 2006). For example, research is being conducted into marine pest species, and investigations into water quality issues have also been conducted. Management actions have been implemented to minimise these disruptions (Parks Victoria 2006). There is a night time curfew on cats in the Borough of Queenscliffe area to try and minimise cat predation on birds in Swan Bay (Parks Victoria 2006). 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 47. Varied catshark *Parascyllium variolatum* over subtidal reef in Port Phillip Heads Marine National Park. Photo by AME.

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 Port Phillip Heads 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 8 and Appendix 2).



Figure 48. Johnstons weedfish *Heteroclinus johnstoni* on subtidal reef in Port Phillip Heads Marine National Park. Photo by AME.

Table 8. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Port Phillip Heads Marine National Park.

Ongoing RPP (and RPP-like) Projects
Deakin University: Megan Underwood, Ashley Bunce, John Arnould, Janet Gwyther The breeding biology and ecology of the white-faced storm petrel (<i>Pelagodroma marina</i>) in Victoria.
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 (also involves other university and industry partners). Biotic connectivity within the temperate Australian marine protected area network at three levels of biodiversity - communities, populations and genes.
Department of Primary Industries: David Ball, Sean Blake, Peter Young Aerial monitoring of coastline changes at Mud Islands impacting seagrass and shorebird habitat.
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 Sea Search - Seagrass, Intertidal Reefs Reef Life Survey - Subtidal Reefs

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

Port Phillip Heads MNP has an ongoing intertidal reef monitoring program (IRMP) and a shallow subtidal reef monitoring program (SRMP). The IRMP in and around the Point Lonsdale and Point Nepean MS began in 2004 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). The MNP site on the intertidal reef in Point Lonsdale and reference site outside of the MNP north of Point Nepean in Cheviot Bay (**Figure 4**) have been surveyed over more than six census events (Gilmour and Edmunds 2007; Stewart *et al.* 2007; Edmunds *et al.* 2010d). The intertidal platform in the MNP is subject to a high level of trampling by the public, the reference site in Cheviot Bay has restricted public access. 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).

The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003b) in and around the Port Phillip Heads MNP began in 1998, in what was then the Harold Holt Marine Reserve. Monitored sites inside the MNP cover four regions and include sites inside Port Phillip Heads MNP, five in Point Lonsdale, two in Point Nepean and one in Popes Eye, and two outside the heads at Point Lonsdale. There are also eight reference sites outside the park. These regions where MNP sites are located vary in exposure to wave action, ranging from sheltered conditions well inside the Heads, to moderately exposed conditions in Nepean Bay and Lonsdale Bay, through to exposed open coast. The MNP and reference sites outside of the MNP (**Figure 4**) have been surveyed over thirteen census events (Lindsay *et al.* 2006; Gilmour and Edmunds 2007; Edmunds *et al.* 2010c). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than 10 m (Edmunds and Hart 2003b). 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 sampling up to 2006 was done at the MNP level. Sites were classified for the analysis as outside Port Phillip Heads, inside in Lonsdale Bay and inside in Nepean Bay. Popes Eye was analysed separately as it had been protected from fishing before the declaration of Port Phillip Heads MNP. The analysis compared sites within MPA to reference sites outside the MPAs pre and post declaration. They found there were no statistical differences in species richness between MPA and reference sites post-declaration of the MNP in Point Lonsdale and Point Nepean (Keough and Carnell 2009). The algae displayed a complex set of results and trends over time (Keough and Carnell 2009). The kelp *Ecklonia radiata* had a greater cover in the MNP compared to reference sites since declaration of the MNP (Keough and Carnell 2009). *Cladophora prolifera* abundance became more similar between MPA and reference sites since declaration (Keough and Carnell 2009). No invertebrate species showed any significant effect of the MNP (Keough and Carnell 2009). There were no obvious patterns that could be linked to the declaration of the MNP in the abundances of fish in or out of the MNP (Keough and Carnell 2009). Species generally showed a large amount of variation between surveys and in their trends over time (Keough and Carnell 2009).

The kelp *E. radiata* showed a small but relatively steady increase in the difference between Popes Eye and its reference site over the surveys (Keough and Carnell 2009). On the other hand, thallose red algae showed change in the difference between sites resulting in a progression towards greater cover at the reference site (Keough and Carnell 2009). *Heliocidaris erythrogramma* and *Haliotis rubra* showed a change in the difference between Popes Eye and the reference site over the survey period (Keough and Carnell 2009). *Heliocidaris erythrogramma* abundance has become similar between the reference site and Popes Eye, with numbers in the reference site declining to Popes Eye levels (Keough and Carnell 2009). In contrast, *H. rubra* has increased its abundance in Popes Eye compared to the reference site (Keough and Carnell 2009). All fish species analysed were more abundant at Popes Eye, but fluctuated through time, with no significant increase in numbers at this site in comparison to the reference site (Keough and Carnell 2009).

Limitations of Keough and Carnell's (2009) analysis 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 MNP area against future threats to

biodiversity and natural processes. A targeted analysis of IRMP and SRMP monitoring data in relation to conservation outcomes for the park and review of the monitoring design will be done by 2013.

The Seagrass Monitoring Program conducted by DPI aims to detect changes in seagrass health in PPB outside expected variability (PoMC 2009). The program consists of three main elements: 1) large-scale mapping of seagrass area; 2) small-scale assessment of seagrass health in the field; and 3) monitoring of environmental factors that are known to influence seagrass health (PoMC 2009). Monitoring includes sites in Swan Bay and Mud Islands.

Community based monitoring programs are undertaken by Reef Watch and Sea Search (Parks Victoria 2006). The Marine Discovery Centre at Queenscliff and Friends and volunteer groups have active connections with the MNP (Parks Victoria 2006). Formed in 1992, the Friends of Mud Islands make monthly visits to the islands to remove weeds such as boxthorn and monitor seagrass and bird-nesting patterns (Parks Victoria 2006). Other Friends groups concerned with the MNP and the nearby foreshore reserves are the Friends of Buckley Park and the Friends of Edwards Point (Parks Victoria 2006). Other volunteer organisations involved in the conservation of the MNPs flora and fauna are the Victorian Wader Studies Group (VWSG) and the Swan Bay Environment Association (Parks Victoria 2006). Formed in 1978, the VWSG conducts long term comprehensive studies of both migrant and resident species of waders and terns throughout the MNP (Parks Victoria 2006). Friends groups associated with the adjacent Point Nepean National Park are: Friends of the Hooded Plover; Friends of the Fort; Point Nepean; Friends of Moonah; Point Nepean National Park; and Friends of South Channel Fort (Parks Victoria 2006).

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 49. Hermit crab *Paguristes frontalis* on subtidal reef at Point Nepean in Port Phillip Heads Marine National Park. Photo by Don Love.

2.1.7 KNOWLEDGE GAPS

Most habitats and their biota have been surveyed in parts of the MNP. Little is known about the ecological communities of both the intertidal and subtidal bare sandy sediment. Major threats have been identified for Port Phillip Heads MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.



Figure 50. The hydroid *Solanderia fusca* and large sponges on deep subtidal reef at Point Lonsdale in Port Phillip Heads Marine National Park. Photo by Don Love.

3 Marine Sanctuaries

3.1 Point Cooke Marine Sanctuary

Point Cooke MS is one of three Marine Sanctuaries in the Victorian Embayments bioregion. The others, all in Port Phillip Bay (PPB) are Jawbone and Ricketts Point MSs. The bioregion also has five Marine National Parks being Port Phillip Heads in PPB, Yaringa, French Island, Churchill Island and Corner Inlet. Point Cooke MS is on the north-west side of PPB at Point Cooke, about 30 km west of Melbourne and 10 km east of Werribee (Figure 51). The MS extends from the high water mark to between 750 m and 1.1 km offshore, marked by a series of inwater navigational marks (Figure 53). The shoreline boundary is 3.4 km long, beginning at the onshore marker west of the Point Cook Homestead and running east along the foreshore around Point Cooke to the onshore marker at the southern boundary of the Cheetham Wetlands (Parks Victoria 2007c). Access is from the beach recreation area, walking tracks within the coastal park and Cheetham Wetlands staging area (Parks Victoria 2007c). The nearest boat ramps are Newport, Altona and Werribee South (Parks Victoria 2007c).

Aboriginal tradition indicates that the sanctuary is part of *Country* of Boon Wurrung people (Parks Victoria 2007c).

The MS adjoins both the Point Cooke Coastal Park and Cheetham Wetlands. It is the largest marine sanctuary in Victoria and protects an area of relatively intact habitats of the western shoreline environments of PPB (Parks Victoria 2007c). The MS has a long period of marine protection, the area south of Point Cooke was originally gazetted as the Point Cook Marine Reserve in 1982, then in 1998 as the Point Cook Fisheries Reserve with all fishing prohibited up to 200 m seaward of the high water mark (Parks Victoria 2007c).

Important natural values of Point Cooke MS are narrow beaches of mud and sand, its low intertidal and shallow subtidal basalt reef with algae and associated epibenthic fauna, beds of the habitat forming cunjevoi *Pyura stolonifera* and small patches of *Zostera* seagrass (ECC 2000; Plummer *et al.* 2003; Carey *et al.* 2007b). Its low basalt reefs are the remains of lava flow across the plains of northern PPB (Plummer *et al.* 2003). The MS is an important venue for marine environmental and conservation education (Parks Victoria 2007c). The beaches of the MS are among the few accessible swimming beaches on the western coast of PPB and popular with swimmers, divers, snorkellers and boating (Parks Victoria 2007c). There are two shipwrecks in the MS, the *Diana* and the *Henrietta*, listed on the Victorian Heritage register (Parks Victoria 2007c).

Sand patches and associated seagrass *Zostera muelleri* beds extend across a wide band of the intertidal reef (Edmunds *et al.* 2010d). The macroalgal coverage on the intertidal reef is highly variable, especially the coverage of sea lettuce *Ulva* spp. and the green alga *Enteromorpha* spp. (Edmunds *et al.* 2010d). Green algae *Caulerpa remotifolia*, brown algae *Padina fraseri* and red algae *Ahnfeltiopsis fastigata* also grow on the reef (Costa *et al.* 2010; O'Hara *et al.* 2010). There are small patches of *Galeolaria caespitosa* and blue mussel *Mytilus edulis* low on the shoreline (Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). The anemones, red waratah *Actinia tenebrosa*, green *Aulactinia veratra*, sand *Oulactis muscosa* and white-striped *Anthothoe albocincta* are also found on the intertidal reef (Koss *et al.* 2005a; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010).

Twenty-six species of mobile invertebrates, including 20 species of molluscs have been found in low abundance on the intertidal reefs of the MS (Koss *et al.* 2005a; Bathgate 2010; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). The herbivorous gastropod *Austrocochlea porcata* is the most abundant invertebrate (Edmunds *et al.* 2010d). Other molluscs found in low densities are the warrener *Turbo undulatus*, conniwink *Bembicium*

spp., limpet *Cellana tramoserica*, and the carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* (Bathgate 2010; Edmunds *et al.* 2010d). Other invertebrates include the shore crabs *Cyclograpsus granulosus* and *Leptograpsodes octodentatus*, seastars *Tosia australis* and *Patiriella calcar* and the invasive marine pest the green shore crab *Carcinus maenas* (Costa *et al.* 2010; O'Hara *et al.* 2010). The Tasmanian blenny *Parablennius tasmanianus* and the weedfish Clinidae are commonly found in the intertidal pools (Plummer *et al.* 2003).

The seagrasses *Heterozostera nigricaulis* and *Halophila australis* form patches of habitat on the subtidal soft sediment in the MS (Blake and Ball 2001; Edmunds *et al.* 2011). Beds of habitat forming cunjevoi *Pyura stolonifera* also occur (Edmunds *et al.* 2011). Large beds of *Caulerpa remotifolia*, *C. longifolia*, *C. brownii* and *C. flexilis* also grow on the soft sediment (Edmunds *et al.* 2011).

Over 19 species of macroalgae have been recorded in low density from the subtidal reef of the MS (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). Dominant species include kelp *Ecklonia radiata*, green algae *Caulerpa remotifolia* and encrusting coralline algae (Edmunds *et al.* 2011). With lower cover (< 5 %) are sea lettuce *Ulva* sp., brown algae *Dilophus marginatus* and *Dictyota dichotoma*, and thallose red algae such as *Gigartina* sp (Edmunds *et al.* 2011). The introduced Japanese kelp *Undaria pinnatifida* and red algae *Grateloupia turuturu* grow on the reefs. Over 21 species of mobile marine invertebrates, dominated by echinoderms like the purple sea urchin *Heliocidaris erythrogramma* and seastars *Tosia australis*, *Meridiastra gunnii*, *Coscinasterias muricata*, are found on the subtidal reef (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). Also abundant are black lip abalone *Haliotis rubra* and the granular seastar *Uniophora granifera* (Edmunds *et al.* 2011). The invasive European fanworm *Sabella spallanzani* occurs on the reef (Edmunds *et al.* 2011). Over 16 species of fish, dominated by the southern hulafish *Trachinops caudimaculatus* occur in the MS (Jung *et al.* 2010; Edmunds *et al.* 2011). Other typical species are the little rock whiting *Neoodax balteatus* and southern goatfish *Upeinichthys vlaminghii* (Edmunds *et al.* 2011). There are occasional sightings of banjo ray *Trygonorrhina fasciata*, zebrafish *Girella zebra*, moonlighter *Tilodon sexfasciatus*, dusky morwong *Dactylophora nigricans* and globefish *Diodon nichthemerus* (Edmunds *et al.* 2011).

Point Cooke MS forms part of the PPB (Western Shoreline) and Bellarine Peninsula Ramsar Site, along with nearby Point Cook Coastal Park and Cheetham Wetlands (DSE 2003). Saltmarsh, dunes and wetlands back onto the MS, and with its sandy beaches, intertidal reefs and mudflats, offshore banks and waters provide roosting and foraging for migratory seabirds and shorebirds (ECC 2000; Plummer *et al.* 2003; Carey *et al.* 2007b). Forty-four threatened bird species have been recorded in or in the immediate surrounds of the MS. This includes the orange-bellied parrot *Neophema chrysogaster*, Australian painted snipe *Rostratula australis* and the intermediate egret *Ardea intermedia* which are listed under the *Flora and Fauna Guarantee (FFG) Act* (1998) and regarded as critically endangered in Victoria. The MS protects feeding areas for 30 internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Six species of marine flora and fauna are believed to be at their distributional limits within the MS.

Serious threats to the Point Cooke MS include limited ecological knowledge of important processes. Invasive marine pests, illegal fishing, disturbance and predation of birds, nutrients from runoff, sediments from dredging, industrial spills, trampling, contaminated groundwater, 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 Point Cooke MS (Parks Victoria 2007c). Ongoing subtidal and intertidal reef monitoring, and specific research also aims to increase ecological knowledge about the natural values of, and threats to, Point Cooke MS.

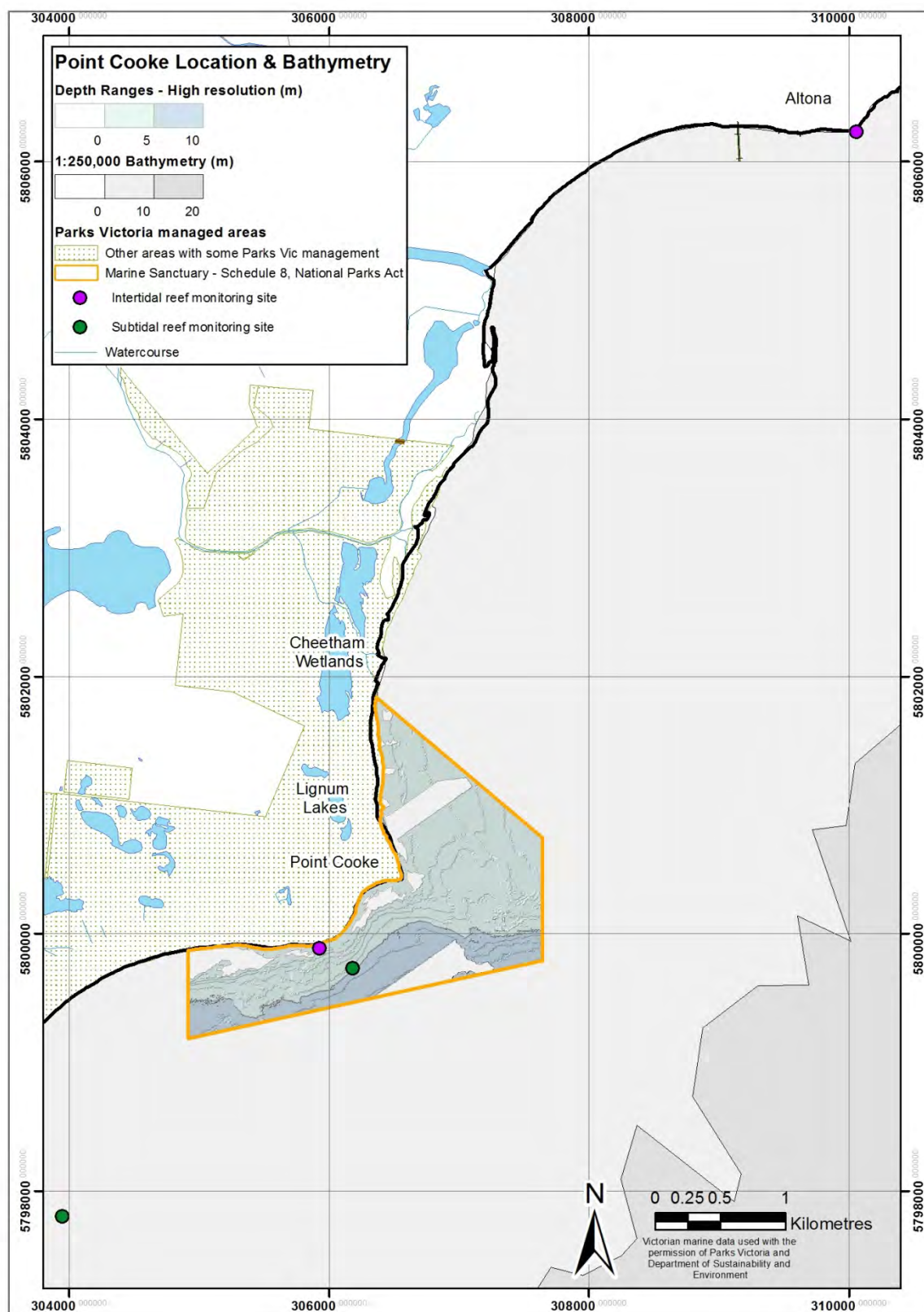


Figure 51. Location map of Point Cooke Marine Sanctuary with bathymetry. Intertidal and subtidal reef monitoring sites inside and outside the MS are shown

3.1.1 PHYSICAL PARAMETERS & PROCESSES

Point Cooke MS is 292 hectares in size which makes it the fourteenth largest of the 24 Marine Protected areas in Victoria and the largest Marine Sanctuary (Table 9 & Figure 53). The MS is shallow, < 4 m deep. The MS has an unequal semidiurnal tidal pattern, with a higher and lower flooding and ebbing event daily. Tidal variation is 0.8 m for spring tides and 0.2 m for neap tides (Plummer *et al.* 2003). The water in the sanctuary is exchanged every 28 – 50 tidal cycles (Parks Victoria 2007c). Surface water temperatures average 20.4 °C in the summer and 11.4 °C in the winter.

The MS is not subject to large waves, strong currents or swell (Edmunds *et al.* 2011). Wind and tidal forces dominate the circulation of water within Port Phillip and the MS (Parks Victoria 2007c). There is little background swell in this part of PPB; the water is calm when the wind is still (Parks Victoria 2007c). In moderate winds the waves are choppy and under 0.5 m, but in strong westerly conditions waves can reach heights of 2 m (Parks Victoria 2007c). Natural hydrodynamic events such as storm surges displace seaweed and kelp communities, erode beaches and deposit sand over the reefs (Parks Victoria 2007c). During periods of strong winds wrack can form a thick blanket over the intertidal area of the MS (Parks Victoria 2007c).

There are no rivers or creeks that flow directly into the sanctuary. South Channel from Cheetham Wetlands drains directly into the MS, Skeleton Creek is 2 km north and Laverton Creek is 4 km north of the MS (Parks Victoria 2007c). Dunnings Road drain which drains the market garden area of Werribee is 7 km west of the MS (Parks Victoria 2007c). Freshwater runoff, phytoplankton blooms and disturbance of nearby fine sediments frequently create turbid conditions in the MS (Edmunds *et al.* 2011).

Table 9. Physical attributes of the Point Cooke Marine Sanctuary.

Park Name	Point Cooke
Conservation status	Marine Sanctuary
Biophysical Region	Victorian Embayments
Size	292 ha (ranked 14 th of 24)
Length of coastline	~3.4 km
Shoreline geology	basalt
Area with depth:	
(low res)* 0-10 m	44.87 ha
(high res) Supratidal	1.14 ha
Intertidal	11.15 ha
Intertidal-2 m	50.72 ha
2-4 m	88.43 ha
4-6 m	64.09 ha
6-8 m	27.78 ha
8-10 m	3.78 ha
Mean tidal variation - spring	0.8 m
Mean tidal variation - neap	0.2 m
Mean water temp - summer	20.4°C
Mean water temp - winter	11.4°C
Adjacent catchment	Conservation, urban, intensive agriculture
Discharges into MNP	South Channel, Cheetham Wetlands
Nearest major estuary (distance & direction)	Werribee River 10 km south west Skeleton Creek 2 km north Laverton Creek 4 km north

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

Point Cooke is an outcrop of Quaternary basalt buried by coastal deposits of sand, shell and gravel. Point Cooke is backed by one prominent parallel coastal ridge 150 m inland, extending northward. In front of this are lower hummocky ridges behind a beach of shell dominated sand. At Point Cooke the prevailing direction of sand movement is northward, delivering sand to the beaches around Altona. There are no declared geologically significant sites in the MS, but there are two significant sites on the adjacent coast of Point Cooke (Figure 54). These are regionally significant parallel sand ridges and Point Cooke itself is a relict spit of an outcrop of Quaternary basalt buried by sand, shell and gravel.

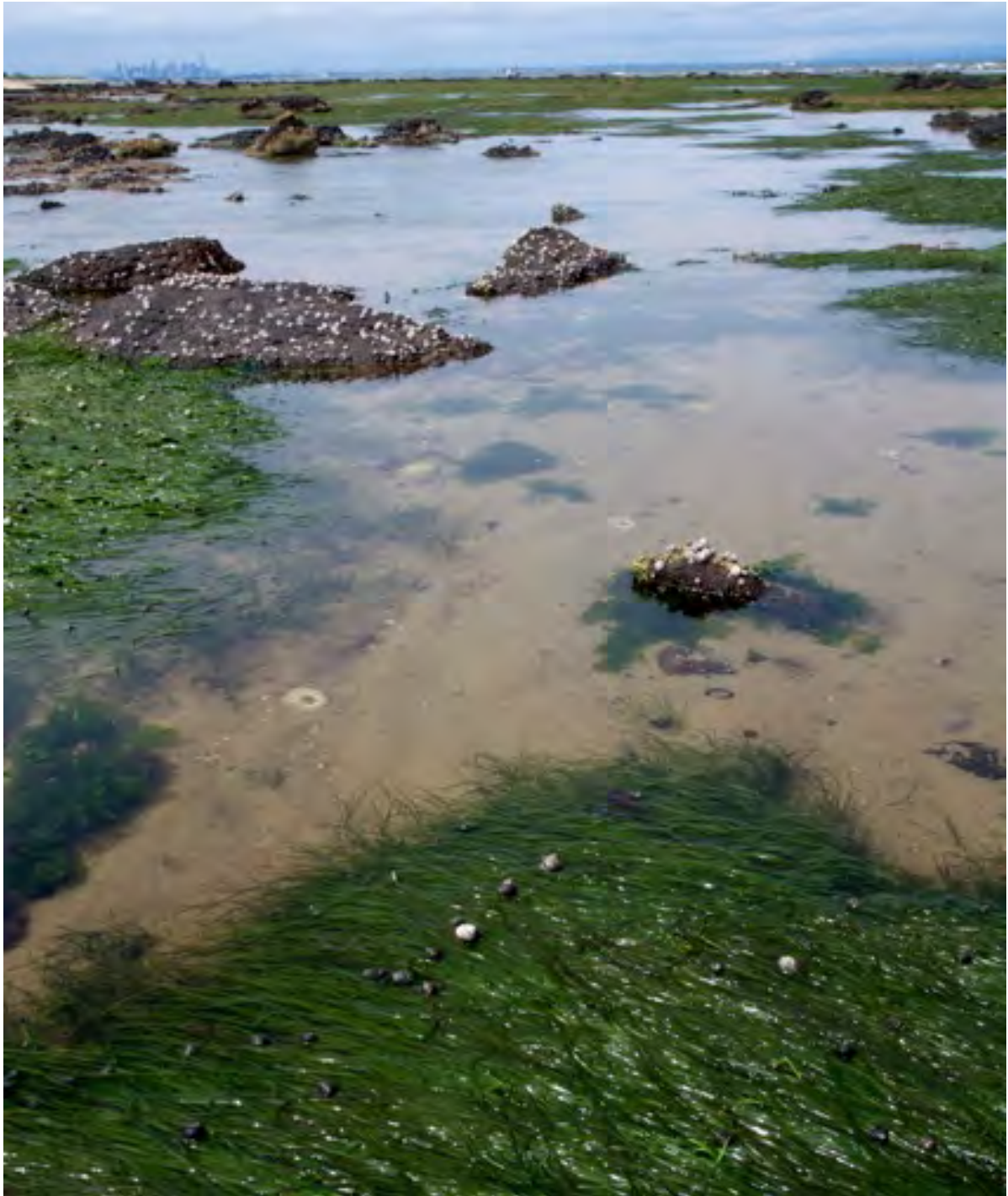


Figure 52. Intertidal reef and sand with seagrass *Zostera muelleri* beds and abundant zebra top shells *Austrocochlea porcata* in Point Cooke Marine Sanctuary. Photo by Trish Rice, Friends of Point Cooke.

3.1.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including 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. Point Cooke habitat was mapped from aerial photography and ground-truthed by site visits and underwater video transects (Blake and Ball 2001).

The shoreline of the MS is composed of intertidal sandy beaches and soft sediments that cover a basalt outcrop (Figure 54). The intertidal soft sediment habitat is low energy sandy beaches fronted by shallow tidal flats (Short 1996). The intertidal and subtidal substrate in the north of the MS is predominantly bare sediment (Blake and Ball 2001). The south west border of the MS is also dominated by bare intertidal and subtidal soft sediment (Blake and Ball 2001). Further offshore on the south west edge, the MS encompasses a small part of a very large bed of macroalgae (Figure 55), predominantly *Caulerpa*, covered sediment (Blake and Ball 2001). Along the near shore north of Point Cooke a narrow band of macroalgae, predominantly sparse *Caulerpa*, grows on the subtidal sediment (Figure 55). Offshore of the point, towards the MS boundary is a large area where both macroalgae and cunjevoi *Pyura stolonifera* grow (Blake and Ball 2001). Cunjevois can form extensive beds over the soft sediment and provide a substrate for the attachment of seaweed as well as habitat for a range of animals.

Sand patches and associated *Zostera muelleri* seagrass beds can extend across a wide band of the north-eastern section of the intertidal reef in the MS (Edmunds *et al.* 2010d). Small patches of seagrass *Heterozostera nigricaulis* and *Halophila australis* grow in the subtidal soft sediments of the MS (Blake and Ball 2001). Seagrass beds are complex and productive environments that provide habitat, nursery and feeding grounds for a wide range of organisms, including some commercially important species.

The intertidal reef is an extensive basalt rock platform and basalt boulder and cobble field around Point Cook headland (Edmunds *et al.* 2010d). The intertidal reef is generally flat, however small undulations across the reef mean that tidal inundation does not occur evenly across the reef (Edmunds *et al.* 2010d). *Ulva* spp can have large (nearly 60%) but temporally variable coverage of the intertidal reef; *Enteromorpha* spp. also occurs in moderate quantities (Edmunds *et al.* 2010d). Aggregating sessile invertebrates are not dominant (Edmunds *et al.* 2010d). Strong southerly winds often cause large amounts of subtidal drift algae to be washed onto the intertidal reef (Edmunds *et al.* 2010d). At times wrack can smother intertidal flora and fauna and create anoxic conditions in rock pools causing die off.

The subtidal reef at Point Cooke is low-relief, textured basalt reef interspersed with patches of sand and mud (Edmunds *et al.* 2011). Large beds of *Caulerpa remotifolia*, *C. longifolia*, *C. brownii* and *C. flexilis* are often present on the reef. The subtidal reef in the southern part of the MS is dominated by macroalgae (Blake and Ball 2001). The kelp *Ecklonia radiata* is present but sparse (Edmunds *et al.* 2011). The encrusting gorgonian coral *Erythropodium* can also be an important habitat forming biota on the reefs (Edmunds *et al.* 2011).

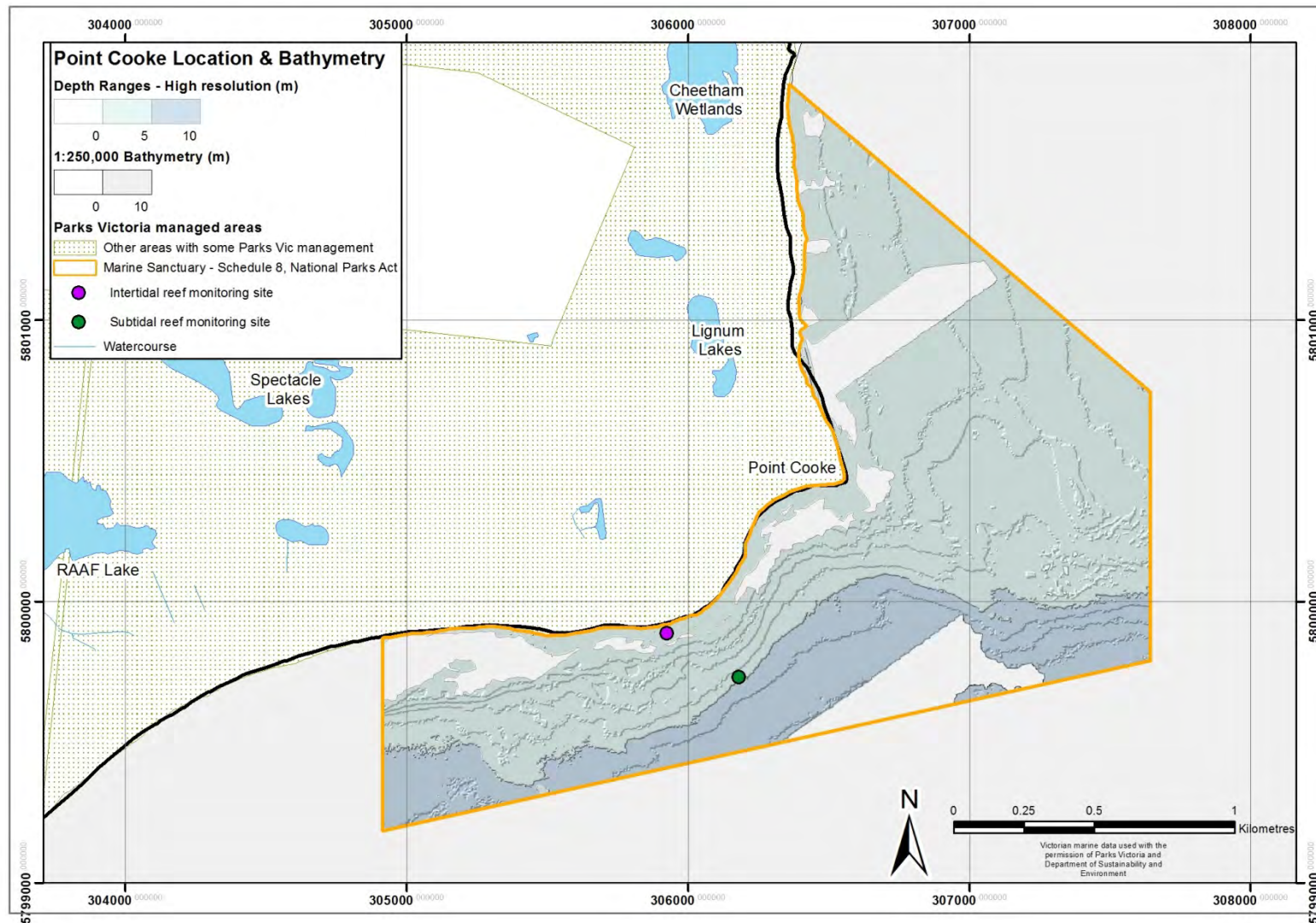


Figure 53. Detailed location map of Point Cooke Marine Sanctuary with bathymetry. The breaks in the high resolution bathymetry are artifacts and do not indicate a change in the bathymetry. Intertidal and subtidal reef monitoring sites inside the MS are shown.

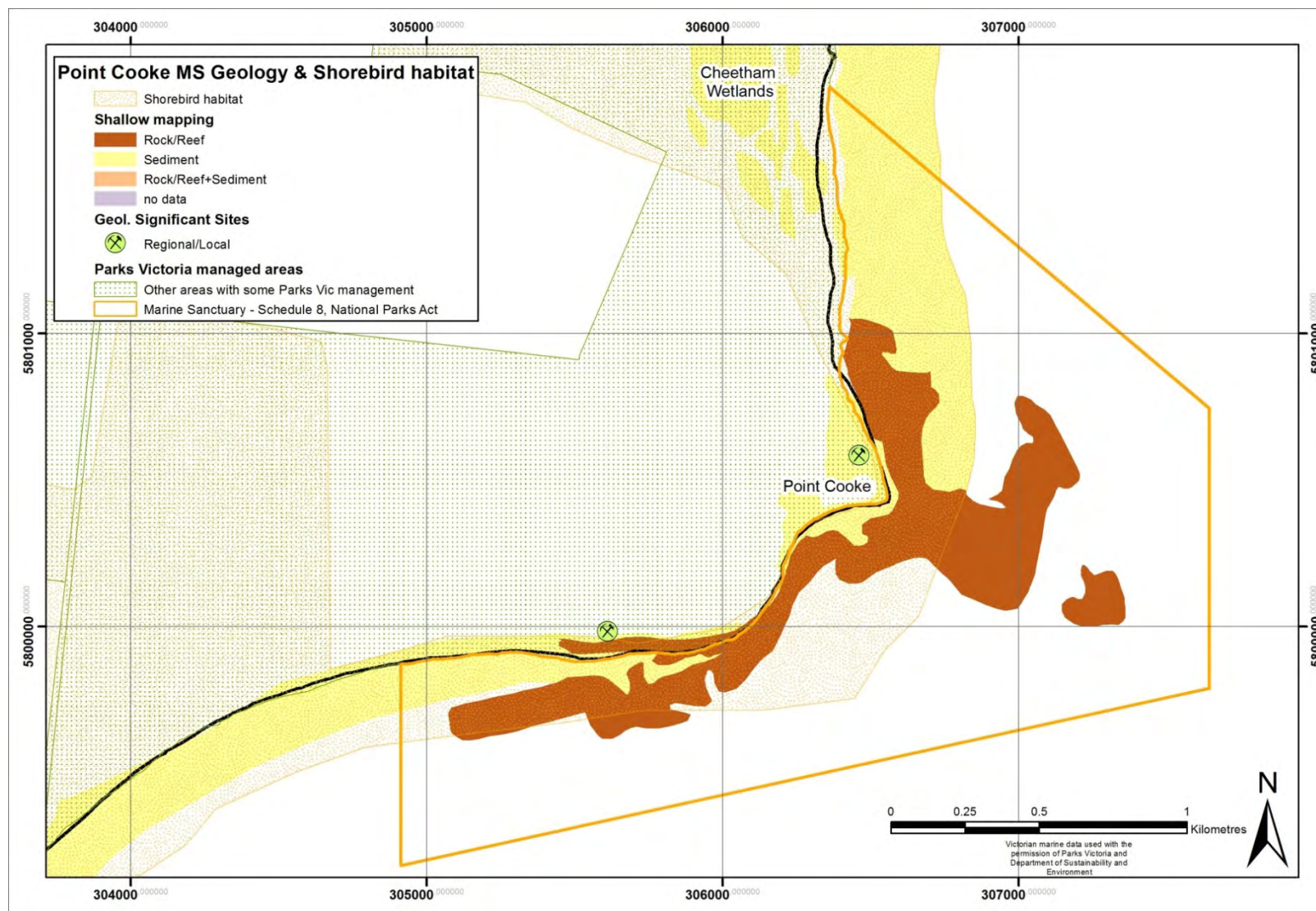


Figure 54 Geology and shorebird habitat of Point Cooke Marine Sanctuary and surrounds, showing sites of geological significance.

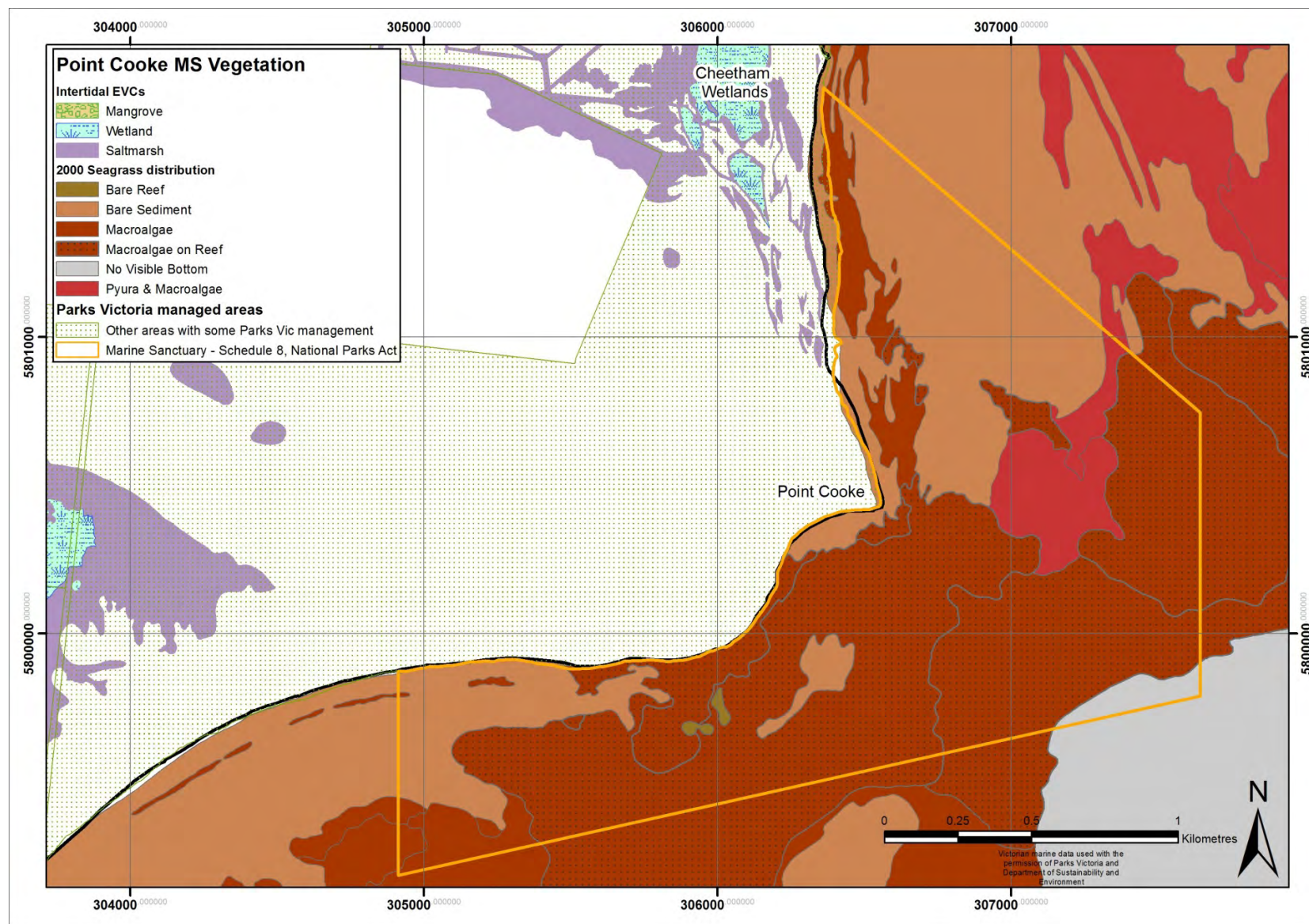


Figure 55. Vegetation map of Point Cooke Marine Sanctuary from Blake and Ball 2001.

3.1.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring surveys in Point Cooke MS. Detailed habitat mapping of the MS has also been conducted by DPI. There have been six Intertidal Reef Monitoring Program (IRMP) surveys of the intertidal reef biota of Point Cooke MS. The biota of the intertidal reef is also monitored by community groups under the Sea Search program. There have been four Subtidal Reef Monitoring Program (SRMP) surveys of the subtidal reef biota in the MS. Records of the species found in the MS indicate red algae dominates the diversity of macrophytes, gastropods the invertebrates and birds the vertebrates in Point Cooke MS (Table 10, Appendix 1). There have been no new surveys of the biota of the soft sediments or the pelagic habitats. There are no recognised significant biota sites in the MS.

Table 10. Summary of the number of species in major biotic groups found in Point Cooke Marine Sanctuary.

Biotic group	Number of species
Macrophytes	32
green algae	7
brown algae	7
red algae	16
pondweeds	1
seagrasses	1
Invertebrates	42
sponges	1
cnidarians	5
polychaetes	1
barnacles	2
decapod crustaceans	7
chitons	2
gastropods	17
bivalves	4
echinoderms	3
Vertebrates	92
fish	13
birds	77
mammals	1

Intertidal

Soft sediment

Macroscopic flora on the intertidal soft sediment is restricted to macroalgae drift and macroalgal epiphytes. The fauna of the intertidal soft sediment habitat in Point Cooke 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. Waves and currents can deposit and erode sand and shell material in the intertidal zone, periodically inundating and exposing areas of reef (Edmunds *et al.* 2010d). Sand patches and associated *Zostera muelleri* (Figure 56) seagrass beds can extend across a wide band of the reef (Edmunds *et al.* 2010d).



Figure 56. Intertidal *Zostera muelleri* seagrass beds in Point Cooke Marine Sanctuary. Photo by Trish Rice, Friends of Point Cooke.



Figure 57. Basalt boulders rimmed by the encrusting tubeworm *Galeolaria caespitosa* on the intertidal reef in Point Cooke Marine Sanctuary. Photo by Trish Rice, Friends of Point Cooke.

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, 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

The algal and sessile invertebrate communities on the intertidal reef of northern PPB are distinct from communities along the exposed coastline (Edmunds *et al.* 2010d). One major difference is that Neptune's necklace *Hormosira banksii* is not found on the intertidal reef of Point Cooke MS (Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). The intertidal community in Point Cooke MS, like Jawbone MS, can be highly variable, probably related to the ephemeral coverage of sea lettuce *Ulva* spp. and the green alga *Enteromorpha intestinalis* (Edmunds *et al.* 2010d). *Ulva* spp can be nearly 60% coverage but very variable over time (Edmunds *et al.* 2010d). *E. intestinalis* is not nearly so dominant but is also temporally variable (Edmunds *et al.* 2010d). Other macroalgae on the intertidal reef include the green algae *Caulerpa remotifolia*, brown algae *Padina fraseri* and red *Ahnfeltiopsis fastigata* (Costa *et al.* 2010; O'Hara *et al.* 2010). Aggregating sessile invertebrates do not contribute greatly to the structure of the reef, although there are small patches of *Galeolaria caespitosa* (Figure 57) and the blue mussel *Mytilus edulis* low on the shoreline (Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). The anemones, red waratah *Actinia tenebrosa*, green *Aulactinia veratra*, sand *Oulactis muscosa* and white-striped *Anthothoe albocincta* are also found on the intertidal reef (Koss *et al.* 2005a; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). Sand patches and associated *Zostera muelleri* seagrass beds can extend across a wide band of the reef (Edmunds *et al.* 2010d; Figure 69).

Mobile invertebrates

Intertidal reefs in PPB generally have a lower, and less variable, richness and diversity of mobile invertebrate species than sites along the open coastline (Edmunds *et al.* 2010d). Twenty-six species of mobile invertebrates, including 20 species of molluscs have been found on the intertidal reefs of the Point Cooke MS (Koss *et al.* 2005a; Bathgate 2010; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). Mobile invertebrate abundance is particularly low in Point Cooke MS with invertebrates most abundant in the lower areas of the shore (Edmunds *et al.* 2010d). The herbivorous gastropod *Austrocochlea porcata* (Figure 58) is the most abundant invertebrate (Edmunds *et al.* 2010d). The warrener *Turbo undulatus* is recorded in low densities on the low shore in the MS (Edmunds *et al.* 2010d). The conniwink *Bembicium* spp. and limpet *Cellana tramoserica* have only been recorded intermittently at very low densities at Point Cooke MS (Edmunds *et al.* 2010d). The carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* also occur in low densities (Bathgate 2010; Edmunds *et al.* 2010d). The shore crabs *Cyclograpsus granulatus* and *Leptograpsodes octodentatus*, and seastars *Tosia australis* and *Patiriella calcar* are also found on the intertidal reef (Costa *et al.* 2010; O'Hara *et al.* 2010), as is the hairy stone crab

Lomis hirta (Koss *et al.* 2005a). The invasive marine pest the green shore crab *Carcinus maenas* is also found on the intertidal reef in the MS (Costa *et al.* 2010; O'Hara *et al.* 2010).

Fish

Fish commonly found in the intertidal pools in Point Cooke MS include the Tasmanian blenny *Parablennius tasmanianus* and the weedfish Clinidae (Plummer *et al.* 2003).



Figure 58. The abundant zebra top shell *Austrocochlea porcata* on the intertidal reef in Point Cooke Marine Sanctuary. Photo by Trish Rice, Friends of Point Cooke

Subtidal

Soft sediment

The seagrass *Heterozostera nigricaulis* and *Halophila australis* forms patches of habitat on the subtidal soft sediment in the MS (Blake and Ball 2001; Edmunds *et al.* 2011). Seagrass beds are complex and productive environments that provide habitat, nursery and feeding grounds for a wide range of organisms, including some commercially important species. They provide habitat for epiphytic algae, grazing invertebrates such as gastropods and amphipods, and larger animals such as crabs and a range of fish. Beds of habitat forming cunjevoi *Pyura stolonifera* also occur in the MS (Edmunds *et al.* 2011). Large beds of *Caulerpa remotifolia*, *C. longifolia*, *C. brownii* and *C. flexilis* are also often present on the soft sediment (Edmunds *et al.* 2011). Modelling of suitability of habitats in PPB and commercial fisheries data concluded that the shallow subtidal soft sediments in the MS are highly suitable for sub-adult King George whiting *Sillaginodes punctata* and greenback flounder *Rhombosolea tapirina* (Morris and Ball 2006). The highly mobile Australian salmon *Arripis trutta* and *A. truttaceus* would probably move through the area over both soft sediment and reef habitats (Morris and Ball 2006). The MS is too shallow to be highly suitable for adult snapper *Pagrus auratus* but the reefs probably provide habitat for the subadults (Morris and Ball 2006).

Reef

Subtidal reefs and the assemblages associated with them (e.g. Figures 61 and 70) 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 (Figure 60) provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present. The macroalgae on the northern Port Phillip Bay reefs is generally sparse compared to the open coastal regions, reflecting the sheltered bay to estuarine environmental conditions (Lindsay *et al.* 2006). Over 19 species of macroalgae have been recorded from the MS (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). The subtidal reef is usually dominated by sparse kelp *Ecklonia radiata* (Figure 59) and the carpeting green alga *Caulerpa remotifolia* (Edmunds *et al.* 2011). Where *Caulerpa* sp. cover is dominant the cover of encrusting coralline algae is low (Edmunds *et al.* 2011). Other common species, but with cover generally less than 5 %, included sea lettuce *Ulva* sp., brown algae *Dilophus marginatus* and *Dictyota dichotoma* and thallose red algae such as *Gigartina* sp. (Edmunds *et al.* 2011). The algae density in Point Cooke MS is generally lower than in Ricketts Point MS and similar to Jawbone MS (Edmunds *et al.* 2011). The introduced Japanese kelp *Undaria pinnatifida* has been observed in the MS since 2009 and the red algae *Grateloupia turuturu* since 2010.



Figure 59. Kelp *Ecklonia radiata*, one of the dominant macroalgae on the subtidal reefs in Point Cooke Marine Sanctuary. Photo by AME.



Figure 60. Subtidal reef macroalgae in Point Cooke Marine Sanctuary: a) *Caulerpa remotifolia*; b) *C. longifolia*; c) *Ulva* sp.; d) *Codium* sp.; e) *Dictyota dichotoma*; and f) thallose red algae. Photos by AME.



a)



b)



c)



d)



e)



f)

Figure 61. Sessile invertebrates on subtidal reef in Point Cooke Marine Sanctuary: a) encrusting osculed yellow sponge; b) massive ruffled orange sponge; c) massive ruffled brown sponge; d) golf ball sponge *Tethya bergquist*; e) hard coral *Plesiastrea versipora*; and f) encrusting soft coral *Erythropodium hicksoni*. Photos by AME.

Mobile invertebrate fauna

Over 21 species of mobile marine invertebrates have been recorded from Point Cooke MS (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). The invertebrate assemblages are dominated by echinoderms including the purple sea urchin *Heliocidaris erythrogramma* and the seastars *Tosia australis*, *Meridiastra gunnii* and *Coscinasterias muricata* (Edmunds *et al.* 2011; Figures 62 and 63). Also abundant are black lip abalone *Haliotis rubra* and the granular seastar *Uniophora granifera* (Edmunds *et al.* 2011). The dominance of *H. erythrogramma* and *H. rubra* in Point Cooke MS is greater than in Ricketts Point and similar to that in Jawbone MS (Edmunds *et al.* 2011). The European fanworm *Sabella spallanzani* has been recorded in the MS (Edmunds *et al.* 2011).



a) b)
Figure 62. Seastars on subtidal reef in Point Cooke Marine Sanctuary: a) eleven armed seastar *Coscinasterias muricata*; and b) eight armed seastar *Meridiastra calcar*. Photos by AME.



Figure 63. Urchin barren on subtidal reef in Point Cooke Marine Sanctuary created by the purple sea urchin *Heliocidaris erythrogramma*. Photo by Andrew Christie, Friends of Point Cooke.

Fish

Over 16 species of fish have been observed on the subtidal reefs in the MS through the SRMP. The southern hulafish *Trachinops caudimaculatus* is one of the most abundant fish species in the MS (Jung *et al.* 2010; Edmunds *et al.* 2011). Other typical species are the little rock whiting *Neoodax balteatus*, southern goatfish *Upeinichthys vlaminghii* and other small, probably post-larval stage, unidentified fishes (Edmunds *et al.* 2011). The abundance of *T. caudimaculatus* and *N. balteatus* can be quite variable on the reef (Edmunds *et al.* 2011). There are occasional sightings of fiddler ray *Trygonorrhina fasciata* (Figure 66), zebrafish *Girella zebra*, moonlighter *Tilodon sexfasciatus*, dusky morwong *Dactylophora nigricans* and globefish *Diodon nichthemerus* (Edmunds *et al.* 2011). The highly mobile Australian salmon *Arripis trutta* and *A. truttaceus* would probably move through the MS over both soft sediment and reef habitats (Morris and Ball 2006).

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 (Figure 64), 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 fish of conservation significance are found in the waters of Point Cooke MS.



Figure 64. Blubber jellyfish *Catostylus mosaicus* in Point Cooke Marine Sanctuary. Photo by Andrew Christie, Friends of Point Cooke.

3.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora

No threatened marine flora has been recorded in Point Cooke MS (Parks Victoria 2007c).

Invertebrates

No threatened invertebrate species have been recorded in Point Cooke MS.

Fish

Pipefish (Figure 65) are found in the seagrass beds in Point Cooke MS. Under the Victorian *Fisheries Act* 1995 all syngnathid species are listed as Protected Aquatic Biota. Nationally they are listed as threatened under the *EPBC Act* 1999.



Figure 65. Pipefish *Stigmatopora nigra* are found in the seagrass beds of Point Cooke Marine Sanctuary. Photo by Andrew Christie, Friends of Point Cooke.

Birds

Forty-four conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Point Cooke MS (Table 11). Thirty are recognized as threatened in Victoria, listed under the *FFG Act* 1988 or the Victorian Rare or Threatened Species (VROTS) list. Three, the orange-bellied parrot *Neophema chrysogaster*, Australian painted snipe *Rostratula australis* and the intermediate egret *Ardea intermedia* are regarded as critically endangered in Victoria. *N. chrysogaster* is also listed as critically endangered nationally and *R. australis* is listed nationally as vulnerable. Thirty birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA).

Table 11. Conservation listed shorebird and seabird records from Point Cooke Marine Sanctuary and surrounds.

Common name	Scientific name	Victorian listing		National listing	International treaty	
		FFG	VROTS	EPBC	CAMBA	JAMBA
orange-bellied parrot	<i>Neophema chrysogaster</i>	L	CE	CE		
Australian painted snipe	<i>Rostratula australis</i>	L	CE	VU	C	
intermediate egret	<i>Ardea intermedia</i>	L	CE			
great knot	<i>Calidris tenuirostris</i>	L	EN		C	J

terek sandpiper	<i>Xenus cinereus</i>	L	EN		C	J
fairy tern	<i>Sternula nereis</i>	L	EN			
little egret	<i>Egretta garzetta</i>	L	EN			
australasian bittern	<i>Botaurus poiciloptilus</i>	L	EN			
little bittern	<i>Ixobrychus minutus</i>	L	EN			
eastern great egret	<i>Ardea modesta</i>	L	VU		C	J
little tern	<i>Sternula albifrons</i>	L	VU		C	J
white-bellied sea-eagle	<i>Haliaeetus leucogaster</i>	L	VU		C	
Baillon's crane	<i>Porzana pusilla</i>	L	VU			
common sandpiper	<i>Actitis hypoleucos</i>		VU		C	J
black-tailed godwit	<i>Limosa limosa</i>		VU		C	J
whimbrel	<i>Numenius phaeopus</i>		VU		C	J
royal spoonbill	<i>Platalea regia</i>		VU			
Caspian tern	<i>Hydroprogne caspia</i>	L	NT		C	J
Latham's snipe	<i>Gallinago hardwickii</i>		NT		C	J
Pacific golden plover	<i>Pluvialis fulva</i>		NT		C	J
red knot	<i>Calidris canutus</i>		NT		C	J
grey plover	<i>Pluvialis squatarola</i>		NT		C	J
white-winged black tern	<i>Chlidonias leucopterus</i>		NT		C	J
eastern curlew	<i>Numenius madagascariensis</i>		NT		C	J
long-toed stint	<i>Calidris subminuta</i>		NT		C	J
glossy ibis	<i>Plegadis falcinellus</i>		NT		C	
pectoral sandpiper	<i>Calidris melanotos</i>		NT			J
Pacific gull	<i>Larus pacificus</i>		NT			
piebald cormorant	<i>Phalacrocorax varius</i>		NT			
nankeen night heron	<i>Nycticorax caledonicus</i>		NT			
sooty oystercatcher	<i>Haematopus fuliginosus</i>		NT			
whiskered tern	<i>Chlidonias hybridus</i>		NT			
common diving-petrel	<i>Pelecanoides urinatrix</i>		NT			
red-necked stint	<i>Calidris ruficollis</i>				C	J
ruddy turnstone	<i>Arenaria interpres</i>				C	J
cattle egret	<i>Ardea ibis</i>				C	J
curlew sandpiper	<i>Calidris ferruginea</i>				C	J
bar-tailed godwit	<i>Limosa lapponica</i>				C	J
sharp-tailed sandpiper	<i>Calidris acuminata</i>				C	J
common greenshank	<i>Tringa nebularia</i>				C	J
common tern	<i>Sterna hirundo</i>				C	J
marsh sandpiper	<i>Tringa stagnatilis</i>				C	J
buff-breasted sandpiper	<i>Tryngites subruficollis</i>				C	J
short-tailed shearwater	<i>Ardenna tenuirostris</i>					J

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

Point Cooke MS is shallow and dominated by intertidal and subtidal reefs. It does not provide habitat for large marine mammals. It does provide occasional habitat for seals and the nationally vulnerable subantarctic fur seal *Arctophoca tropicalis* has been sighted in or near the MS.

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state did not identify any biota endemic to Point Cooke MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Six biota (Table 12) are presumed to be at their distributional limit in Point Cooke MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). A seagrass, a shrimp, a chiton and sea cucumber are presumed to be at the eastern limit of their distribution within Point Cooke MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). A crab and a ghost shrimp are presumed to be at the western limit of their distribution in Point Cooke MS. The distributional limits of the biota listed in Table 12 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 12. Marine species at their distribution limits in Point Cooke Marine Sanctuary (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Phylum	Order	Family	Species	Common name	Category
Magnoliophyta	Potamogetonales	Zannichelliaceae	<i>Lepidaena marina</i>	seagrass	PE
Crustacea	Caridea	Alpheidae	<i>Athanopsis australis</i>	shrimp	PE
Crustacea	Brachyura	Mictyridae	<i>Mictyris platycheles</i>	crab	PW
Crustacea	Thalassinidea	Axiidae	<i>Axiopsis werribee</i>	ghost shrimp	PW
Mollusca	Polyplacophora	Acanthochitonidae	<i>Acanthochitona gatliffi</i>	chiton	PE
Echinodermata	Holothuroidea	Chiridotidae	<i>Scoliorhapis sp MoV 1643</i>	sea cucumber	PE

PE = presumed eastern limit, PW = presumed western limit



Figure 66. Fiddler ray *Trygonorrhina fasciata* on the subtidal reef in Point Cooke Marine Sanctuary. Photo by Trish Rice, Friends of Point Cooke.

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 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). Fourteen 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 MS is indicated in brackets:

1. Invasive species competing for space with local marine biota (all of MS);
2. Poaching of abalone leading to reduced populations (subtidal reef);
3. Walkers disturbing shorebirds, seabirds and waterfowl (intertidal soft sediment and reef);
4. Increasing development leading to increasing runoff and thus increasing nutrient loads, resulting in changes to macroalgal species composition (intertidal and subtidal reef);
5. Rising sea level due to climate change leading to reduced shorebird habitat and reduced habitat value of rocky reef (intertidal soft sediment and reef);
6. Failure to document ecological change leading to effects on sanctuary biota (all of MS);
7. Ineffectiveness of seaward signs and boundary markers (too few/too far apart) resulting in illegal fishing in sanctuary and thus reduced populations of fish and abalone (subtidal reef and soft sediment);
8. Current Port of Melbourne channel deepening project causing increased turbidity affecting plant populations, and the release of contaminants from sediments affecting fish and filter feeding organisms (all of MS);
9. Dogs off-lead disturbing shorebirds and waders, leading to reduced reproduction and thus declining populations (intertidal soft sediment and reef);
10. Feral carnivores (foxes, cats) preying on shorebirds and waders, leading to reduced reproduction and thus declining bird populations (intertidal soft sediment and reef);
11. Industrial spills or seepage into Skeleton Creek affecting biota in the sanctuary (all of MS);
12. Increasing human population leading to increasing trampling and resulting in damage to intertidal shellfish and seagrass (intertidal soft sediment and reef);
13. General collecting of species leading to reduced populations of target species (intertidal reef); and
14. Groundwater seepage of pesticides and herbicides from market gardens affecting algae and invertebrates and the sanctuary (intertidal and subtidal reef).

The introduction of marine pests threatens the integrity of marine biodiversity and may also reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are found in Port Phillip Bay (Parks Victoria 2003). The introduced green shore crab *Carcinus maenas* is found within Point Cooke MS. The European fan worm *Sabella spallanzani* has been recorded in the MS since 2003. Invasive Japanese kelp *Undaria pinnatifida* (Figure 67) has been recorded in the MS since early 2009 and the red algae *Grateloupia turuturu* since 2010. Other species of particular concern include the Northern Pacific seastar *Asterias amurensis* and broccoli weed *Codium fragile* (*subsp. fragile*) (Parks Victoria 2003).

There have been reports of abundances of the purple urchin, *Heliocidaris erythrogramma* (Figure 68), increasing in abundance forming barrens habitat in the northern part of the bay, including in Point Cooke Marine Sanctuary. In areas where barrens have been established

erect macroalgae are usually absent. It is unclear whether the recent increases in abundance are part of a natural cycle or part of a persistent increase in this native species.



Figure 67. Invasive Japanese kelp *Undaria pinnatifida* on the subtidal reef in Point Cooke Marine Sanctuary. Photo by Andrew Christie, Friends of Point Cooke.

A virus affecting abalone called abalone viral ganglioneuritis 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 Cooke 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 Point Cooke MS and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in 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 Point Cooke MS (Parks Victoria 2007c). For example, research is being conducted into marine pest species, and investigations into water quality issues have also been conducted. 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 68. Purple sea urchin *Heliocidaris erythrogramma* on the subtidal reef in Point Cooke Marine Sanctuary. Photo by Andrew Christie, Friends of Point Cooke.

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 Point Cooke 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 13 and Appendix 2).



Figure 69. Intertidal sand and reef flats with seagrass *Zostera muelleri* beds in Point Cooke Marine Sanctuary. Photo by Andrew Christie, Friends of Point Cooke.

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 Point Cooke 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.
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

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

Point Cooke MS has an ongoing intertidal (IRMP) and a shallow subtidal (SRMP) reef monitoring program. The intertidal reef monitoring program in and around the Point Cooke MS began in 2003 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). Since then there have been six surveys (Edmunds *et al.* 2004b; Hart *et al.* 2005; Edmunds *et al.* 2010d). 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). The monitoring site (Figure 53) is on the largest continuous area of reef to the west of Point Cooke in the MS (Edmunds *et al.* 2010d). The reference site is at Altona (Figure 53), with intertidal habitat similar to that at Point Cooke could not be found any closer (Edmunds *et al.* 2004b).

The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003b) around Point Cooke MS began in 2003 and there have been 4 surveys (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). The SRMP involves standardised underwater diver-mediated visual survey methods (Edmunds and Hart 2003b). The SRMP surveys a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish. Monitoring is undertaken at Point Cooke MS along four contiguous 50m transects at a single site in 3-4 m over the reef and patches of sand (Figure 53). The reference site is located offshore from the RAAF Base at Laverton in the same water depth (Edmunds *et al.* 2011).

Preliminary analysis of both the IRMP and SRMP data collected a few years after declaration was done across the three PPB MSs. Intertidal biota did not show a difference in number of species or abundance due to protection (Keough and Carnell 2009). Long term monitoring is needed to provide the power to adequately test the effect of protection (Keough and Carnell 2009). Even then the effects may vary among MPAs, perhaps varying with the level of threat from harvesting of fauna (Keough and Carnell 2009). Subtidal biota did not show a difference in species richness or number of species between MPA and reference sites post-declaration (Keough and Carnell 2009). The abundances of common algae did vary between MS and reference sites, but generally in no obvious or consistent way, reducing confidence that the difference observed is an effect of the MSs (Keough and Carnell 2009). Further surveys may clarify these results. The sea star *Uniophora granifera* was the only invertebrate to display a difference in abundance between MS and reference sites across the three MSs (Keough and Carnell 2009). *U. granifera* was more abundant in reference sites compared to the MSs. None of the fish species displayed clear and consistent trends in abundance inside and outside of the three MSs (Keough and Carnell 2009). The abundances of fish were generally quite low, except for the hulafish *Trachinops caudimaculatus*. A separate research project on the impact of protection through MPAs on intertidal reef gastropods in PPB and Central coast found an MPA effect on the sizes of the limpets *Cellana tramoserica* and *Patelloida alticostata* (Bathgate 2010). Both species had larger shell length in MPAs than non-MPA sites. For *C. tramoserica*, this effect is most apparent at sites like Point Cooke and Jawbone MSs which have a long history of protection prior to their current declaration as MPAs (Bathgate 2010).

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.

A review will also be taken of the monitoring programs. Community based monitoring of the intertidal and subtidal reef under Sea Search is being conducted by Marine Care Point Cooke group (Koss *et al.* 2005b). This group is also cataloguing the natural values of the MS, monitoring Port Jackson sharks and participating in the Reef Watch fish count. Other groups that have a close association with the sanctuary include the Friends of Point Cook Coastal Park, Friends of Skeleton Creek, and the Victorian Wader Study Group (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.

3.1.7 KNOWLEDGE GAPS

No surveys have been conducted on the ecological communities of intertidal and subtidal soft sediments other than bird surveys and habitat mapping. Little is known about intertidal fish in the MS. No information exists at present for water column assemblages. Major threats have been identified for Point Cooke MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.



Figure 70. Purple sponge on the subtidal reef of Point Cooke Marine Sanctuary. Photo by Andrew Christie, Friends of Point Cooke.

3.2 Jawbone Marine Sanctuary

Jawbone MS is one of three Marine Sanctuaries in the Victorian Embayments bioregion. All the MSs in the bioregion are in Port Phillip Bay (PPB) and include Point Cooke and Ricketts Point MSs. The bioregion also has five Marine National Parks: Port Phillip Heads, Yaringa, French Island, Churchill Island and Corner Inlet. Jawbone MS is in the north-west of PPB, offshore from Williamstown about 10 km from Melbourne CBD (Figure 71). The MS begins west of the fishing clubs in Bayview Street and runs west 1.9 km along the foreshore around the Jawbone to wader beach south of McGuire Crescent (Parks Victoria 2007a). It abuts the Jawbone Flora and Fauna reserve and extends from the high water mark to a maximum of 300 m offshore (Parks Victoria 2007a).

The mudflats, thick coastal vegetation and adjacent wetlands seclude and separate the MS from the adjacent urban area (Parks Victoria 2007a). The area was protected from human disturbance and urban development by the existence of the Merrett Rifle Range for 110 years until 1987 (Parks Victoria 2007a). Since then the intertidal area from the western boundary to the fence line east of Compass Hill, and extending 50 m seaward from high water mark has been declared a Special Protection Area and access from both shore and water is prohibited (Parks Victoria 2007a). Access to the MS is on designated walking tracks via Jawbone Reserve and Jawbone Flora and Fauna Reserve (Parks Victoria 2007a). The MS has five shipwrecks listed on the Victorian Heritage Register and is part of a ship scuttling ground (Parks Victoria 2007a).

Aboriginal tradition indicates that the sanctuary is part of *Country* of Boon Wurrung people (Parks Victoria 2007c).

Important natural values of Jawbone MS are its mangroves *Avicennia marina* growing on the soft sediment between massive basalt boulders on the intertidal reef, one of the few stands of mangrove in PPB (ECC 2000; Carey *et al.* 2007b; Parks Victoria 2007a). Its intertidal and subtidal basalt reefs support diverse algae, invertebrate and fish communities (ECC 2000; Carey *et al.* 2007b; Parks Victoria 2007a). Its seagrass beds provide habitat for invertebrates and a nursery for juvenile fish species (Parks Victoria 2007a). Its basalt reefs, shallow inshore waters, mudflats and seagrass beds provide foraging and roosting area for local and migratory seabirds and shorebirds (ECC 2000; Carey *et al.* 2007b; Parks Victoria 2007a). The adjoining coastal vegetation, including its saltmarsh communities, provide habitat for local and migratory seabirds and shorebirds and are of State significance (ECC 2000; Carey *et al.* 2007b; Parks Victoria 2007a). The intertidal and nearshore habitats and associated ecological values of the MS have been protected from human disturbance for over 110 years and as such are valuable for scientific reference (Parks Victoria 2007a).

Macroalgal and sessile invertebrate cover on the intertidal reefs is very low (Edmunds *et al.* 2010d). There is ephemeral coverage of sea lettuce *Ulva* spp. and the green alga *Enteromorpha* spp. (Edmunds *et al.* 2010d). Turfing and coralline algae, the seagrass *Zostera muelleri* and calcareous tube-worm *Galeolaria caespitosa* are present very low in the intertidal zone (Edmunds *et al.* 2010d). The invasive marine pest broccoli weed *Codium fragile* (*subsp. fragile*) is found on the intertidal reefs of the MS (Edmunds *et al.* 2010d). Twenty species of mobile invertebrates, including 19 species of molluscs have been found on the intertidal reefs of Jawbone MS (Bathgate 2010; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). The intertidal mobile invertebrate community at Jawbone is dominated by the top shell *Austrocochlea porcata*, the conniwink *Bembicium* spp., the black nerite *Nerita atramentosa* and the variegated limpet *Cellana tramoserica* (Bathgate 2010; Edmunds *et al.* 2010d). Found in low abundance are the whelk *Lepsiella vinosa*, top shell *Austrocochlea odontis*, warrener *Turbo undulatus*, limpets *Notoacmea mayi*, *Patelloida alticostata*, *Siphonaria* spp. and the seastar *Parvulastra exigua* (Edmunds *et al.* 2010d). The introduced green shore crab *Carcinus maenas* is found within Jawbone MS. No information

is known for the fish species of the intertidal reef (Plummer *et al.* 2003). Associated with the mangroves are saltmarsh, extensive wet saltmarsh herbland dominated by the beaded glasswort *Sarcocornia quinqueflora* and landward of that coastal hypersaline shrubland (Plummer *et al.* 2003; Victorian Saltmarsh Study 2011).

A lot of the subtidal soft sediment in the MS is bare of vegetation. In the north west of the MS there is a large bed of seagrass *Zostera/Heterozostera* (Blake and Ball 2001). Over 16 species of macroalgae have been recorded on the subtidal reefs in the MS. The subtidal reef in Jawbone MS is not diverse, with low to moderate abundances of kelp *Ecklonia radiata*, *Sargassum* spp (generally only as basal leaves), filamentous brown algae Ectocarpales and encrusting coralline algae (Edmunds *et al.* 2011). Encrusting coralline algal can be abundant. The algal communities are indicative of high nutrients and low salinities which suggests a large estuarine influence from Kororoit Creek (Edmunds *et al.* 2011). Sessile invertebrates include the coral *Plesiastrea versipora* and sponges (Edmunds *et al.* 2011). The invasive marine pest Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile* (*subsp. fragile*) have been observed in the MS since 2009.

Over 14 species of mobile invertebrates have been recorded from the subtidal reefs of the MS (Edmunds *et al.* 2011). The mobile invertebrate assemblage is dominated by the sea urchin *Heliocidaris erythrogramma*, the seastars *Meridiastra gunnii*, *Meridiastra calcar* and *Coscinasterias muricata* and the blacklip abalone *Haliotis rubra* and to a lesser extent the biscuit star *Tosia australis* (Edmunds *et al.* 2011). The introduced northern Pacific seastar *Asterias amurensis* and European fanworm *Sabella spallanzanii* have been observed sporadically in low numbers in the MS (Edmunds *et al.* 2011). The introduced green shore crab *Carcinus maenas* is found within Jawbone MS. Over 17 species of fish have been observed on the subtidal reefs with the southern hulafish *Trachinops caudimaculatus* the most dominant (Jung *et al.* 2010; Edmunds *et al.* 2011). Present in very low densities are zebrafish *Girella zebra*, dusky morwong *Dactylophora nigricans* and little rock whiting *Neodax balteatus* (Edmunds *et al.* 2011).

Jawbone MS provides important feeding and roosting habitat for thirty-six threatened bird species such as the orange-bellied parrot *Neophema chrysogaster*, grey-tailed tattler *Heteroscelus brevipes* and the intermediate egret *Ardea intermedia*, which are listed under the *Flora and Fauna Guarantee (FFG) Act* (1998) and regarded as critically endangered in Victoria. The MS protects feeding areas for twenty-four internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Five species of marine flora and fauna are believed to be at their distributional limits within the MS.

Serious threats to the Jawbone MS include limited ecological knowledge of important processes. Trampling, illegal fishing, sediments from dredging, disturbance of birds, nutrients from stormwater, invasive marine pests, pollutants from Kororoit Creek 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 Jawbone MS (Parks Victoria 2007a). Ongoing subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Jawbone MS.

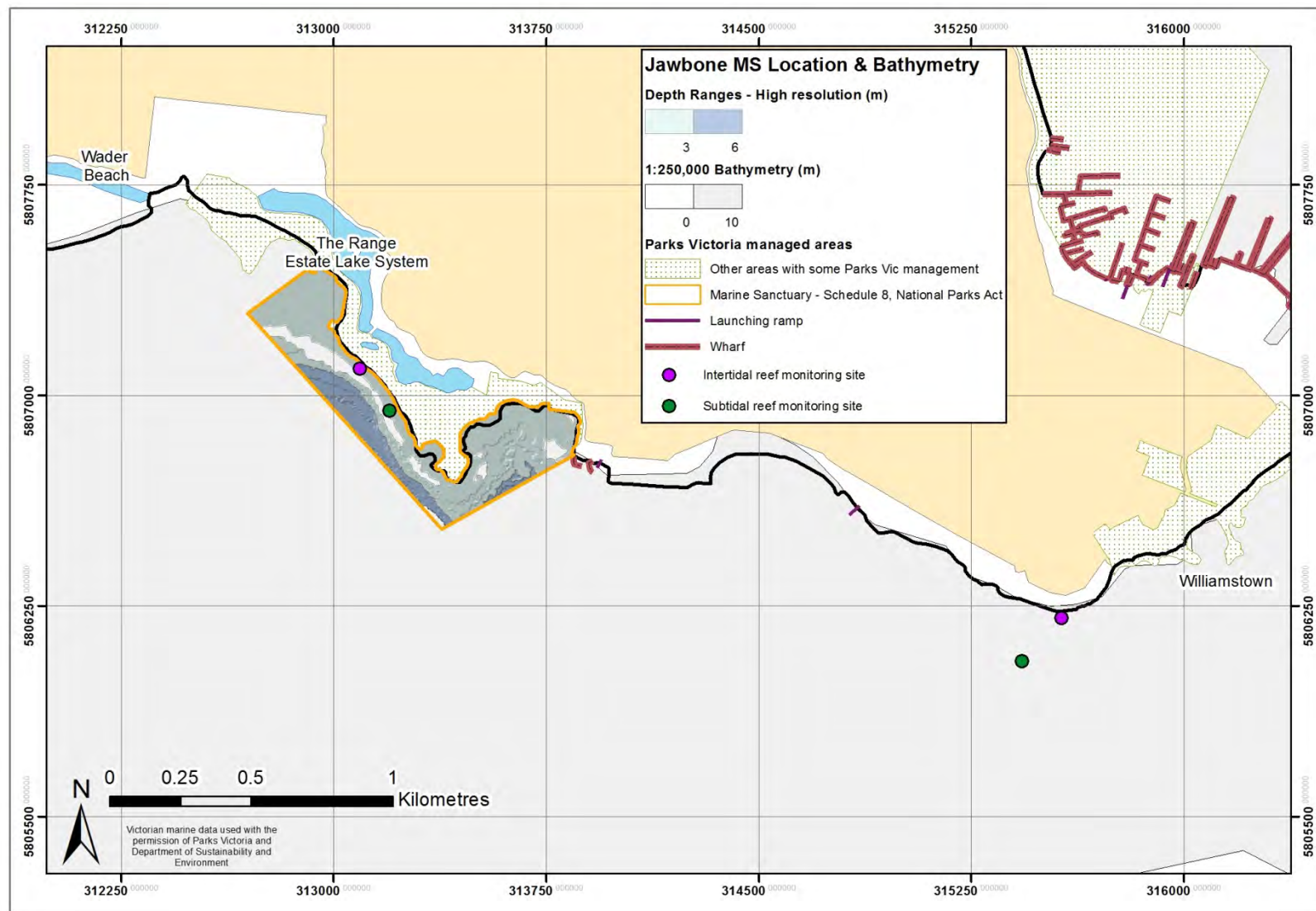


Figure 71. Location map of Jawbone Marine Sanctuary with bathymetry. Intertidal and subtidal reef monitoring sites inside and outside the MS are shown.

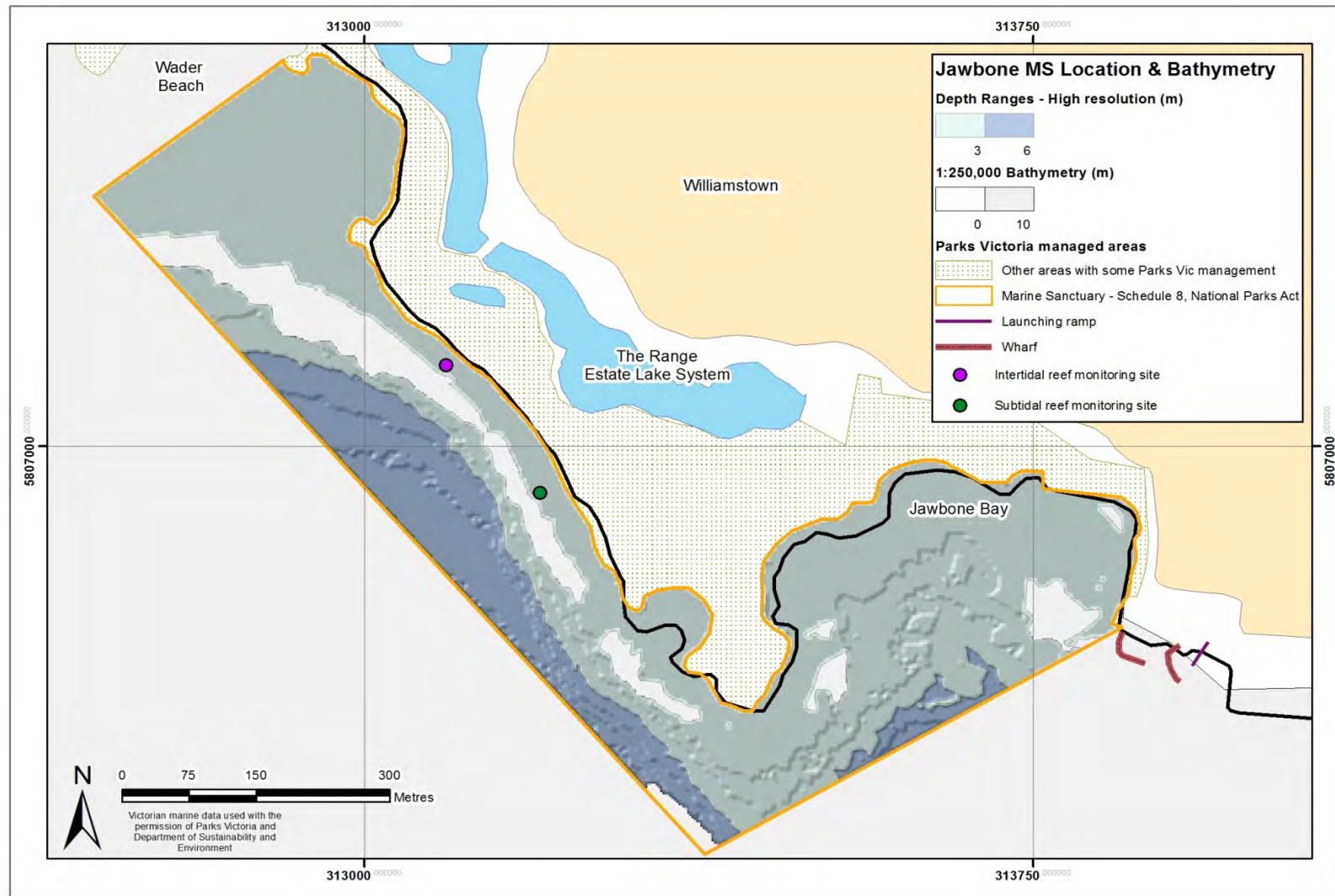


Figure 72. Detailed location map of Jawbone Marine Sanctuary with bathymetry. Intertidal and subtidal reef monitoring sites inside the MS are shown.

3.2.1 PHYSICAL PARAMETERS & PROCESSES

Jawbone MS (Figure 73) is 30.5 hectares in size which makes it the sixth smallest of the 24 Marine National Parks or Sanctuaries in Victoria. The MS is shallow, with the majority of the park < 4 m deep (Table 14 & Figure 72). The MS has an unequal semidiurnal tidal pattern, with a higher and lower flooding and ebbing event daily. Tidal variation within the MS is 0.8 metres for spring tides and 0.2 metres for neap tides (Plummer *et al.* 2003). The water in the sanctuary is exchanged every 28 – 50 tidal cycles (Parks Victoria 2007a). Surface water temperatures average 20.4 °C in the summer and 11.6 °C in the winter (Plummer *et al.* 2003).

The MS is not subject to large waves, strong currents or swell (Edmunds *et al.* 2011). There is little background swell in this part of PPB; the water is calm when the wind is still (Parks Victoria 2007a). In moderate winds the waves are choppy and under 0.5 m, but in strong westerly conditions waves can reach heights of 2 m (Parks Victoria 2007a). Natural hydrodynamic events such as storm surges displace seaweed and kelp communities, erode beaches and deposit sand over the reefs (Parks Victoria 2007a).

There are no rivers or creeks that flow directly into the sanctuary. One stormwater drain near Bayview Street at the rear of the Williamstown High School discharges into the eastern end of the sanctuary (Parks Victoria 2007a). Overflow and seepage from The Range Estate Lake system may also reach the MS. To the west Kororoit Creek is only 500 m from the MS boundary. To the south west Cherry Creek/Melbourne Water Drainage Easement and Laverton Creek may also influence the MS (Parks Victoria 2007a). The MS is subject to episodes of lower salinities from drains and the Kororoit River (Edmunds *et al.* 2011). Freshwater runoff, phytoplankton blooms and disturbance of nearby fine sediments frequently create turbid conditions in the MS (Edmunds *et al.* 2011).

Table 14. Physical attributes of the Jawbone Marine Sanctuary.

Park Name	Jawbone
Conservation status	Marine Sanctuary
Biophysical Region	Victorian Embayments
Size	30.5 ha (ranked 19 th of 24)
Length of coastline	~1.9 km
Shoreline geology	basalt
Area with depth:	
(low res)* 0-10 m	3.32 ha
(high res) Supratidal	2.25 ha
Intertidal	11.77 ha
Intertidal-2 m	4.89 ha
2-4 m	4.83 ha
4-6 m	3.31 ha
6-8 m	0.14 ha
Mean tidal variation - spring	0.8 m
Mean tidal variation - neap	0.2 m
Mean water temp - summer	20.4°C
Mean water temp - winter	11.6°C
Adjacent catchment	Urban and conservation
Discharges into MNP	Bay Street stormwater drain
Nearest major estuary (distance & direction)	Kororoit Creek 0.5 km west Cherry Creek 2 km south west Laverton Drain 5.5 km south west Yarra River 6 km north east

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

The Jawbone area consists of sandy beach flanked by basalt rock outcrops that are the seaward end of flows of basalt lavae that characterize Melbourne's western plains (Plummer *et al.* 2003). Merrett Rifle Range shore platform, with its Quaternary volcanics, intertidal reef, shell deposits and mangroves is of regional geological significance (Figure 71). To the west of the MS Altona East sand bars are part of a major sand bars/spit/ridge system of regional geological significance.



Figure 73. Aerial view of Jawbone Marine Sanctuary. Photo by Tim Allen.

3.2.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. Jawbone habitat was mapped from aerial photography and ground-truthed by site visits and underwater video transects (Blake and Ball 2001).

There is very little intertidal sandy beach in Jawbone MS (Figure 75). The only continuous beach is in Jawbone Bay in the south of the MS, fronted by 300 to 400 m wide sand flats (Short 1996). There is an extensive area of basalt intertidal reef and boulder field in the MS (Parks Victoria 2007a; Edmunds *et al.* 2010d). The intertidal reef forms a band up to 30 m wide and extends for several hundred metres from the point at Jawbone (Figure 72 & Figure 75), to the southwest boundary of the MS (Edmunds *et al.* 2010d). Large basalt blocks over 2 m in diameter are attached to the basalt base (Parks Victoria 2007a). Among the large

blocks are loose boulders and the occasional patches of gravel (Parks Victoria 2007a). The large basalt boulders create medium to high relief intertidal reef with considerable habitat structure because of the large amount of vertical substratum and crevices (Edmunds *et al.* 2010d). The intertidal reef at Jawbone MS has a large estuarine influence because of the proximity of Kororoit Creek (Edmunds *et al.* 2010d). Landward the intertidal reef is buried by sand, silt and shells. It has patches of white mangroves *Avicennia marina* (Figure 76), which extend around into a shallow lagoon behind the platform (Parks Victoria 2007a). Many of these mangroves have established their roots in pockets of sediment lodged in fissures in the fractured basalt (Parks Victoria 2007a). There are remnants of a stone wall from the former Merrett Rifle Range along the shoreline of Jawbone Bay (Parks Victoria 2007a).

Onshore, the mangrove shrubland is backed by extensive wet saltmarsh herbland and landward of that, coastal hypersaline shrubland (Figure 76). A small patch of saline aquatic meadow occurs within the MS boundaries on the north west coast. There is an area of mangrove and salt marsh habitat at the eastern end of the sanctuary near Kororoit Creek fronted by wide sand flats (Short 1996; Edmunds *et al.* 2010d).

In the south east of the MS the nearshore subtidal habitat of Jawbone Bay is bare sediment with some areas of macroalgae on subtidal reef (Blake and Ball 2001). Drift algae can be a large presence on the subtidal soft sediments. Offshore in the Bay and along the shore to the west of the point at Jawbone the subtidal reef is predominantly bare. In the southern corner of the MS offshore of the point, macroalgae grows on the subtidal reef (Figure 76). The subtidal reef at Jawbone MS is in shallow water (< 4 m) and consists of large basalt boulders and bedrock sloping steeply to sand at the toe of the reef (Edmunds *et al.* 2011). The kelp *Ecklonia radiata* is only sparse and not a dominant habitat forming algae in the MS. The green algae *Enteromorpha* and the encrusting coral *Plesiastrea* can be important habitat forming biota on the reef. In the north west of the MS there is a large bed of seagrass *Zostera/Heterozostera* and macroalgal covered reef (Blake and Ball 2001).



Figure 74. Nudibranch *Ceratosoma brevicaudatum* on the subtidal reef of Jawbone Marine Sanctuary. Photo by Sandy Webb, Friends of Jawbone.

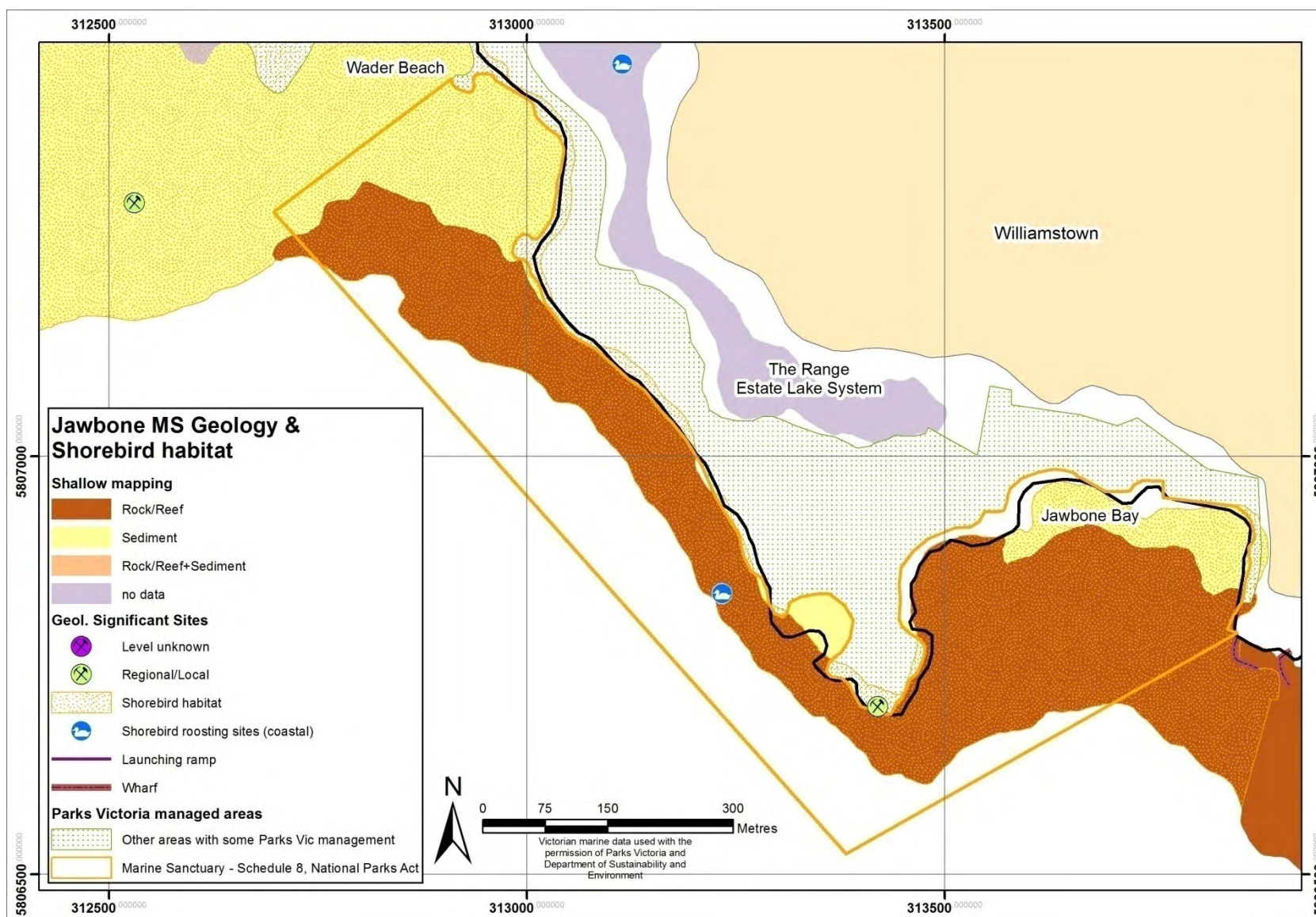


Figure 75. Geology and shorebird habitat of Jawbone Marine Sanctuary and surrounds, showing sites of geological and biotic significance.

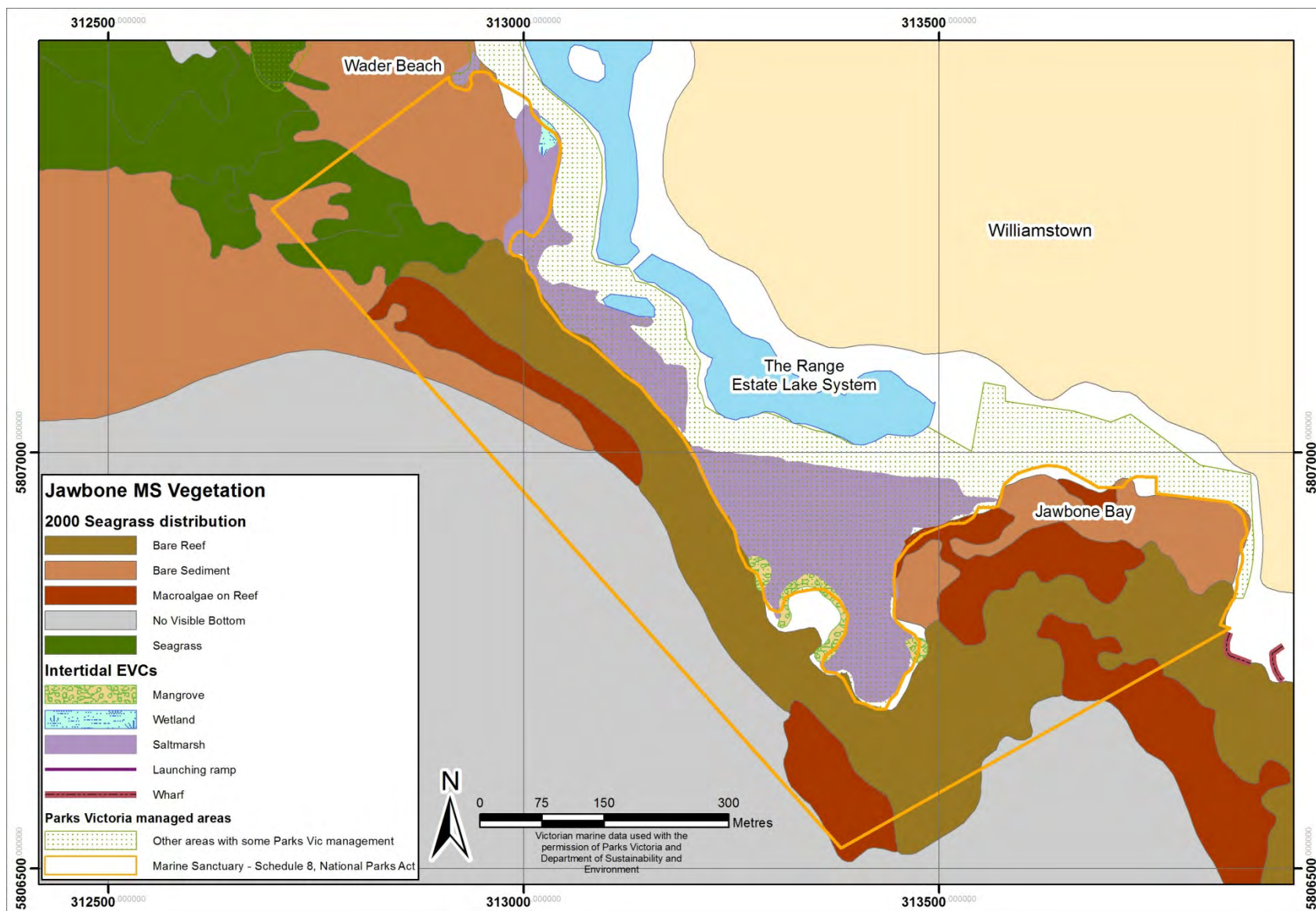


Figure 76. Vegetation map of Jawbone Marine Sanctuary and surrounds.

3.2.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring surveys in Jawbone MS. Habitat maps have also been developed for the MS by DPI. There have been six Intertidal Reef Monitoring Program (IRMP) surveys of the intertidal reef biota of Jawbone MS. There have been four Subtidal Reef Monitoring Program (SRMP) surveys of the subtidal reef biota in the MS. Records of species found in the MS show that algae dominate the diversity of macrophytes, gastropods the invertebrates and birds the vertebrates in Jawbone MS (Table 15, Appendix 1). There have been no new surveys of the biota of the soft sediments, or the pelagic habitats. Important locations for some birds are shown in Figure 75. There is one recognised significant biota site in the MS. Rocky Point is a minor summer wader roost for pied oystercatchers and large numbers of cormorants. Nearby the artificial wetland New Jawbone Pond is a major roosting site for shorebirds.

Table 15. Summary of the number of species in major biotic groups found in Jawbone Marine Sanctuary.

Biotic group	Number of species
Macrophytes	23
blue-green algae	1
green algae	6
brown algae	6
red algae	7
lichens	1
pondweeds	1
seagrasses	1
Invertebrates	23
sponges	1
cnidarians	2
polychaetes	1
barnacles	2
decapod crustaceans	1
gastropods	15
echinoderms	1
Vertebrates	81
fish	13
birds	60
mammals	6

Intertidal

Soft sediment

Macroscopic flora on the intertidal soft sediment is restricted to macroalgae drift and macroalgal epiphytes. The fauna of the intertidal soft sediment habitat in Jawbone 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 mangrove *Avicennia marina* community at Jawbone Marine Sanctuary is very unusual because it grows on the sediment amongst massive basalt boulders rather than on intertidal mudflats which is unique for Victoria (Plummer *et al.* 2003). Associated with the mangroves are saltmarsh extensive wet

saltmarsh herbland dominated by the beaded glasswort *Sarcocornia quinqueflora* and landward of that, coastal hypersaline shrubland (Plummer *et al.* 2003; Victorian Saltmarsh Study 2011).

Reef

Rocky intertidal reefs (Figures 77 and 78), also called rocky reefs or intertidal platforms, are generally found in Victoria on and near headlands with stretches of sandy beaches either side. Along with beaches, intertidal reefs are one of the most accessible components of the marine environment as they are the interface between the ocean and the land (Power and Boxshall 2007). As such they are valued as important habitats by people and tend to be visited more than other sections of the coast (Carey *et al.* 2007a; Carey *et al.* 2007b). This means they are often subjected to human pressures like harvesting, fossicking and trampling as well as pressures from pollution sources on land and in the sea (Power and Boxshall 2007).

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



Figure 77. Intertidal basalt reef in Jawbone Marine Sanctuary. Photo by AME.

Macroalgae and aggregating invertebrates

Most of the algal and sessile invertebrate communities on the intertidal reef of northern Port Phillip Bay are distinct from communities along the exposed coastline (Edmunds *et al.* 2010d). The abundance of macroalgae and sessile invertebrates is very low at Jawbone MS, covering less than 5% of the reef (Edmunds *et al.* 2010d). Neptune's necklace *Hormosira banksii* is not found on the intertidal reefs of Jawbone MS (Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). The intertidal community at Jawbone MS, like Point Cooke, can be highly variable, probably related to the ephemeral coverage of sea lettuce *Ulva* spp. and the green alga *Enteromorpha* spp. (Edmunds *et al.* 2010d). Turfing and coralline algae, the seagrass *Zostera muelleri* and the calcareous tube-worm *Galeolaria caespitosa* (Figure 79) are present very low in the intertidal zone (Edmunds *et al.* 2010d). The invasive marine pest broccoli weed *Codium fragile* (subsp. *fragile*) is found on the intertidal reefs of the MS (Edmunds *et al.* 2010d).



Figure 78. Submerged intertidal reef in Jawbone Marine Sanctuary. Photo by Emily Matheson, Parks Victoria.

Mobile invertebrates

Intertidal reefs in PPB generally have a lower, and less variable, richness and diversity of mobile invertebrate species than sites along the open coastline (Edmunds *et al.* 2010d). Twenty species of mobile invertebrates, including 19 species of molluscs have been found on the intertidal reefs of Jawbone MS (Bathgate 2010; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010; Figure 74). The mobile invertebrate community at Jawbone is dominated by the top shell *Austrocochlea porcata*, the conniwink *Bembicium* spp., the black nerite *Nerita atramentosa* and the variegated limpet *Cellana tramoserica* (Bathgate 2010; Edmunds *et al.* 2010d). The carnivorous whelk *Lepsiella vinosa* is found in low abundance (Edmunds *et al.* 2010d). Also found in low abundance are the top shell *Austrocochlea odontis*, warrener *Turbo undulatus*, limpets *Notoacmea mayi*, *Patelloida alticostata*, *Siphonaria* spp. and the seastar *Parvulastra exigua* (Edmunds *et al.* 2010d). The introduced green shore crab *Carcinus maenas* is found within Jawbone MS.

Fish

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

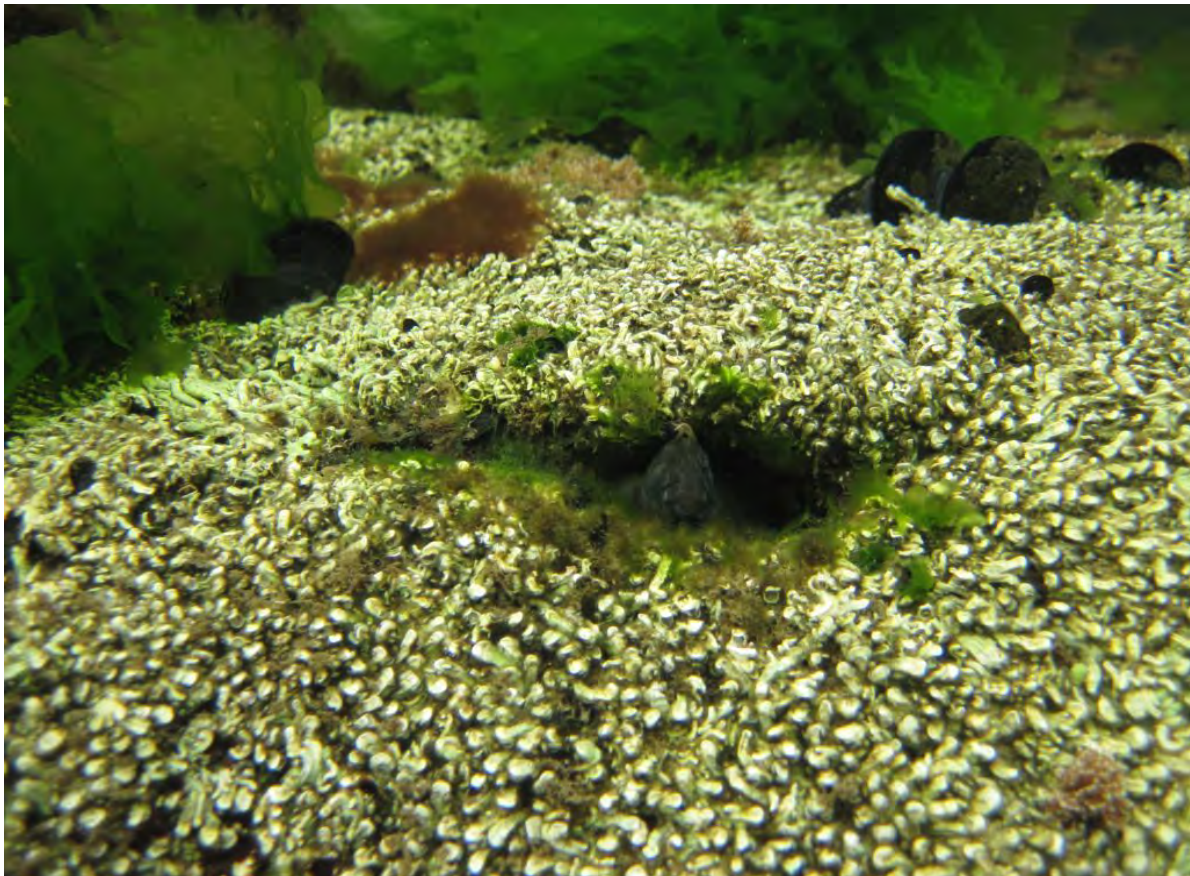


Figure 79. The calcareous tube-worm *Galeolaria caespitosa* is found on both intertidal and subtidal reefs in Jawbone Marine Sanctuary. Photo by Emily Matheson, Parks Victoria.

Subtidal

Soft sediment

A lot of the subtidal soft sediment in the MS is bare of vegetation. In the north west of the MS there is a large bed of seagrass *Zostera/Heterozostera* (Blake and Ball 2001). Modelling of suitability of habitats in PPB and commercial fisheries data concluded that the shallow subtidal soft sediments in the MS are highly suitable for sub-adult King George whiting *Sillaginodes punctata* and greenback flounder *Rhombosolea tapirina* (Morris and Ball 2006). The highly mobile Australian salmon *Arripis trutta* and *A. truttaceus* would probably move through the area over both soft sediment and reef habitats (Morris and Ball 2006). The MS is too shallow to be highly suitable for adult snapper *Pagrus auratus* but the reefs probably provide habitat for the subadults (Morris and Ball 2006).

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.



Figure 80. Subtidal reef in Jawbone Marine Sanctuary covered with *Ulva* sp., coralline and thallose red algae, and *Codium* sp.. Photo by Emily Matheson, Parks Victoria.

Flora and sessile invertebrates

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 macroalgae at the northern PPB reefs is generally sparse compared to the open coastal regions, reflecting the sheltered bay to estuarine environmental conditions (Lindsay *et al.* 2006). Over 16 species of macroalgae have been recorded in the MS through the SRMP. The subtidal reef in Jawbone MS is not diverse, with low to moderate abundances of kelp *Ecklonia radiata*, *Sargassum* spp (generally only as basal leaves; Figure 81), filamentous brown algae Ectocarpales and encrusting coralline algae (Edmunds *et al.* 2011). Encrusting coralline algae can be abundant. The algal density is lower than that observed in Ricketts Point MS but similar to Point Cooke MS (Edmunds *et al.* 2011). The lower abundances of larger brown algae and higher abundances of Ectocarpales in Jawbone MS suggest a large estuarine influence from Kororoit Creek as they are an indicator of higher nutrient concentrations and lower salinities (Edmunds *et al.* 2011). Other distinctive reef covering organisms were the coral *Plesiastra versipora* (Figure 85) and sponges (Figure 82), these animals having less than 10% cover (Edmunds *et al.* 2011). The invasive marine pest Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile* (*subsp. fragile*) have been observed in the MS since 2009. The European fanworm, *Sabella spallanzanii*, has also been found in Jawbone MS.



Figure 81. The brown algae *Sargassum* sp. on the subtidal reef in Jawbone Marine Sanctuary. Photo by AME.



Figure 82. Encrusting ruffled orange sponge, golf ball sponge *Tethya bergquistae* and brown forkweed *Dictyota dichotoma* on the subtidal reef in Jawbone Marine Sanctuary. Photo by AME.

Mobile invertebrate fauna

Over 14 species of mobile invertebrates have been recorded from the subtidal reefs of the MS (Edmunds *et al.* 2011). The mobile invertebrate assemblages are dominated by the sea urchin *Heliocidaris erythrogramma*, the seastars *Meridiastra gunnii*, *Meridiastra calcar* and *Coscinasterias muricata* and the blacklip abalone *Haliotis rubra* (Edmunds *et al.* 2011; Figure 83). The biscuit star *Tosia australis* (Figure 87) can also occur in high abundances (Edmunds *et al.* 2011). The dominance of *H. erythrogramma* and *H. rubra* at Jawbone and Point Cooke MSs is greater than in Ricketts Point (Edmunds *et al.* 2011). The southern mud oyster *Ostrea angasi* and rasping hermit crab *Strigopagurus strigimanus* are also found in the MS. As are colourful nudibranchs including the dorid *Ceratosoma brevicaudatum* (Edmunds *et al.* 2011). The introduced northern Pacific seastar *Asterias amurensis* have been observed sporadically in low numbers in the MS (Edmunds *et al.* 2011). The introduced green shore crab *Carcinus maenas* is found within Jawbone MS.



Figure 83. Blacklip abalone *Haliotis rubra* on the subtidal reef of Jawbone Marine Sanctuary. Photo by Emily Matheson, Parks Victoria.

Fish

Seventeen species of fish (e.g. Figures 84 and 88) have been observed on the subtidal reefs through the SRMP program. The southern hulafish *Trachinops caudimaculatus* is very abundant in Jawbone MS (Jung *et al.* 2010; Edmunds *et al.* 2011). Other species, present in very low densities, are zebrafish *Girella zebra*, dusky morwong *Dactylophora nigricans* and little rock whiting *Neoodax balteatus* (Edmunds *et al.* 2011). The highly mobile Australian salmon *Arripis trutta* and *A. truttaceus* would probably move through the area over both soft sediment and reef habitats (Morris and Ball 2006). Four species of leatherjacket have been observed on the subtidal reefs of the MS, the six-spined *Meuschenia freycineti*, toothbrush *Acanthaluteres vittiger*, pygmy *Brachaluteres jacksonianus* and horseshoe *Meuschenia hippocrepis* (Edmunds *et al.* 2011). Small species observed directly on the reef surface include the dragonet *Bovichtus angustifrons*, common weedfish *Heteroclinus perspicillatus*, goby *Nesogobius* sp and the Tasmanian blenny *Parablennius tasmanianus* (Edmunds *et al.* 2011). The sparsely-spotted stingaree *Urolophus paucimaculatus* and warty prowfish *Aetapcus maculatus* have also been observed in the MS (Edmunds *et al.* 2011).

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, seabirds and fish of conservation significance are found in the waters of Jawbone MS.



Figure 84. Fiddler ray *Trygonorrhina fasciata* over subtidal sediment in Jawbone Marine Sanctuary. Photo by Emily Matheson, Parks Victoria.

3.2.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora

No threatened marine flora has been recorded in Jawbone MS (Parks Victoria 2007a).

Invertebrates

No threatened invertebrate species have been recorded in Jawbone MS.

Fish

Under the Victorian *Fisheries Act* 1995 all syngnathid species are listed as Protected Aquatic Biota. Nationally they are listed as threatened under the *EPBC Act* 1999. The brushtail pipefish *Leptoichthys fistularius* has been recorded from Jawbone MS. The grey nurse shark *Carcharias taurus* has been sighted in or in the immediate surrounds of Jawbone MS. This species is FFG listed and regarded as critically endangered nationally.

Birds

The PPB (Western Shoreline) and Bellarine Peninsula Ramsar Site extends south from Altona to Limeburners Bay and incorporates the MS (DSE 2003). Thirty-six conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Jawbone MS. Twenty-seven are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list (Table 16). Three, the orange-bellied parrot *Neophema chrysogaster*, grey-tailed tattler *Heteroscelus brevipes* and the intermediate egret *Ardea intermedia* are regarded as critically endangered. *N. chrysogaster* is also listed as critically endangered nationally. It migrates annually to coastal Victoria between March and October and was most recently sighted in the Jawbone area in the intertidal saltmarsh in 1988 (Parks Victoria 2007a).

Twenty-four birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA; Table 16). Many of these birds feed on the intertidal mudflats at Wader Beach and roost on the beach or nearby rocks (Parks Victoria 2007a). The large basalt boulders have many horizontal and vertical faces, which are important intertidal roosting sites for a large number of seabirds and shorebirds including cormorants, pelicans, gulls and terns (Parks Victoria 2007a).

Table 16. Conservation listed shorebird and seabird records from Jawbone Marine Sanctuary and surrounds.

Common name	Scientific name	Victorian listing		National listing	International treaty	
		FFG	VROTS	EPBC	CAMBA	JAMBA
orange-bellied parrot	<i>Neophema chrysogaster</i>	L	CE	CE		
grey-tailed tattler	<i>Heteroscelus brevipes</i>	L	CE		C	J
intermediate egret	<i>Ardea intermedia</i>	L	CE			
great knot	<i>Calidris tenuirostris</i>	L	EN		C	J
fairy tern	<i>Sternula nereis</i>	L	EN			
little egret	<i>Egretta garzetta</i>	L	EN			
little bittern	<i>Ixobrychus minutus</i>	L	EN			
fairy prion	<i>Pachyptila turtur</i>		VU	VU		J
eastern great egret	<i>Ardea modesta</i>	L	VU		C	J
little tern	<i>Sternula albifrons</i>	L	VU		C	J
royal spoonbill	<i>Platalea regia</i>		VU			
white-bellied sea-eagle	<i>Haliaeetus leucogaster</i>	L	VU		C	
black-tailed godwit	<i>Limosa limosa</i>		VU		C	J
Caspian tern	<i>Hydroprogne caspia</i>	L	NT		C	J
eastern curlew	<i>Numenius madagascariensis</i>		NT		C	J
red knot	<i>Calidris canutus</i>		NT		C	J
Latham's snipe	<i>Gallinago hardwickii</i>		NT		C	J
Pacific golden plover	<i>Pluvialis fulva</i>		NT		C	J
grey plover	<i>Pluvialis squatarola</i>		NT		C	J
sanderling	<i>Calidris alba</i>		NT		C	J
white-winged black tern	<i>Chlidonias leucopterus</i>		NT		C	J
Pacific gull	<i>Larus pacificus</i>		NT			
sooty oystercatcher	<i>Haematopus fuliginosus</i>		NT			
pied cormorant	<i>Phalacrocorax varius</i>		NT			
nankeen night heron	<i>Nycticorax caledonicus</i>		NT			

whiskered tern	<i>Chlidonias hybridus</i>		NT			
black-faced cormorant	<i>Phalacrocorax fuscescens</i>		NT			
red-necked stint	<i>Calidris ruficollis</i>				C	J
curlew sandpiper	<i>Calidris ferruginea</i>				C	J
bar-tailed godwit	<i>Limosa lapponica</i>				C	J
sharp-tailed sandpiper	<i>Calidris acuminata</i>				C	J
common greenshank	<i>Tringa nebularia</i>				C	J
cattle egret	<i>Ardea ibis</i>				C	J
ruddy turnstone	<i>Arenaria interpres</i>				C	J
common tern	<i>Sterna hirundo</i>				C	J
short-tailed shearwater	<i>Ardenna tenuirostris</i>					J

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

Jawbone MS is shallow and dominated by intertidal and subtidal reefs. It does not provide habitat for large marine mammals. It does provide occasional habitat for four conservation listed seals (Table 17). The bottlenose dolphin *Tursiops truncatus* has also been observed in the surrounds of the MS but is generally more common in the south of PPB.

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

Common name	Scientific name	Victorian listing VROTS	National listing EPBC
southern elephant seal	<i>Mirounga leonina</i>		VU
subantarctic fur seal	<i>Arctophoca tropicalis</i>		VU
New Zealand fur seal	<i>Arctophoca forsteri</i>	VU	
Australian fur seal	<i>Arctocephalus pusillus doriferus</i>		L

L = listed, VU = Vulnerable

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state did not identify any biota endemic to Jawbone MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Five biota (Table 18) are presumed to be at their distributional limit in Jawbone MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). One red algae, one seagrass and a pipefish are presumed to be at the eastern limit of their distribution in Jawbone MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). One red algae and a prawn are presumed to be at the western limit of their distribution in Jawbone MS. 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 Jawbone Marine Sanctuary (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Phylum	Order	Family	Species	Common name	Category
Rhodophyta	Ceramiales	Ceramiaceae	<i>Bornetia tenuis</i>	red algae	PE
Rhodophyta	Ceramiales	Ceramiaceae	<i>Rhipidothamnion secundum</i>	red algae	PW
Magnoliophyta	Potamogetonales	Zannichelliaceae	<i>Lepidaena cylindracarpa</i>	seagrass	PE
Crustacea	Dendrobranchiata	Penaeidae	<i>Penaeus plebejus</i>	prawn	PW
Chordata	Syngnathiformes	Syngnathidae	<i>Leptoichthys fistularius</i>	brushtail pipefish	PE

PE = presumed eastern limit, PW = presumed western limit

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 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 MS is indicated in brackets:

1. Increasing public access via informal tracks through the adjacent reserve, resulting in trampling causing destruction or any damage in the intertidal zone (intertidal reef);
2. Commercial-scale poaching of shellfish (abalone and mussels) causing reduction of populations to below sustainable limits (subtidal reef);
3. Lack of information / knowledge of biota and indigenous values for management of ecosystem, resulting in sub-optimal management actions with consequent effects on biodiversity in MS (all of MS);
4. Sedimentation and reduced light penetration due to the PoMC Channel Deepening project, resulting in changes to algae and seagrass, with flow-on effects to other marine biota (all of MS);
5. Small size of sanctuary resulting in edge effects (concentration of activity) and leading to lack of effective protection for populations within MS (all of MS);
6. Dogs off-lead disturbing of migratory wading birds (intertidal soft sediment and reef);
7. Stormwater containing freshwater, contaminants, litter and nutrients, discharging from the drain near the school, and affecting biodiversity in the sanctuary (all of MS);
8. Introduction of marine pests new to MS, causing changes to ecological processes (all of MS);
9. Continuous heavy metal or petrochemical pollution from Kororoit Creek affecting biodiversity in the sanctuary (all of MS); and
10. Spills causing heavy metal or petrochemical pollution from Kororoit Creek affecting biodiversity in the sanctuary (all of MS).

The introduction of marine pests threatens the integrity of marine biodiversity and may also reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are found in Port Phillip Bay (Parks Victoria 2003). The introduced green shore crab *Carcinus maenas* is found within Jawbone MS. The Northern Pacific seastar *Asterias amurensis* and the European fan worm *Sabella spallanzanii* have been recorded in the MS since 2003. Invasive Japanese kelp *Undaria pinnatifida* (Figure 85) and broccoli weed *Codium fragile* (subsp. *fragile*) have been recorded in the MS since 2009. The potential for further invasions is high (Parks Victoria 2007a).



Figure 85. The invasive Japanese kelp *Undaria pinnatifida* on the subtil reef of Jawbone Marine Sanctuary. Photo by AME.

There have been reports of abundances of the purple urchin, *Heliocidaris erythrogramma*, increasing in abundance forming barrens habitat in the northern part of the bay, including in Jawbone Marine Sanctuary. In areas where barrens have been established erect macroalgae are usually absent. It is unclear whether the recent increases in abundance are part of a natural cycle or part of a persistent increase in this native species.

A virus affecting abalone called abalone viral ganglioneuritis 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 Jawbone 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 presumed to be at the eastern or western limit of their distributional range at Jawbone MS and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in 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 Jawbone MS (Parks Victoria 2007a). For example, research is being conducted into marine pest species, and investigations into water quality issues have been conducted. Management actions have been implemented to minimise these threats (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.



Figure 86. Hard coral *Plesiastrea versipora* on the subtidal reef of Jawbone Marine Sanctuary. Photo by AME.



Figure 87. Biscuit seastar *Tosia australis* is an abundant invertebrate on the subtidal reef of Jawbone Marine Sanctuary. Photo by AME.

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 Jawbone 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 19 and Appendix 2).

Table 19. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Jawbone 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 Intertidal Reef Monitoring Program
Community Based Monitoring Sea Search - Seagrass

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

Jawbone MS has an ongoing intertidal (IRMP) and a shallow subtidal (SRMP) reef monitoring program. The intertidal reef monitoring program in and around the Jawbone MS began in 2003 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). Since then there have been six surveys (Edmunds *et al.* 2004b; Hart *et al.* 2005; Edmunds *et al.* 2010d). 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). The monitoring site (Figure 72) is on a continuous area of reef on the extensive fractured basalt reef and boulder field in the MS (Edmunds *et al.* 2010d). The reference site (Figure 72) is at Point Gellibrand, Williamstown (Edmunds *et al.* 2010d).

The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003a) around Jawbone MS began in 2003 and there have been four surveys (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). The SRMP involves standardised underwater diver-mediated visual survey methods (Edmunds and Hart 2003a). The SRMP surveys a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish. Monitoring is undertaken at Jawbone MS along four contiguous 50 m transects at a single site very close to shore in 2 - 3 m in 3 - 4 m (Figure 72). The reference site is located approximately 2 km east at Point Gellibrand, Williamstown in 2 m of water (Edmunds *et al.* 2011).

Preliminary analysis of both the IRMP and SRMP data collected a few years after declaration was conducted across the three PPB MSs. Intertidal biota did not show a difference in number of species or abundance due to protection (Keough and Carnell 2009). Long term monitoring is needed to provide the power to adequately test the effect of protection (Keough and Carnell 2009). Even then the effects may vary among MPAs, perhaps varying with the level of threat from harvesting of fauna (Keough and Carnell 2009). Subtidal biota did not show a difference in species richness or number of species between MPA and reference sites post-declaration (Keough and Carnell 2009). The abundances of common algae did vary between MS and reference sites, but generally in no obvious or consistent way, reducing confidence that the difference observed is an effect of the MSs (Keough and Carnell 2009). Further surveys may clarify these results. The sea star *Uniophora granifera* was the only invertebrate to display a difference in abundance between MS and reference sites across the three MSs (Keough and Carnell 2009). *U. granifera* was more abundant in reference sites compared to the MSs. None of the fish species displayed clear and consistent trends in abundance inside and outside of the three MSs (Keough and Carnell 2009). The abundances of fish were generally quite low, except for the hula fish *Trachinops caudimaculatus*. A separate research project on the impact of protection through MPAs on intertidal reef gastropods in PPB and Central coast found an MPA effect on the sizes of the limpets *Cellana tramoserica* and *Patelloida alticostata* (Bathgate 2010). Both species had larger shell length in MPAs than non-MPA sites. For *C. tramoserica*, this effect is most apparent at sites like Point Cooke and Jawbone MSs which have a long history of protection prior to their current declaration as MPAs (Bathgate 2010).

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. A review will also be taken of the intertidal monitoring program.

Community based monitoring of the seagrass habitat, under Sea Search is being conducted by Jawbone Marine Sanctuary Care group (Koss *et al.* 2005b). This group is also cataloguing the natural values of the MS, surveying and removing introduced species, monitoring mangroves and seagrass and participating in the Reef Watch fish count. Other groups that have a close association with the sanctuary include the Friends of Williamstown Wetlands, Friends of Altona Coastal Park and the Victorian Wader Study Group (Parks Victoria 2007a).

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

3.2.7 KNOWLEDGE GAPS

No surveys have been conducted on the ecological communities of intertidal and subtidal soft sediments, other than bird surveys and habitat mapping. No information exists at present for water column assemblages. Major threats have been identified for Jawbone MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.



Figure 88. Globefish *Diodon nictitans* on the subtidal reef of Jawbone Marine Sanctuary. Photo by Emily Matheson, Parks Victoria.

3.3 Ricketts Point Marine Sanctuary

Ricketts Point MS is one of three Marine Sanctuaries in the Victorian Embayments bioregion, which are all in Port Phillip Bay (PPB). The other two MSs include Jawbone and Point Cooke. The bioregion also includes Port Phillip Heads, Yaringa, French Island, Churchill Island and Corner Inlet Marine National Parks. Ricketts Point MS is on the north-east coast of PPB and is approximately 20 km from Melbourne CBD (Figure 90). It abuts the Bayside City Council Foreshore Reserve from Table Rock Point in Beaumaris to Quiet Corner in Black Rock. It extends from the high water mark to approximately 450 m offshore (Parks Victoria 2005).

Aboriginal tradition indicates that the sanctuary is part of *Country* of Boon Wurrung people (Parks Victoria 2005).

Important natural values of Ricketts Point MS are its sandy beaches, intertidal and subtidal sandstone reefs, subtidal soft sediments and seagrass meadows (ECC 2000; Carey *et al.* 2007b). It has a wide intertidal shore platform (ECC 2000; Carey *et al.* 2007b). The extensive intertidal and subtidal sandstone reef incorporates a variety of microhabitats including rockpools, numerous holes and gullies, boulders and crags (Plummer *et al.* 2003). The headlands and reefs are interspersed with sandy beaches and subtidal soft-sediment with intertidal and subtidal seagrass beds (Plummer *et al.* 2003). While not within the MS boundaries, sand dunes and cliffs back the MS in places (Plummer *et al.* 2003). The MS is a popular site for snorkelling, diving and education (Plummer *et al.* 2003).

The intertidal reef in Ricketts Point MS has a moderate coverage of *Hormosira banksii* along the seaward edge of the platform (Koss *et al.* 2005a; Edmunds *et al.* 2010d). The reef has a low cover of *Ulva* spp., *Enteromorpha* spp., algal turf, *Corallina officinalis*, *Notheia anomala* and *Gelidium pusillum* (Koss *et al.* 2005a; Edmunds *et al.* 2010d). There are small patches of the calcareous tube-worm *Galeolaria caespitosa*, eastern shore barnacle *Chthamalus antennatus* and little black horse mussel *Limnoperna pulex* (Koss *et al.* 2005a; Edmunds *et al.* 2010d). There are patches of the blue-green algae *Symploca* sp. across the reef (Edmunds *et al.* 2010d). The invasive marine pest broccoli weed *Codium fragile* (subsp. *fragile*) is found on the intertidal reef (Costa *et al.* 2010; O'Hara *et al.* 2010).

There are over 31 species of mobile invertebrates, including 26 species of mollusc on the intertidal reefs of the MS (Koss *et al.* 2005a; Bathgate 2010; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). Most common is the herbivorous zebra top shell *Austrocochlea porcata*, with the variegated limpet *Cellana tramoserica* and conniwink *Bembicium* spp. relatively common (Bathgate 2010; Edmunds *et al.* 2010d). Other invertebrates include the warrener *Turbo undulatus*, black nerite *Nerita atramentosa* and the carnivorous gastropods *Lepsiella vinosa* and *Cominella lineolata* (Edmunds *et al.* 2010d). The introduced green crab *Carcinus maenas* is found on the intertidal reef (Koss *et al.* 2005a; Costa *et al.* 2010; O'Hara *et al.* 2010). The Tasmanian blenny *Parablennius tasmanianus*, the common weedfish *Heteroclinus perpicillatus* and the dragonet *Bovichtus angustifrons* are found in intertidal rockpools in the MS (Plummer *et al.* 2003).

Over 32 species of macroalgae have been recorded on the subtidal reefs of Ricketts Point MS (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). They are dominated by *Sargassum-Caulerpa* assemblages, *Caulerpa geminata* and *C. remotifolia*, along with *Sargassum spinuligerum*, sparse kelp *Ecklonia radiata* and a mixture of smaller red and brown seaweeds. The reef in Ricketts Point MS generally has higher algal density than Jawbone or Point Cooke MSs (Edmunds *et al.* 2011). The reef also has sea urchin barrens, in which encrusting coralline algae and the hard coral *Plesiastrea versipora* are common (Edmunds *et al.* 2011). The invasive Japanese kelp, *Undaria pinnatifida*, has also recently been found in the MS.

There are relatively few mobile invertebrate species on the subtidal reef at Ricketts Point MS which is dominated by the purple sea urchin *Heliocidaris erythrogramma* (Edmunds *et al.* 2011). Other common species are the blacklip abalone *Haliotis rubra*, biscuit star *Tosia australis*, eleven-armed seastar *Coscinasterias muricata* and velvet star *Petricia vernicina* (Edmunds *et al.* 2011). The invasive Northern Pacific seastar, *Asterias amurensis*, has also recently been found at Ricketts Point. Thirty-five species of fish have been observed on the subtidal reef on the MS, dominated by the southern hulafish *Trachinops caudimaculatus* and to a lesser extent by southern goatfish *Upeneichthys vlaminghii* and little rock whiting *Neodax balteatus* (Edmunds *et al.* 2011). Other prominent large species of fish include zebra fish *Girella zebra*, moonlighter *Tilodon sexfasciatus* and horseshoe leatherjacket *Meuschenia hippocrepis* (Edmunds *et al.* 2011). Transient species such as Australian salmon *Arripis trutta* and snapper *Chrysophrys auratus* have been observed in the MS (Edmunds *et al.* 2011).

Ricketts Point MS intertidal reef platforms are regionally significant for roosting and feeding shorebirds (Carey *et al.* 2007b). It provides important feeding and roosting habitat for eleven threatened bird species such as the white-bellied sea-eagle *Haliaeetus leucogaster* and the royal spoonbill *Platalea regia* which are listed under the *Flora and Fauna Guarantee (FFG)* Act (1998) and regarded as vulnerable in Victoria. The MS protects feeding areas for seven internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). The southern hooded shrimp *Athanopsis australis* is presumed endemic to the MS. The red algae *Bonnemaisonia australis* and the swimming crab *Ovalipes catharus* are believed to be at their distributional limits within the MS.

Serious threats to the Ricketts Point MS include limited ecological knowledge of important processes. Invasive marine pests, trampling, nutrients from discharges, sediments from dredging, disturbance of birds, inadequate monitoring and management, 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 Ricketts Point MS (Parks Victoria 2005). Ongoing intertidal and subtidal reef monitoring, and specific research also aims to increase ecological knowledge about the natural values of, and threats to Ricketts Point MS.

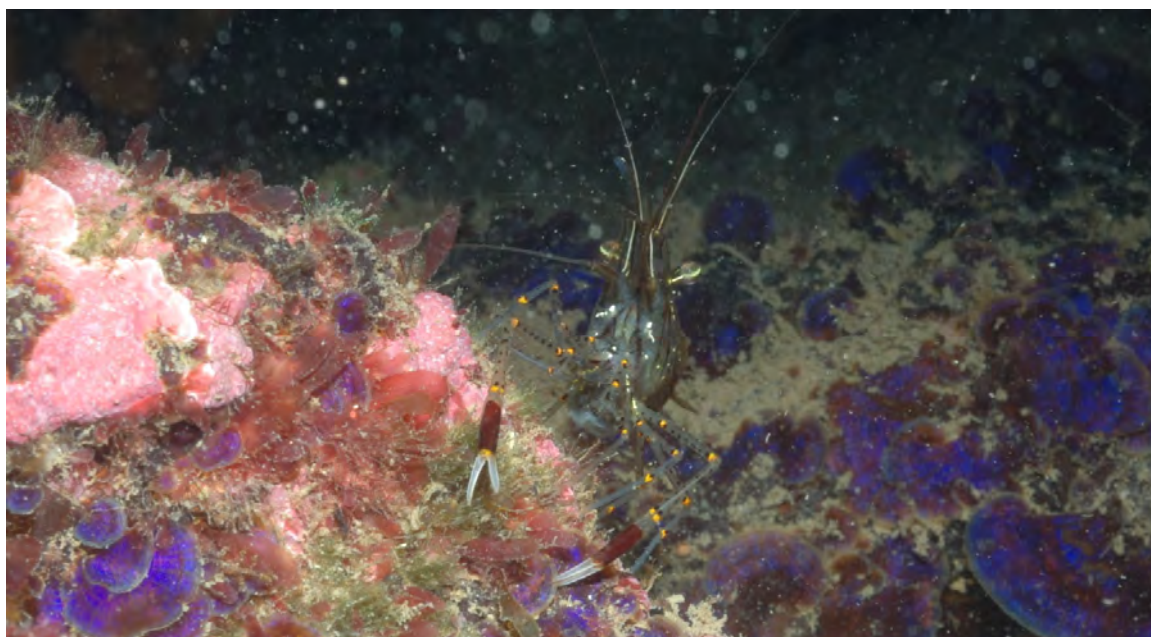


Figure 89. Shrimp *Palaemon serenus* in amongst peacock-weed *Lobophora variegata* on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.

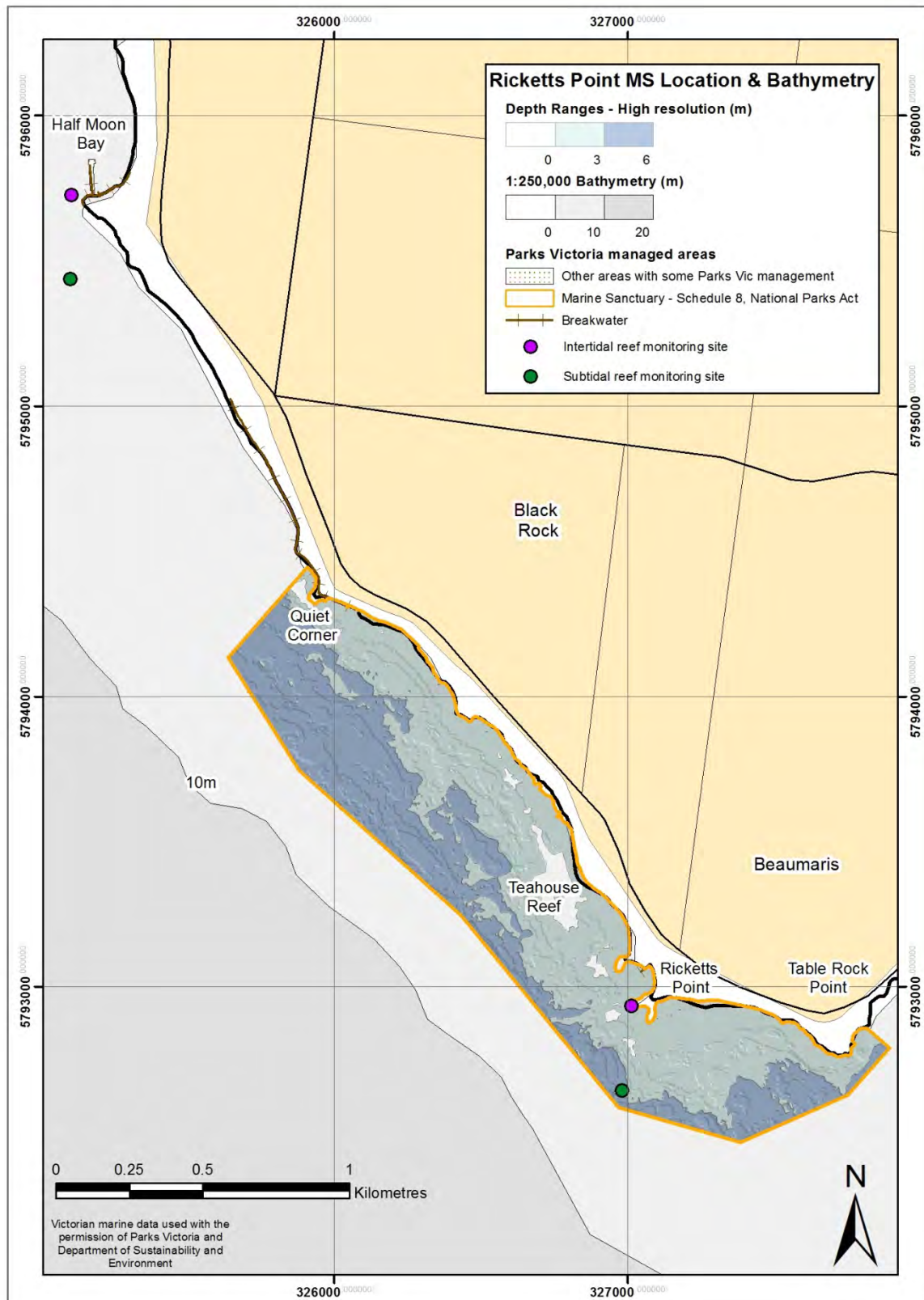


Figure 90. Location map of Ricketts Point Marine Sanctuary with bathymetry. Intertidal and subtidal reef monitoring sites inside and outside the MS are shown.

3.3.1 PHYSICAL PARAMETERS & PROCESSES

Ricketts Point MS is 120.6 hectares in size which makes it the 16th largest of the 24 Marine National Parks and Sanctuaries in Victoria (Table 20 & Figure 93). It is shallow with the majority of the MS < 4 m deep. Tidal variation is 0.8 metres for spring tides and 0.2 metres for neap tides (Plummer *et al.* 2003). Surface water temperatures average 20.3 °C in the summer and 11.6 °C in the winter. It is not subject to large waves, strong currents or swell like MPAs on the open coast (Edmunds *et al.* 2011). It is exposed to westerly weather across the long fetch of PPB that can create turbulent wind-driven waves (Edmunds *et al.* 2011). There are no estuaries that discharge directly into the MS but five stormwater drains do including Ebdon Park and Nautilus Street drains (Plummer *et al.* 2003; Parks Victoria 2005). The MS experiences episodes of lower salinities from the stormwater drains and the plume of the Yarra River (Short 1996; Edmunds *et al.* 2011). Freshwater runoff, phytoplankton blooms and disturbance of nearby fine sediments frequently create turbid conditions in the MS (Edmunds *et al.* 2011).

There are two declared sites of geological or geomorphological or biotic significance in the MS (Figure 94). Ricketts Point is of regional structural, palaeontological and geomorphological significance with its wide Tertiary Black Rock sandstone shore platform. Table Rock Point is also of regional significance due to its mix of Tertiary Black Rock sandstone as part of the Beaumaris monocline and the sea caves produced by undermining of the cliffs. Outside the MS the Beaumaris Cliffs have sites of both regional and international geological significance.

Table 20. Physical attributes of the Ricketts Point Marine Sanctuary.

Park Name	Ricketts Point
Conservation status	Marine Sanctuary
Biophysical Region	Victorian Embayments
Size	120.6 ha (ranked 16 th of 24)
Length of coastline	~2.9 km
Shoreline geology	Sandstone and basalt
Area with depth:	
(low res)* 0-10 m	3.94 ha
(high res) Supratidal	1.68 ha
Intertidal	16.29 ha
Intertidal-2 m	27.81 ha
2-4 m	45.01 ha
4-6 m	25.18 ha
6-8 m	0.68 ha
Mean tidal variation - spring	0.8 m
Mean tidal variation - neap	0.2 m
Mean water temp - summer	20.3°C
Mean water temp - winter	11.6°C
Adjacent catchment	urban
Discharges into MNP	No direct discharges
Nearest major estuary (distance & direction)	Yarra River 16 km north west Mordialloc Creek 4 km south east

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

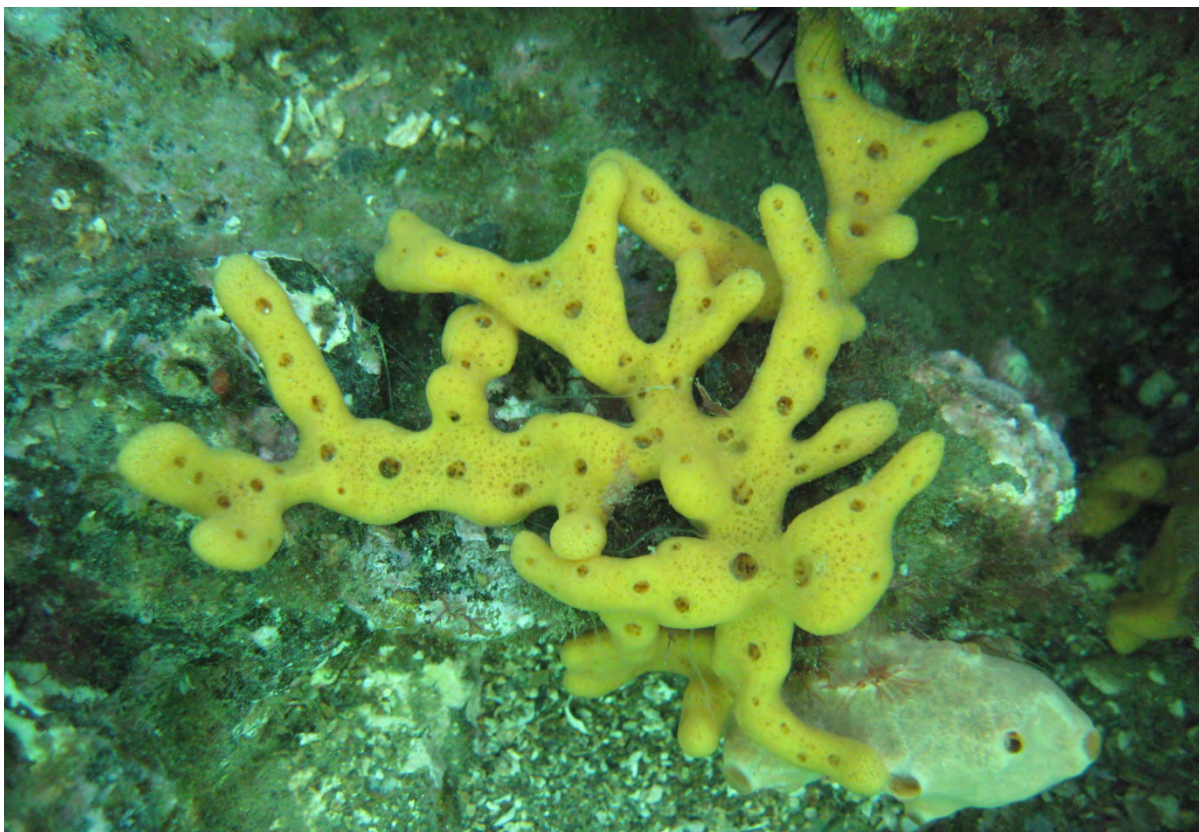


Figure 91. Encrusting ruffled yellow sponge on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by AME.

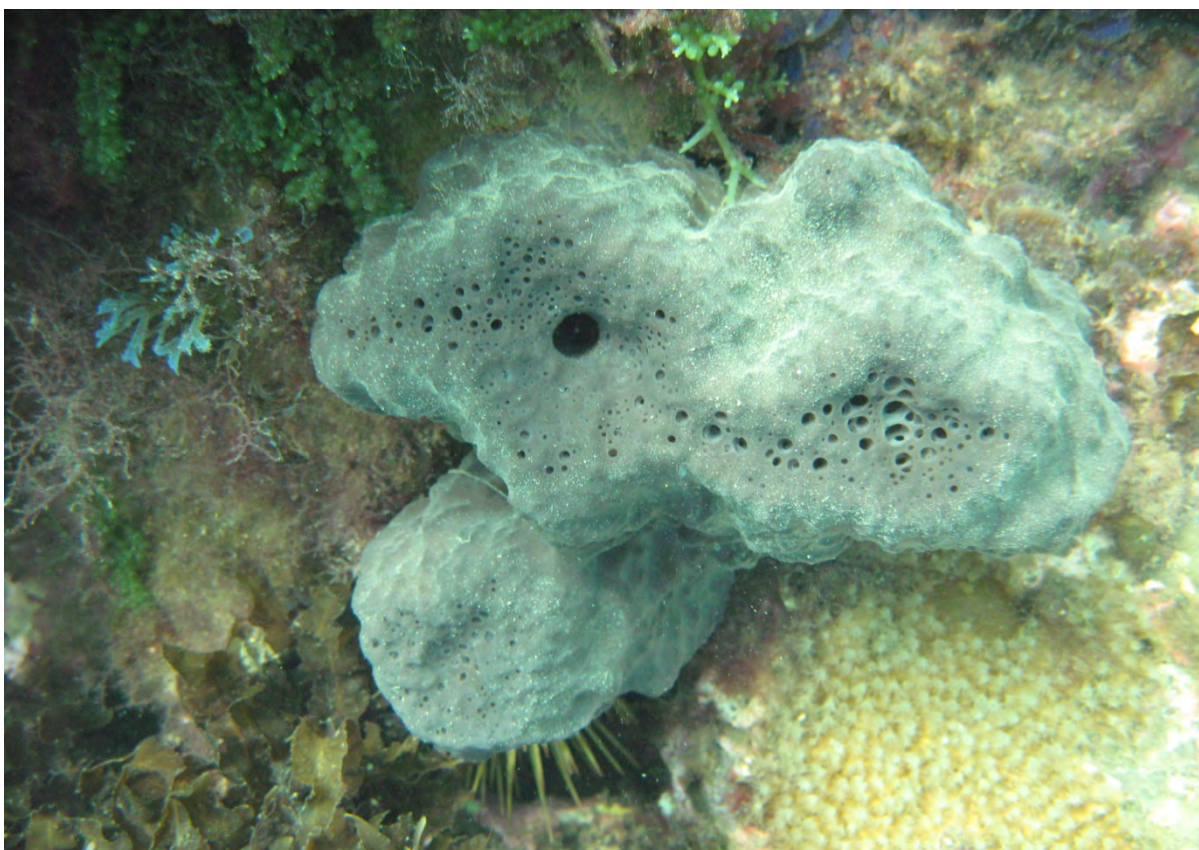


Figure 92. Massive ruffled grey sponge on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by AME.

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). 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. Ricketts Point MS habitat has been mapped from aerial photography and ground-truthed by site visits and underwater video transects (Blake and Ball 2001), and also through a community based mapping project implemented by Marine Care Ricketts Point.

The intertidal soft sediment in the MS is a small 650 m long, south facing strip of sand below the cliffs of Table Rock Point at the Beaumaris Life Saving Club and a more extensive 1.6 km long beach from Ricketts Point to Quiet Corner (Short 1996). The first beach is surrounded by wide intertidal reef, the second beach is interrupted by three high vegetated bluffs (Short 1996). This forms three narrow crenulate beaches facing south-west and exposed to periodic strong, south-west winds and waves (Short 1996). Intertidal and subtidal reef offshore of the beaches is extensive (Figure 93 & Figure 94).

There are several sections of intertidal reef in the Ricketts Point MS (Figure 94). The main intertidal reef is an extension of the Ricketts Point Headland (Edmunds *et al.* 2010d). This reef is large (approximately 60 x 70 m) and encompasses several different habitat types including fractured basalt reef with prominent outcrops and steps, cobble field habitat and areas of intertidal mud and seagrass (Edmunds *et al.* 2010d). The central region of the platform at Ricketts Point is solid basalt reef that is above the high tide mark and supports patches of the beaded glasswort *Sarcocornia quinqueflora* (Edmunds *et al.* 2010d). There are also small rock pools in this central area (Edmunds *et al.* 2010d). To the north and south of the central region are cobble field and sediment habitats (Edmunds *et al.* 2010d). To the west, on the seaward edge of the platform, the reef is fractured basalt with small boulders (Edmunds *et al.* 2010d). Across the intertidal area there are low basalt protrusions, which provide some vertical structure (Edmunds *et al.* 2010d).

A small amount of seagrass *Heterozostera nigricaulis* has been mapped (Figure 95) on the subtidal soft sediment between Tea House and Middle intertidal reefs (Blake and Ball 2001). Bare subtidal sediment is offshore of the beaches in Watkins Bay, north of middle reef and south of McGregor reef (Blake and Ball 2001).

The subtidal reef at Ricketts Point is low relief sandstone reef with occasional steps and crevices, erosion holes and small rubble patches (Edmunds *et al.* 2011). Sparse kelp *Ecklonia radiata* grows along with *Caulerpa* spp. in the reef habitat (Edmunds *et al.* 2011). The hard coral *Plesiastrea* covers a significant proportion of the subtidal reef in places.

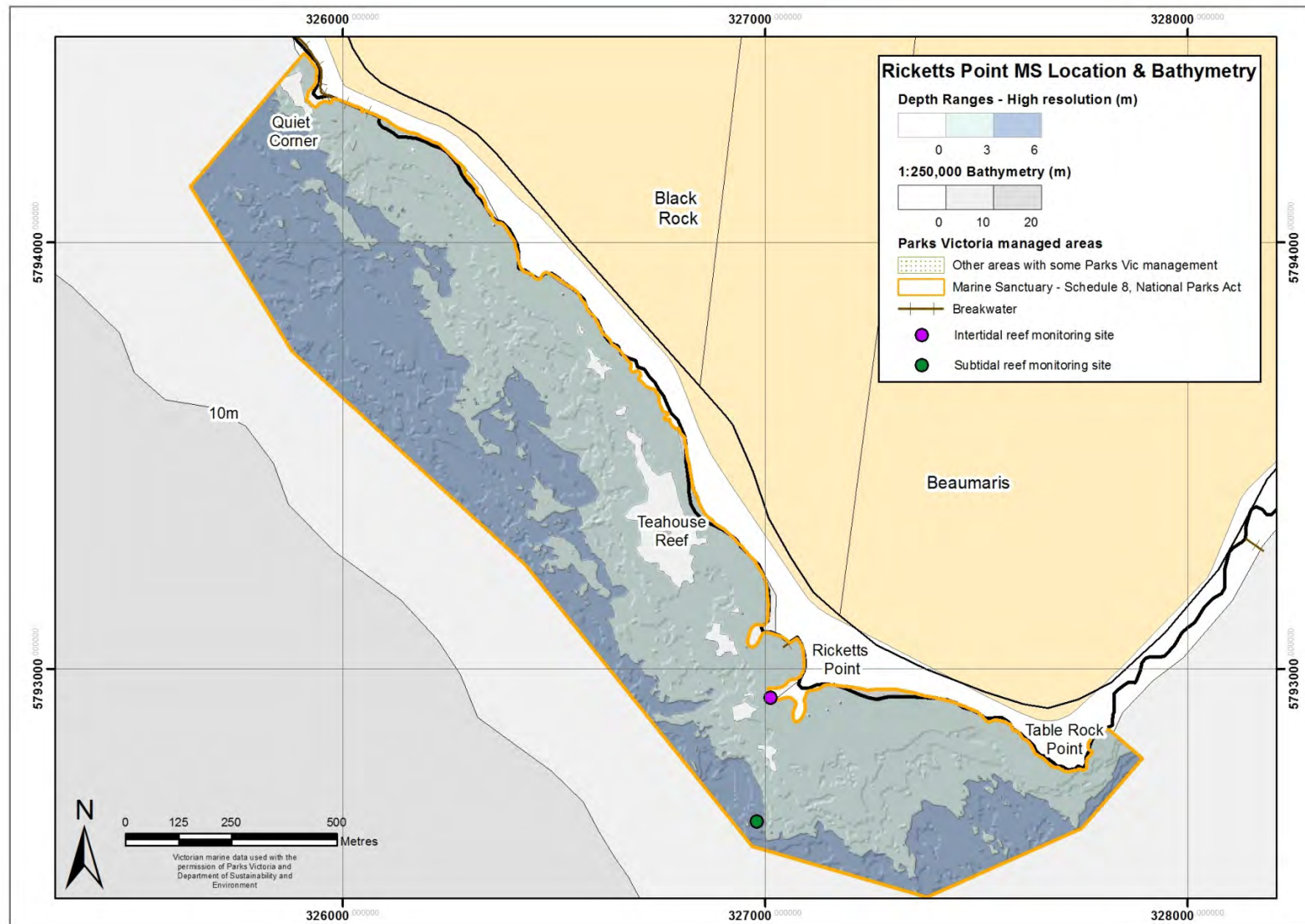


Figure 93. Detailed location map of Ricketts Point Marine Sanctuary with bathymetry. Intertidal and subtidal reef monitoring sites inside the MS are shown.

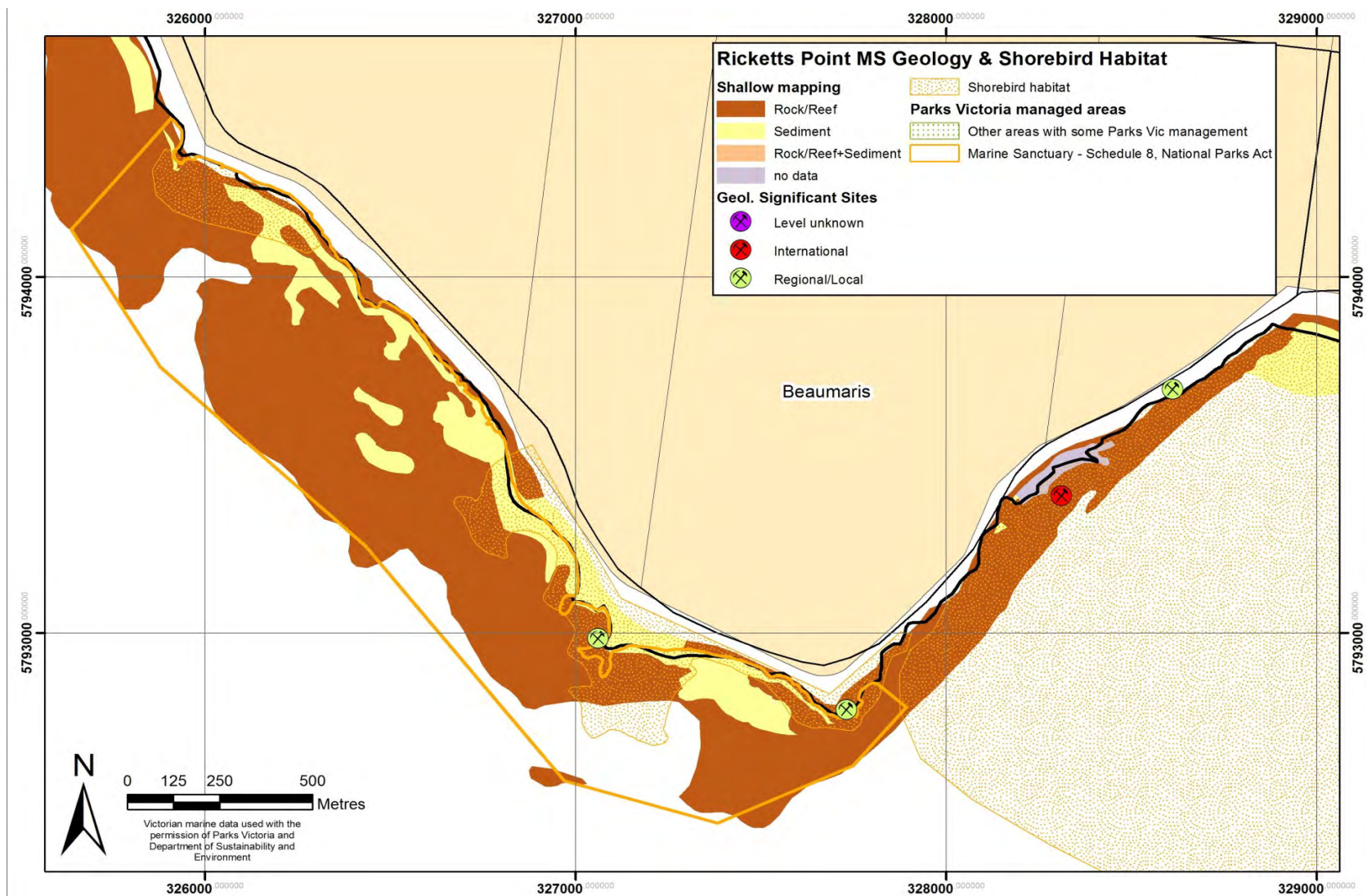


Figure 94. Geology and shorebird habitat of Ricketts Point Marine Sanctuary and surrounds, showing sites of geological significance.

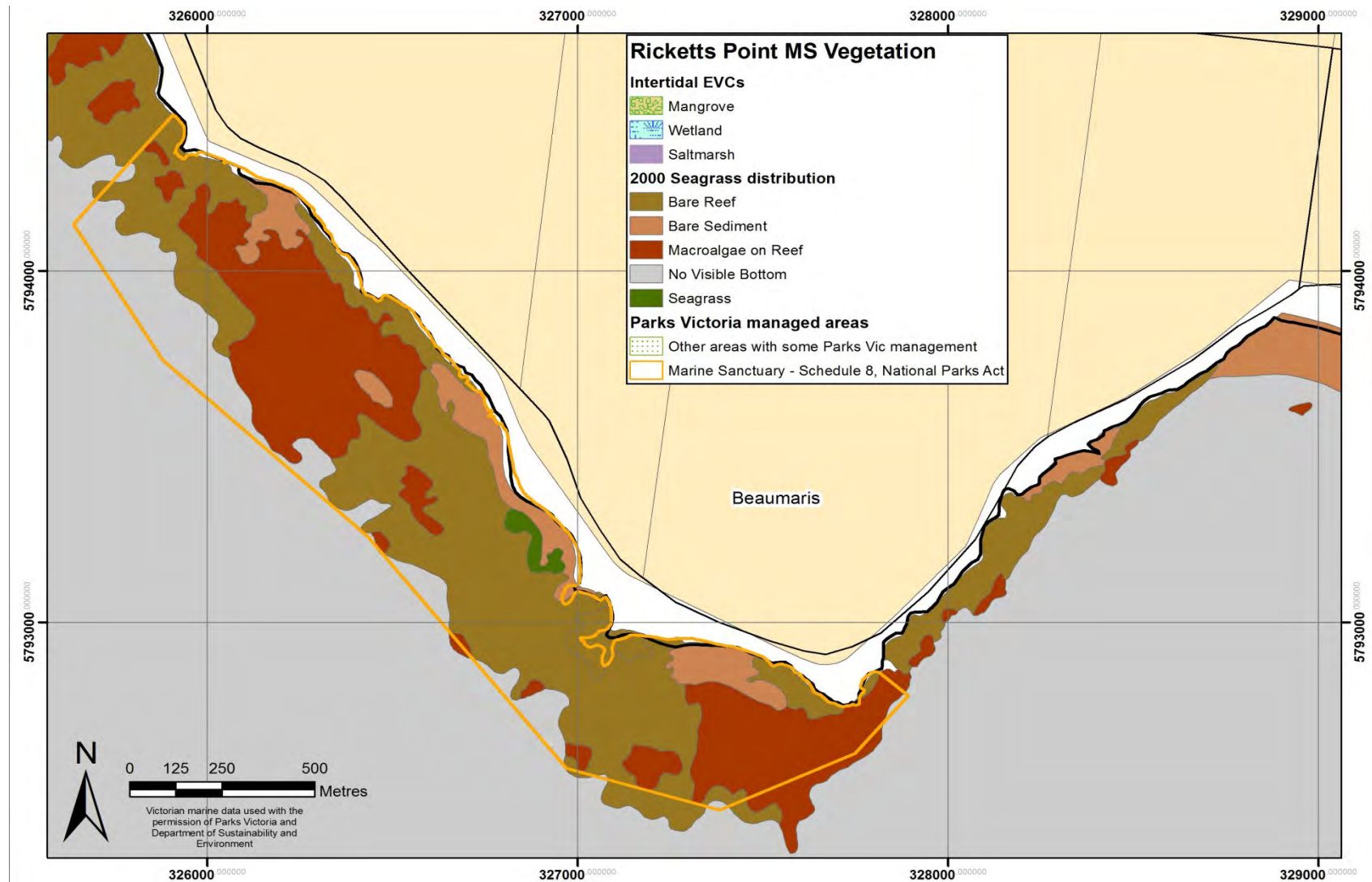


Figure 95. Vegetation map of Ricketts Point Marine Sanctuary and surrounds.

3.3.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring surveys in Ricketts Point MS. Marine habitat maps have been mapped by DPI, and also as part of a community based mapping project implemented by Marine Care Ricketts Point. There have been six Intertidal Reef Monitoring Program (IRMP) surveys of the intertidal reef biota of Ricketts Point MS. The biota of the intertidal and subtidal reefs are also monitored by the Marine Care community group and as part of Reef Life Survey and Sea Search community based monitoring programs. There have been five Subtidal Reef Monitoring Program (SRMP) of the subtidal reef biota in the MS. Records of species found in the MS show that brown dominate the diversity of macrophytes, gastropods the invertebrates and birds the vertebrates in Ricketts Point MS (Table 21, Appendix 1). There have been no new surveys of the biota of the soft sediments or the pelagic habitats. There are no recognised significant biota sites in the MS.

Table 21. Summary of the number of species in major biotic groups found in Ricketts Point Marine Sanctuary.

Biotic group	Number of species
Macrophytes	56
blue-green algae	1
green algae	10
brown algae	25
red algae	16
lichens	1
saltmarsh	1
seagrasses	2
Invertebrates	40
sponges	1
cnidarians	4
polychaetes	1
barnacles	4
decapod crustaceans	5
chitons	2
gastropods	20
bivalves	2
echinoderms	1
Vertebrates	60
fish	23
birds	30
mammals	6

Intertidal

Soft sediment

Macroscopic flora on the intertidal soft sediment is restricted to macroalgae drift and macroalgal epiphytes. The fauna of the intertidal soft sediment habitat in Ricketts Point MS has not been surveyed (Plummer *et al.* 2003). 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. Intertidal seagrass beds of *Zostera muelleri* support gastropods, bivalves, barnacles, sea stars, polychaetes, ascidians, sea jellies, hydroids, sponges and fish (Koss *et al.* 2005a). The seagrass the southern strapweed *Posidonia australis* has been observed in the MS by Sea Search community intertidal monitoring.

Reef

Rocky intertidal reefs (Figure 96), 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 of 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).



Figure 96. Intertidal reef in Ricketts Point Marine Sanctuary. Photo by AME.

Macroalgae and sessile invertebrates

The algal and sessile invertebrate communities on the intertidal reef of northern Port Phillip Bay are distinct from communities along the exposed coastline (Edmunds *et al.* 2010d). They generally have a lower, and less variable, richness and diversity of mobile invertebrate species than sites along the open coastline (Edmunds *et al.* 2010d). Ricketts Point MS has a moderate coverage of *Hormosira banksii* along the seaward edge of the platform making it more like the intertidal reefs of the open coast than Jawbone or Point Cooke MSs reefs (Koss *et al.* 2005a; Edmunds *et al.* 2010d). The high shore area of the reef is exposed for long times between high tide periods resulting in a low algal coverage (Edmunds *et al.* 2010d). Patches of the blue-green algae *Symploca* sp. is highly variable across the reef (Edmunds *et al.* 2010d). The cover of *Ulva* spp. and *Enteromorpha* spp. is low (Koss *et al.* 2005a; Edmunds *et al.* 2010d). Algal turf, *Corallina officinalis*, *Notheia anomala* and *Gelidium pusillum* occur in low abundances as does the saltmarsh *Sarcocornia quinqueflora* (Koss *et al.* 2005a; Edmunds *et al.* 2010d). Other macroalgae observed on the intertidal reef include the brown algae *Caulocystis uvifera* and *Cystophora subfarcinata*, and red algae *Capreolia implexa* (Costa *et al.* 2010; O'Hara *et al.* 2010). Small patches of the calcareous tube-worm *Galeolaria caespitosa* are present, occurring in higher abundance low on the shore (Koss *et al.* 2005a; Edmunds *et al.* 2010d). The eastern shore barnacle *Chthamalus antennatus* is also present in low abundances (Edmunds *et al.* 2010d), as are the little black horse mussel *Limnoperna pulex* and red waratah anemone *Actinia tenebrosa* (Koss *et al.* 2005a). Rock pools also contain *Chaetomorpha*, Ectocarpaceae and *Polysiphonia* (Plummer *et al.* 2003). The invasive marine pest broccoli weed *Codium fragile* (subsp. *fragile*) is also found on the intertidal reef (Costa *et al.* 2010; O'Hara *et al.* 2010).

Mobile invertebrates

There have been 31 species of mobile invertebrates, including 26 species of molluscs recorded from the intertidal reefs of Ricketts Point MS (Koss *et al.* 2005a; Bathgate 2010; Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010). The herbivorous zebra top shell *Austrocochlea porcata* is the most common species (Edmunds *et al.* 2010d). The variegated limpet *Cellana tramoserica* is also relatively common, as are species of the conniwink *Bembicium* spp (Bathgate 2010; Edmunds *et al.* 2010d). Less common species, in varying abundances, include the warrener *Turbo undulatus*, the black nerite *Nerita atramentosa* and the carnivorous gastropods *Lepsiella vinosa* and *Cominella lineolata* (Edmunds *et al.* 2010d). The introduced green crab *Carcinus maenas* is found on the intertidal reef (Koss *et al.* 2005a; Costa *et al.* 2010; O'Hara *et al.* 2010).

Fish

The Tasmanian blenny *Parablennius tasmanianus*, the common weedfish *Heteroclinus perpicillatus* and the dragonet *Bovichtus angustifrons* are all common in intertidal rockpools in the MS (Plummer *et al.* 2003).

Subtidal

Soft sediment

There are no quantitative studies on unvegetated soft sediment within the Ricketts Point MS (Plummer *et al.* 2003). A small amount of seagrass *Heterozostera nigricaulis* has been mapped on the subtidal soft sediment between Tea House and Middle intertidal reefs (Blake and Ball 2001). Bare subtidal sediment is offshore of the beaches in Watkins Bay, north of middle reef and south of McGregor reef (Blake and Ball 2001). Modelling of suitability of habitats in PPB and commercial fisheries data concluded that the shallow subtidal soft sediments in the MS are highly suitable for sub-adult King George whiting *Sillaginodes punctata* and greenback flounder *Rhombosolea tapirina* (Morris and Ball 2006). The highly mobile Australian salmon *Arripis trutta* and *A. truttaceus* would probably move through the area over both soft sediment and reef habitats (Morris and Ball 2006). The MS is too shallow to be highly suitable for adult snapper *Pagrus auratus* but the reefs probably provide habitat for the subadults (Morris and Ball 2006).

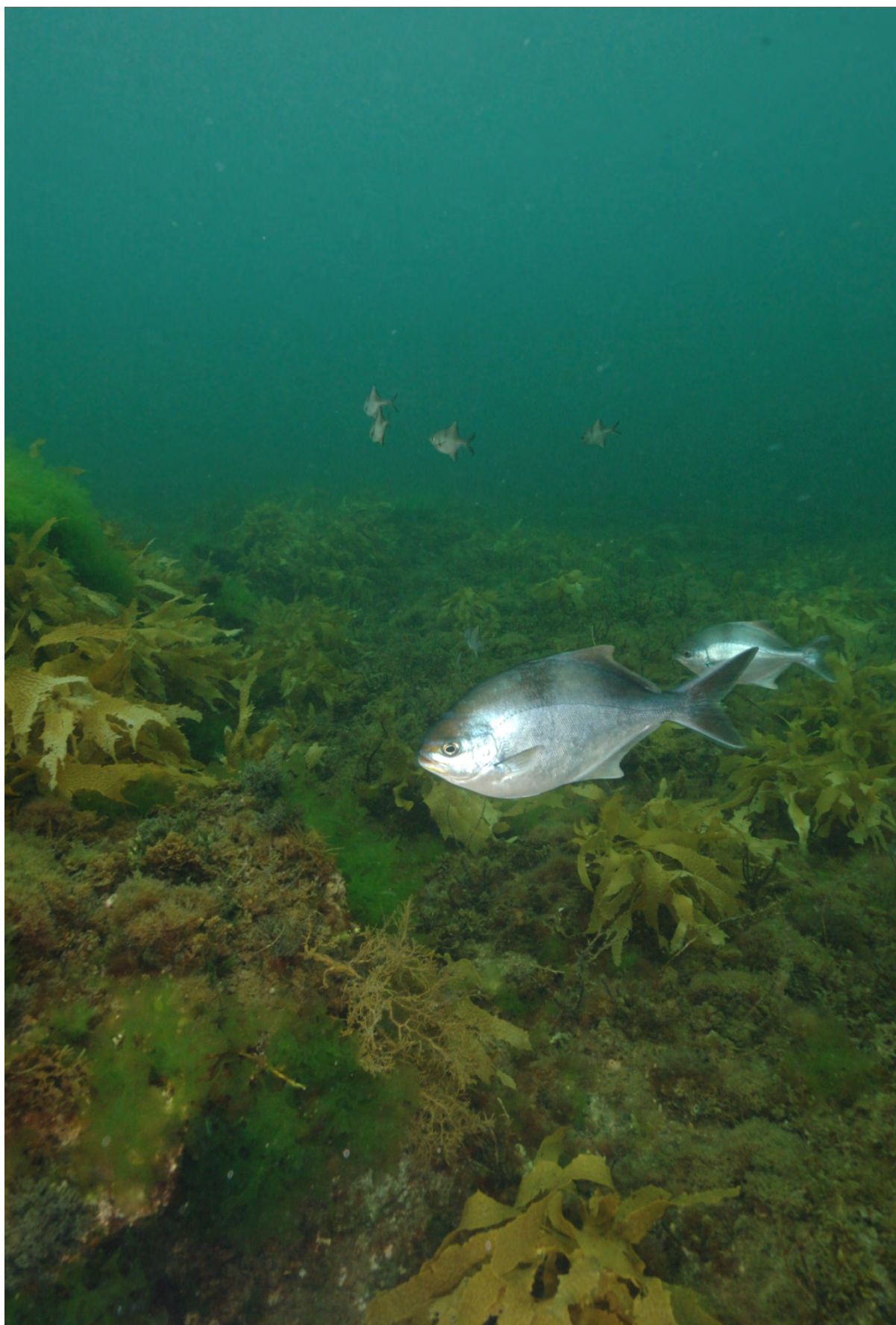


Figure 97. Sea sweep *Scorpius lineolata* over macroalgal covered subtidal reef in Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.

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.



Figure 98. Hard coral *Plesiastrea versipora* on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.

Flora

Seaweeds (Figure 99) provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present. The macroalgae on the northern Port Phillip Bay reefs is generally sparse compared to the open coastal regions, reflecting the sheltered bay to estuarine environmental conditions (Lindsay *et al.* 2006). Over thirty-two species of macroalgae have been recorded on the subtidal reefs of Ricketts Point MS (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). The subtidal reef is dominated by *Sargassum-Caulerpa* assemblages (Edmunds *et al.* 2011; Figure 109). *Caulerpa* sp include the green mat forming *Caulerpa geminata* and *C. remotifolia*. Algal communities on subtidal reefs also include the kelp *Ecklonia radiata*, *Sargassum spinuligerum* and a mixture of smaller red and brown seaweeds. *Caulerpa* species coverage can be very variable at seasonal and annual scales (Edmunds *et al.* 2011). The coverage of *S. spinuligerum* is not as variable as *Caulerpa* sp. but large changes have been observed over time. The cover of kelp *E. radiata* does not vary much and oscillates between 10 % and < 2 % on the reef (Edmunds *et al.* 2011). The reef in Ricketts Point MS generally has higher algal density than those in Jawbone and Point Cooke MSs (Edmunds *et al.* 2011). The reef also has sea urchin barrens habitat, formed by the purple urchin *Heliocidaris erythrogramma*, which are dominated by encrusting coralline algae (Edmunds *et al.* 2011). The invasive Japanese kelp *Undaria pinnatifida* has also been found recently at Ricketts Point Marine Sanctuary.

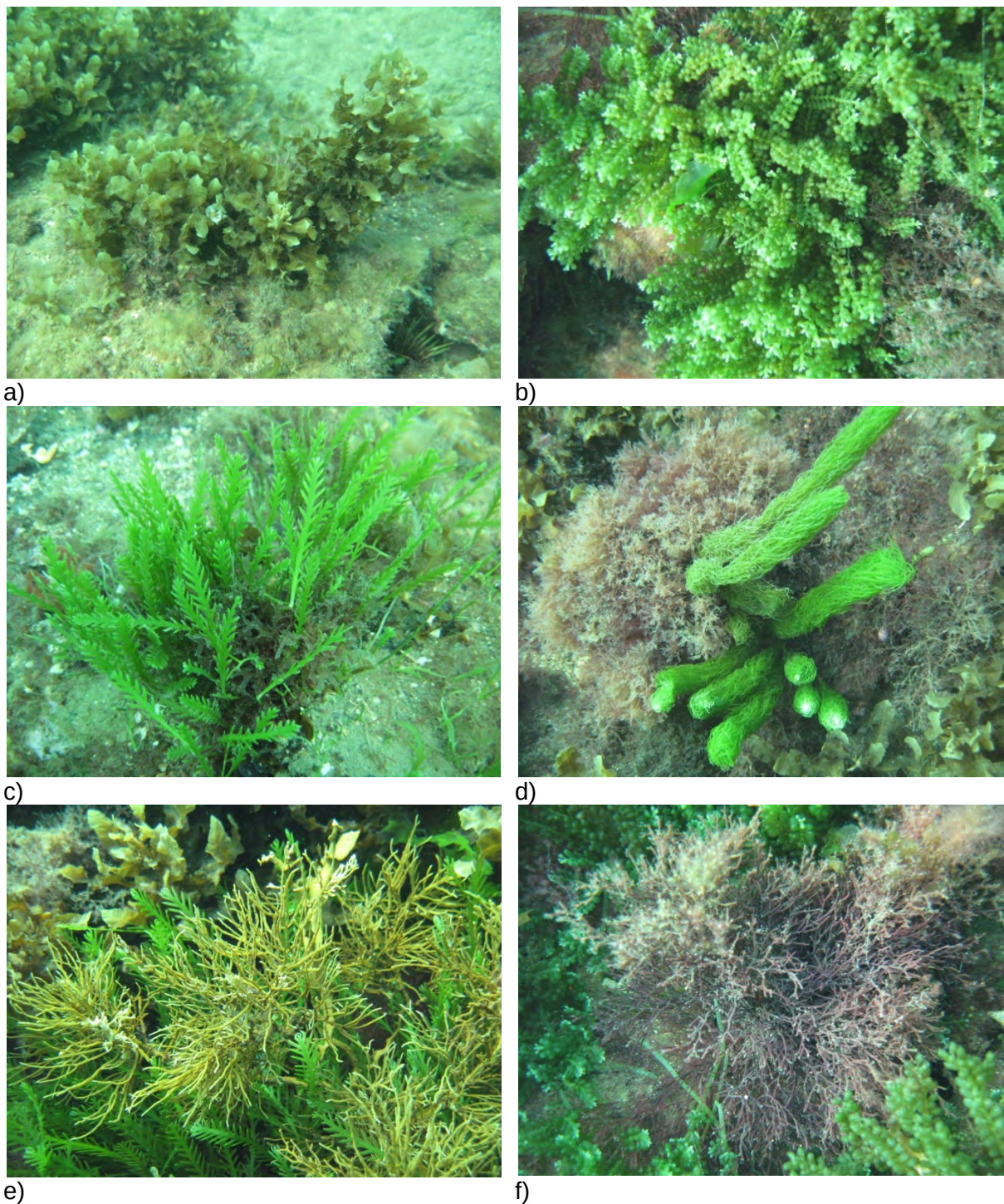


Figure 99. Macroalgae found on the subtidal reefs of Ricketts Point Marine Sanctuary: a) *Sargassum* sp.; b) *Caulerpa geminata*; c) *Caulerpa remotifolia*; d) *Caulerpa longifolia*; e) *Cystophora retroflexa*; and f) *Laurencia filiformis*. Photos by AME.



Figure 100. Purple sea urchin *Heliocidaris erythrogramma* on macroalgal covered subtidal reef in Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.



Figure 101. Blacklip abalone *Haliotis rubra* on macroalgal covered subtidal reef in Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.



Figure 102. Hydroids on the subtidal reef in Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.



Figure 103. The anemone *Anthothoe albocincta* on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.

Invertebrate fauna

There are relatively few invertebrate species (e.g. Figures 89, 91, 92, 102 and 103) on the subtidal reefs at Ricketts Point MS, which is dominated by high abundances of the purple sea urchin *Heliocidaris erythrogramma* (Edmunds *et al.* 2011; Figure 100). Other common species are blacklip abalone *Haliotis rubra* (Figure 101), biscuit star *Tosia australis*, eleven-armed seastar *Coscinasterias muricata* (Figure 104) and velvet star *Petricia vernicina* (Edmunds *et al.* 2011). The dominance of *H. erythrogramma* and *H. rubra* in Ricketts Point is not as great as in Jawbone and Point Cooke MSs (Edmunds *et al.* 2011). Also found on the reefs are the red swimmer crab *Nectocarcinus integrifrons*, rasping hermit crab *Strigopagurus strigimanus*, cartrut shell *Dicathais orbita* and granular seastar *Uniophora granifera*. The colorful dorid nudibranch *Ceratosoma brevicaudatum* (Figure 108) is also seen on the subtidal reefs in the MS (Edmunds *et al.* 2011). The hard coral *Plesiastrea versipora* is common on subtidal reefs in the MS (Edmunds *et al.* 2011; Figures 98 and 107). The invasive Northern Pacific seastar, *Asterias amurensis*, has also recently been found at Ricketts Point.



Figure 104. The eleven-armed seastar *Coscinasterias muricata* on the subtidal reef in Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.

Fish

Fish assemblages in the MS are slightly more diverse and larger species were more abundant, compared with other reefs in northern PPB (Edmunds *et al.* 2011). Thirty-five species of fish have been observed on the subtidal reef through the SRMP monitoring program. The fish assemblage is numerically dominated by the southern hulafish *Trachinops caudimaculatus* (Figure 105) and to a lesser extent by southern goatfish *Upeneichthys vlaminghii* and little rock whiting *Neoodax balteatus* (Edmunds *et al.* 2011). Both *T. caudimaculatus* and *N. balteatus* abundance can be very variable (Edmunds *et al.* 2011). Other prominent large species of fish include zebra fish *Girella zebra* (Figure 106), moonlighter *Tilodon sexfasciatus* and horseshoe leatherjacket *Meuschenia hippocrepis* (Edmunds *et al.* 2011). Species of leatherjacket include toothbrush *Acanthaluteres vittiger*, yellow-tailed *Meuschenia flavolineata*, rough *Scobinichthys granulatus*, pygmy *Brachaluteres jacksonianus* and six spined leatherjacket *Meuschenia freycineti* (Edmunds *et al.* 2011). Other fish observed on the reef include the dragonet *Bovichtus angustifrons*, common weedfish *Heteroclinus perspicillatus* and fiddler ray *Trygonorrhina fasciata*. Transient species such as Australian salmon *Arripis trutta* and snapper *Chrysophrys auratus* have been observed in the MS (Edmunds *et al.* 2011).



Figure 105. The southern hulafish *Trachinops caudimaculatus* is abundant on the subtidal reefs in Ricketts Point Marine Sanctuary. Photo by Julian Finn.



Figure 106. Zebra fish *Girella zebra* on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.

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, seabirds and an invertebrate of conservation significance are found in the waters of Ricketts Point MS.

3.3.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora

No threatened marine flora has been recorded in Ricketts Point MS (Parks Victoria 2005).

Invertebrates

One species of invertebrate found in Ricketts Point MS, the southern hooded shrimp *Athanopsis australis*, is listed under the *FFG Act 1988*.

Fish

No conservation listed fish species are found in Ricketts Point MS.

Birds

Eleven conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Ricketts Point MS (Table 22). Six are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Two, the white-bellied sea-eagle *Haliaeetus leucogaster* and the royal spoonbill *Platalea regia* are regarded as vulnerable. No nationally conservation listed birds have been recorded from the MS. Seven birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA; Table 22).

Marine mammals and reptiles

Ricketts Point MS is shallow and dominated by intertidal and subtidal reefs. It does not provide habitat for large marine mammals. It does provide occasional habitat for three conservation listed seals (Table 23). The bottlenose dolphin *Tursiops sp* and common dolphin *Delphinus delphis* have also been observed in the surrounds of the MS.

Table 22. Conservation listed shorebird and seabird records from Ricketts Point Marine Sanctuary and surrounds.

Common name	Scientific name	Victorian listing		National listing	International treaty	
		FFG	VROTS	EPBC	CAMBA	JAMBA
white-bellied sea-eagle	<i>Haliaeetus leucogaster</i>	L	VU		C	
royal spoonbill	<i>Platalea regia</i>		VU			
glossy ibis	<i>Plegadis falcinellus</i>		NT		C	
Pacific gull	<i>Larus pacificus</i>		NT			
piebald cormorant	<i>Phalacrocorax varius</i>		NT			
white-fronted tern	<i>Sterna striata</i>		NT			
common tern	<i>Sterna hirundo</i>				C	J
sooty shearwater	<i>Ardenna grisea</i>				C	J
ruddy turnstone	<i>Arenaria interpres</i>				C	J
short-tailed shearwater	<i>Ardenna tenuirostris</i>				J	J
Arctic jaeger	<i>Stercorarius parasiticus</i>				J	J

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

Table 23. Conservation listed marine mammal records from Ricketts Point Marine Sanctuary and surrounds.

Common name	Scientific name	Victorian listing	National listing
		VROTS	EPBC
southern elephant seal	<i>Mirounga leonina</i>		VU
New Zealand fur seal	<i>Arctophoca forsteri</i>	VU	
Australian fur seal	<i>Arctocephalus pusillus doriferus</i>		L

L= listed, VU = Vulnerable

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that within Ricketts Point MS the southern hooded shrimp *Athanopsis australis* is presumed to be endemic to the MS (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Two biota (Table 24) are presumed to be at their distributional limit in Point Cooke MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). One red algae is presumed to be at the eastern limit of its distribution in Ricketts Point MS (O'Hara and Barmby 2000; O'Hara and Poore 2000). One crab is recorded to be at the western limit of its distribution in Ricketts Point MS. 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 Ricketts Point Marine Sanctuary (O'Hara and Barmby 2000; O'Hara and Poore 2000; O'Hara 2002).

Phylum	Order	Family	Species	Common name	Category
Rhodophyta	Bonnemaisoniales	Bonnemaisoniaceae	<i>Bonnemaisonia australis</i>	Red algae	PE
Crustacea	Brachyura	Portunidae	<i>Ovalipes catharus</i>	Crab	RW

PE = presumed eastern limit, RW = recorded 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 ten years, were considered and ranked to identify hazards. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Twelve hazards with the potential to be of extreme risk were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the MS is indicated in brackets:

1. New or existing marine pests outcompeting local species (all of MS);
2. Trampling by visitors affecting intertidal organisms (intertidal soft sediment and reef);
3. Uninformed and excessive use of the sanctuary by visitor groups affecting intertidal assemblages (intertidal soft sediment and reef);
4. Lack of environmental etiquette (e.g. individuals trampling organisms, or neglecting to return rocks to their original position) affecting intertidal sand and rock habitats and communities (intertidal soft sediment and reef);
5. Nutrients from stormwater discharges affecting intertidal algae (intertidal reef);
6. Dogs not under effective control, disturbing (*i.e.* causing a change in behaviour of) native shorebirds and seabirds, including migratory waders (intertidal soft sediment and reef);
7. Lack of accessible ecological knowledge affecting management and consequently the functioning of organisms and the ecosystem of the sanctuary (all of MS);
8. Increased turbidity and thus decreased light penetration, and the release of toxicants, both resulting from the Channel Deepening project, and affecting sanctuary assemblages and habitats (all of MS);
9. Coastal management practices in areas adjacent to the sanctuary (e.g. construction of groynes/seawalls, protection of roads, maintenance of carparks) affecting habitats (e.g. by altering longshore drift of sand) (all of MS);
10. Failure to document ecological change affecting sanctuary assemblages and habitats (all of MS);
11. Bureaucratic timelines and inertia, and lack of co-ordination among multiple management agencies, affecting sanctuary assemblages and habitats (all of MS); and
12. Lack of consistent resourcing for sanctuary management (*i.e.* for Parks Victoria and Fisheries Victoria, with flow-on effects to Friends groups etc.) affecting assemblages and habitats (all of MS).

The introduction of marine pests threatens the integrity of marine biodiversity and may also reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are found in Port Phillip Bay (Parks Victoria 2003). The introduced green shore crab *Carcinus maenas* is found within Ricketts Point MS. Invasive Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile* (*subsp. fragile*) have been recorded in the MS since 2010 and the Northern Pacific seastar *Asterias amurensis* since 2011. Sightings of the European marine fanworm *Sabella spallanzanii* in the MS are currently being confirmed.



Figure 107. Green colour morph of the hard coral *Plesiastrea versipora* growing on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by AME.

There have been reports of abundances of the purple urchin, *Heliocidaris erythrogramma*, increasing in abundance forming barrens habitat in the northern part of the bay, including in Ricketts Point Marine Sanctuary. In areas where barrens have been established erect macroalgae are usually absent. It is unclear whether the recent increases in abundance are part of a natural cycle or part of a persistent increase in this native species.

A virus affecting abalone called abalone viral ganglioneuritis 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 Ricketts Point 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 couple of species are at the eastern or western limit of their distributional range at Ricketts Point MS and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in 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 Ricketts Point MS (Parks Victoria 2005). 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 2005). 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.

3.3.6 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 Ricketts Point 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).

Ricketts Point MS has an ongoing intertidal (IRMP) and a shallow subtidal (SRMP) reef monitoring program. The intertidal reef monitoring program in and around the Ricketts Point MS began in 2003 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). Since then there have been over six surveys (Edmunds *et al.* 2004b; Hart *et al.* 2005; Edmunds *et al.* 2010d). 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 mobile invertebrates and the percentage cover of macroalgae and aggregated sessile invertebrates are surveyed within quadrats along the transects (Hart and Edmunds 2005). The monitoring site (Figure 93) is on solid basalt reef at the western seaward edge of the intertidal area in the MS (Edmunds *et al.* 2010d). The reference site is on a small area of intertidal reef at Halfmoon Bay.

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 Ricketts Point 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. University of Melbourne: Jan Carey Developing Report Cards for the Marine National Parks.
RMIT University: Jessica Reeves A key to marine flora and fauna in Ricketts Point Marine Sanctuary.
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 (and Research) Reef Life Survey – Subtidal Reefs Marine Care Ricketts Point – research, monitoring and habitat mapping

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



Figure 108. The nudibranch *Ceratosoma brevicaudatum* is found on the subtidal reefs in Ricketts Point Marine Sanctuary. Photo by Julian Finn.

The shallow subtidal reef monitoring program (SRMP) around Ricketts Point MS began in 2003 and there have been over four surveys (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). The SRMP involves standardised underwater diver-mediated visual survey methods (Edmunds and Hart 2003a). The SRMP surveys a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish. Monitoring is undertaken at Ricketts Point MS along four contiguous 50 m transects in a single site near Tea House reef in 3 m depth, near the reef/sand edge (Figure 93). The reference site is 3 km north of the MS in Halfmoon Bay in the same water depth (Edmunds *et al.* 2011).

Preliminary analysis of both the IRMP and SRMP data collected a few years after declaration was done across the three PPB MSs. Intertidal biota did not show a difference in number of species or abundance due to protection (Keough and Carnell 2009). Long term monitoring is needed to provide the power to adequately test the effect of protection (Keough and Carnell 2009). Even then the effects may vary among MPAs, perhaps varying with the level of threat from harvesting of fauna (Keough and Carnell 2009). Subtidal biota did not show a difference in species richness or number of species between MPA and reference sites post-declaration (Keough and Carnell 2009). The abundances of common algae did vary between MS and reference sites, but generally in no obvious or consistent way, reducing confidence that the difference observed is an effect of the MSs (Keough and Carnell 2009). Further surveys may clarify these results. The sea star *Uniophora granifera* was the only invertebrate to display a difference in abundance between MS and reference sites across the three MSs (Keough and Carnell 2009). *U. granifera* was more abundant in reference sites compared to the MSs. None of the fish species displayed clear and consistent trends in abundance inside and outside of the three MSs (Keough and Carnell 2009). The abundances of fish were generally quite low, except for the hulafish *Trachinops caudimaculatus*. A separate research project on the impact of protection through MPAs on intertidal reef gastropods in PPB and Central coast found an MPA effect on the sizes of the limpets *Cellana tramoserica* and *Patelloida alticostata* (Bathgate 2010). Both species had larger shell length in MPAs than non-MPA sites. For *C. tramoserica*, this effect is most apparent at sites like Point Cooke and Jawbone MSs which have a long history of protection prior to their current declaration as MPAs (Bathgate 2010).

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. A review will also be taken of the intertidal monitoring program.

Community based monitoring of the intertidal and subtidal reefs is being conducted by the Marine Care Ricketts Point group. Other community based monitoring programs are also implemented at Ricketts Point including Reef Life Survey, for subtidal reefs, and Sea Search, for intertidal reefs which is implemented by school groups. This group is also cataloguing the natural values of the MS, mapping habitat, monitoring the extent of urchin barrens, and participating in marine pest management and the Reef Watch fish count (<http://www.marinecare.org.au/>). They have also established a Marine Education Centre. Other groups that have a close association with the sanctuary include the Beaumaris Conservation Society, Black Rock and Sandringham Conservation Society (BRASCA), Friends of Table Rock, Bayside Friends of Nature Wildlife, Friends of Watkins Bay and Friends of Ricketts Point Landside (Parks Victoria 2005).

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.

3.3.7 KNOWLEDGE GAPS

No surveys have been conducted on the ecological communities of intertidal and subtidal soft sediments, other than bird surveys and habitat mapping. No information exists at present for water column assemblages. Major threats have been identified for Ricketts Point MS but we have limited knowledge of the effect on the natural values, particularly ecological communities.

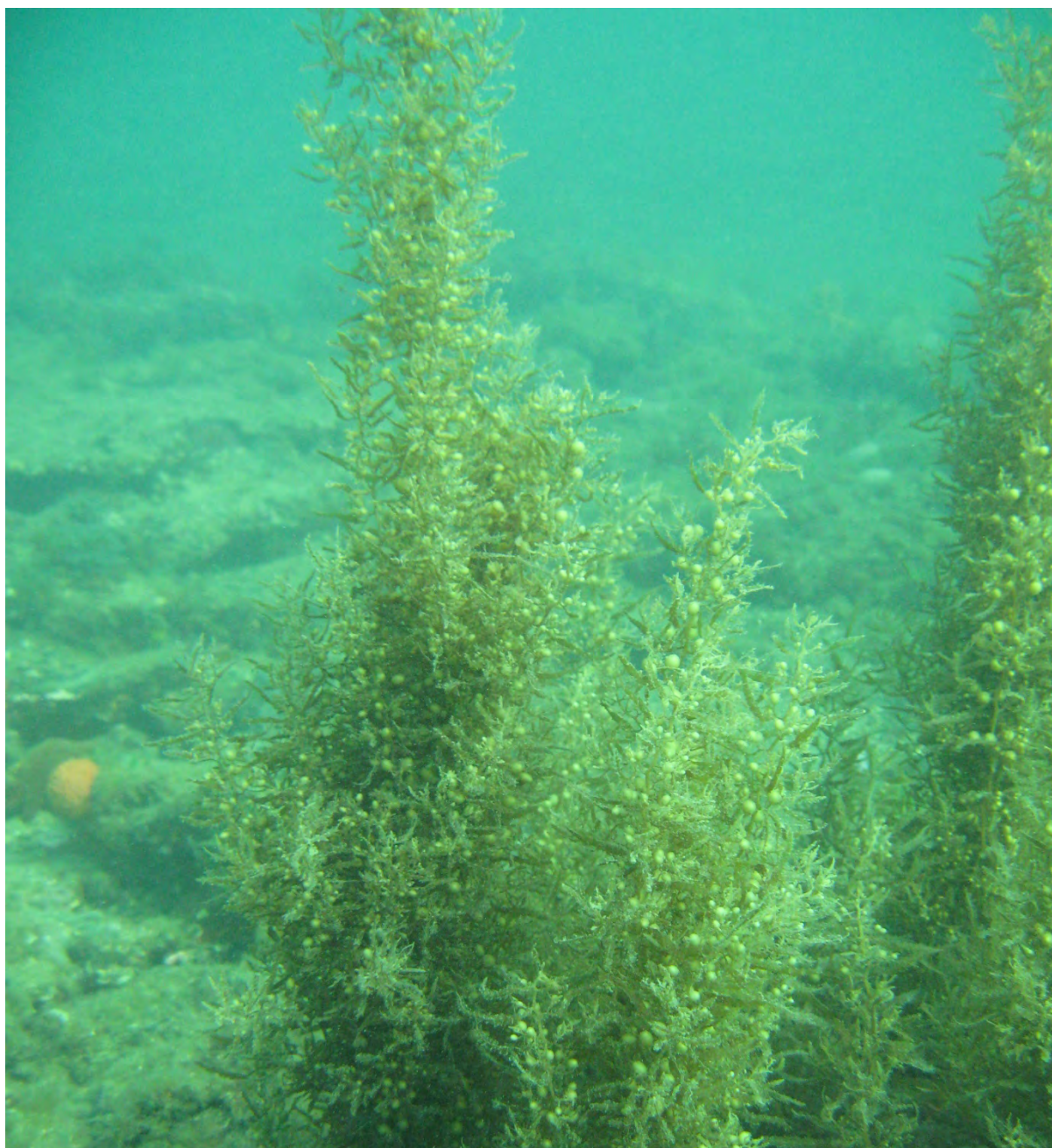


Figure 109. *Sargassum verruculosum* growing on the subtidal reef of Ricketts Point Marine Sanctuary. Photo by Julian Finn, Museum of Victoria.

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 Port Phillip Bay area of the Victorian Embayments bioregion 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 Victorian Embayments bioregion is a discontinuous region that includes all Victorian bays, inlets and estuaries to a minimum water area of $> 1 \text{ km}^2$ (IMCRA 1998b; IMCRA 2006). In this bioregion only PPB, Western Port Bay and Corner Inlet contain MPAs (IMCRA 2006). The bioregion has a moist temperate climate, varying west to east in runoff and seasonality, and has more variable water temperature and salinity than the open coast. The embayments vary in form but their maximum depth is generally $< 20 \text{ m}$. The biota of the Victorian embayments include a diverse range of biotic assemblages found in estuarine and open coast environments depending on the water body's morphological and hydrological characteristics (Parks Victoria 2003; IMCRA 2006). Port Phillip Bay is a marine embayment with constricted water exchange, deep central muds; eastern sandy shores, *Pyura* beds and shallow reef habitats; and sheltered reef, seagrass, drift algae and estuarine habitats in the west. The benthic assemblages in the muddy central region are distinct from those in the sand to the west and east. The west coast of PPB supports important bird habitat, most of which is included in Ramsar Sites.

Within the Victorian Embayments bioregion, there are five Marine National Parks and three Marine Sanctuaries. The Port Phillip Heads MNP is the only MNP in PPB but incorporates six different sections near the entrance to the bay. There are three MNPs in Western Port Bay: Yaringa; French Island; and Churchill Island while Corner Inlet has one self-named MNP. The three MSs (Point Cooke, Jawbone and Ricketts Point) are all in PPB. All MPAs adjoin the coast, except the Popes Eye, Mud Islands and Portsea Hole sections of the Port Phillip Heads MNP. The MPAs range in size from the large, multisection Port Phillip Heads MNP (3475 ha) to Jawbone MS (30.5 ha). Point Cooke MS (292 ha) is the largest MS in Victoria. All the MPAs in the bioregion, except Corner Inlet MNP, are relatively accessible from Victoria's major population centers of Melbourne and Geelong. Only part of Port Phillip Heads MNP and Corner Inlet MNP adjoin terrestrial National Parks, but all other MPAs adjoin reserves or other conservation areas.

Aboriginal tradition indicates that the Bellarine Peninsula side of the MNP is part of *Country* of the Wathaurung people, and the Mornington Peninsula side of the MNP, including Mud Islands, is part of *Country* of the Boon Wurrung people (Parks Victoria 2006). Jawbone,

Point Cooke and Ricketts Point MSs are all part of *Country* of Boon Wurrung people (Parks Victoria 2007a).

Some special use areas exist in PPB MPAs. Three 'Sea Use Designation' overlays apply in Port Phillip Heads MNP off inner Point Nepean: the Ticonderoga Bay Sanctuary Zone for bottlenose dolphin *Tursiops truncatus* protection and two public safety areas (Parks Victoria 2006). A Special Protection Area overlay also applies in Swan Bay to protect seagrass beds, seabird and shorebird habitat (Parks Victoria 2006). A Special Protection Area also protects some of the intertidal habitat in Jawbone MS with all access from both shore and water prohibited (Parks Victoria 2007a).

To effectively target management activities such as emergency response, monitoring and research, knowledge of the distribution and extent of marine habitats is required. 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. In the shallow waters of all the MPAs high resolution bathymetry mapping has increased our understanding of habitats. All MPAs in PPB have a mix of intertidal and subtidal soft sediment and rocky habitats. Intertidal habitat is predominately beaches amongst rocky headlands, with Jawbone MS also having extensive mudflats. On beaches flora 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. On the intertidal mudflats seagrass, saltmarsh, mangroves and significant amounts of benthic microalgae can grow. Very high numbers of invertebrate species may live on subtidal soft sediment habitat. The reefs in the MPAs are calcarenite in Port Phillip Heads MNP, and basalt in the MSs. The exceptions to this are the artificial basalt reef of Popes Eye in Port Phillip Heads MNP and sandstone reef in Ricketts Point MS. Port Phillip Heads MNP has deep (> 15 m) subtidal reef in Point Lonsdale, Point Nepean and Portsea Hole. The dominant habitat type in the MPAs is subtidal soft sediment. The MSs also have substantial intertidal and shallow subtidal rocky reef.

Intertidal seagrass, usually *Zostera muelleri*, is an important habitat in Port Phillip Heads MNP, particularly in Swan Bay and Mud Islands, and in Point Cooke and Jawbone MSs (Blake and Ball 2001; Hirst *et al.* 2009; Edmunds *et al.* 2010d). The aquatic macrophyte *Lepilaena marina* is also important in Swan Bay. Invertebrate fauna of Swan Bay intertidal seagrass beds are dominated by Corophiid amphipods and the amphipod *Allorchestes compressa*, and polychaetes including capitellids, the nereid *Ceratonereis pseudoerythraeensis* and orbinid *Scoloplos cylindrifer* (Plummer *et al.* 2003). Gastropods, bivalves, tanaids and epibenthic harpacticoids are also abundant (Plummer *et al.* 2003). The invertebrate fauna of unvegetated intertidal soft sediments in Swan Bay are dominated by a few taxa of oligochaete and polychaete worms, *Capitella* sp., bivalve *Mysella donaciformis*, gastropod *Salinator fragilis* and crane flies Tipulidae (Morris and Keough 2003). Wrack on the shore in Swan Bay in Port Phillip Heads MNP and Point Cooke MS can be considerable, extensive enough to cover the inshore seagrass beds (Hirst *et al.* 2009; Edmunds *et al.* 2010d).

The main habitat forming algae on the intertidal reefs in the MPAs is Neptune's necklace *Hormosira banksii* in Port Phillip Heads MNP and Ricketts Point MS, and an ephemeral coverage of sea lettuce *Ulva* spp. and *Enteromorpha* spp. in Point Cooke and Jawbone MSs (Edmunds *et al.* 2010d). The intertidal reefs of Port Phillip Heads MNP are diverse compared to the MSs with one species of seagrass *Amphibolis antarctica*, and over 29 species of algae (Costa *et al.* 2010; O'Hara *et al.* 2010). Turfing and coralline algae are present in all the MPAs, as are small patches of the encrusting tube worm *Galeolaria caespitosa* low on the shoreline (Costa *et al.* 2010; Edmunds *et al.* 2010d; O'Hara *et al.* 2010).

The intertidal reefs in Port Phillip Heads MNP are dominated by the slit limpet *Clypidina rugosa*, variegated limpet *Cellana tramoserica* and striped coniwink *Bembicium nanum* (Edmunds *et al.* 2010d). The small black periwinkle *Nodilittorina acutispira* can be very abundant, but its abundance varies immensely (Edmunds *et al.* 2010d). In the north of PPB in the MSs, the herbivorous zebra top shell *Austrocochlea porcata* is the most abundant invertebrate (Edmunds *et al.* 2010d). Other molluscs found in low densities on these reefs are the coniwink *Bembicium* spp. and limpet *C. tramoserica* (Bathgate 2010; Edmunds *et al.* 2010d). The black nerite *Nerita atramentosa* is common in Jawbone MS. The carnivorous gastropods *Cominella lineolata* and *Lepsiella vinosa* are found in all the MPAs but are not as abundant as the herbivorous molluscs. The Tasmanian blenny *Parablennius tasmanianus* and the weedfish Clinidae are commonly found in the intertidal pools in Point Cooke and Ricketts Point MSs (Plummer *et al.* 2003).

Seagrass is an important habitat in Port Phillip Heads MNP, particularly on the soft intertidal and subtidal sediments in Mud Islands and Swan Bay. In Mud Islands large beds of *H. nigricaulis* grows in the lagoon and on the seaward edges of the islands in waters up to 8 m deep (Hutchinson *et al.* 2011). In Swan Bay *H. nigricaulis*, *Zostera muelleri*, *Halophila australis*, *Ruppia maritima*, *R. tuberosa*, *R. polycarpa* *Lepilaena marina*, and *L. cylindrocarpa* grow on the subtidal flats (Blake and Ball 2001; Edmunds *et al.* 2004a; Ball *et al.* 2009; Hirst *et al.* 2009). Deeper waters in the south and centre of Swan Bay tend to be dominated by algae such as *Caulerpa* spp. and filamentous algae (Blake and Ball 2001). The seagrasses *H. nigricaulis* and *H. australis* form patches of habitat on the subtidal soft sediment in the Point Cooke MS (Blake and Ball 2001; Edmunds *et al.* 2011). In the north west of Jawbone MS there is a large bed of seagrass *Zostera/Heterozostera* (Blake and Ball 2001). A small amount of seagrass *H. nigricaulis* has been mapped between Tea House and Middle intertidal reefs in Ricketts Point MS (Blake and Ball 2001). In Point Cooke MS beds of habitat forming cunjevoi *Pyura stolonifera* and large beds of *Caulerpa remotifolia*, *C. longifolia*, *C. brownii* and *C. flexilis* also grow on the soft sediment (Edmunds *et al.* 2011).

The *H. nigricaulis* habitat in Mud Islands supports at least twenty-seven species of finfish and one species of squid (Hutchinson *et al.* 2011). In the shallow beds, smallmouth hardyheads *Atherinosoma microstoma* and hardyhead recruits *Atherinidae* spp. are abundant along with the wide-body pipefish *Stimatorpora nigra*, spotted pipefish *S. argus* bridled leatherjacket *Acanthaluteres spilomelanurus*, little rock whiting *Neoodax balteatus* and blue sprat *Sparatelloides robustus* (Hutchinson *et al.* 2011). In the deeper seagrass beds the most abundant fish is the wide-body pipefish *S. nigra*. Also abundant are leatherjackets, including the bridled *A. spilomelanurus*, toothbrush *A. vittiger* and pygmy *Brachaluteres jacksonianus* along with the little rock whiting *N. balteatus* (Hutchinson *et al.* 2011). In Swan Bay the seagrass has large numbers of the spotted pipefish *S. argus* along with other species of pipefish such as *Vanacampus phillipi*. Other fish include the hardyhead *Leptatherina presbyteroides*, the bridled leather jacket *A. spilomelanurus*, the spot-shoulder weed fish *Heteroclinus perspicillatus* and the cobbler *Gymnapistes marmoratus* (Plummer *et al.* 2003). A number of commercially important species, rough leatherjacket *Scobinichthys granulatus*, six-spined leatherjacket *Meuschenia freycineti*, and King George whiting *Sillaginodes punctatus*, settle directly into subtidal *H. nigricaulis* beds in PPB (Blake and Ball 2001; Plummer *et al.* 2003). Skates, rays and stingarees are particularly common on the sand beds in the Port Phillip Heads MNP (Edmunds *et al.* 2009b). Species include the eagle ray *Myliobatis australis*, smooth stingray *Dasyatis brevicaudata*, banjo ray *Trygonorrhina fasciata*, southern fiddler ray *T. guaneria*, sparsely spotted stingaree *Urolophus paucimaculatus* and spotted stingaree *U. gigas* (Edmunds *et al.* 2009b).

Macroalgae provide important habitat structure for other organisms on shallow subtidal reefs. There is considerable difference in species and structure of the canopy forming algae on the subtidal reefs in Port Phillip Heads MNP compared to the three MSs. Around 20-50 species of macroalgae are found on the shallow subtidal reefs of Port Phillip Heads MNP,

with a number of rare species found in Point Nepean (Edmunds *et al.* 2009b; Edmunds *et al.* 2010c). There are four general macroalgal communities corresponding with four subtidal reef groupings in Port Phillip Heads MNP: outside the Heads; inside the Heads in Point Lonsdale; inside the Heads in Point Nepean; and well inside the Heads at Popes Eye (Edmunds *et al.* 2010c). These groupings correspond with differences in wave exposure and depth (Edmunds *et al.* 2010c).

Outside the Heads in Point Lonsdale, the reefs have a *Phyllospora comosa* dominated canopy (Ball and Blake 2007; Edmunds *et al.* 2010c). Understorey species include *Haliptilon roseum*, *Phacelocarpus peperocarpus*, *Pterocladia lucida*, *Ballia callitricha* and *Areschougia congesta*. Outside of the Heads on the low relief reef of Point Nepean *E. radiata* stands form dense canopy interspersed with smaller thallose algae, including *Caulerpa flexilis*, *Plocamium angustum*, *Melanthalia obtusata* and *P. peperocarpus* (Edmunds *et al.* 2004a; Ball and Blake 2007). Inside the Heads, kelp *E. radiata* and crayweed *P. comosa* are dominant along with *Cladophora prolifera*, *Cystophora moniliformis*, *C. retorta* and *Seirococcus axillaris* (Edmunds *et al.* 2010c). The seagrass *Amphibolis antarctica* forms substantial beds in the middle of Lonsdale Bay and in Nepean Bay along with patches of mixed brown algae (Edmunds *et al.* 2010c). The green alga *Cladophora prolifera* is usually present in Nepean Bay, but in low abundances (Edmunds *et al.* 2009b). Popes Eye is dominated by the kelp *E. radiata* and has a high predominance of the green algae *C. prolifera* and *Caulerpa* species with no *P. comosa* or *C. moniliformis* (Edmunds *et al.* 2010c). Popes Eye has a moderate abundance of red algal species (Edmunds *et al.* 2010c).

The number of macroalgae species in the MSs ranges from 16 in Jawbone to over 32 in Ricketts Point (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). All three MSs have moderate to sparse coverage of kelp *E. radiata* and encrusting coralline algae. The green algae *Caulerpa remotifolia* is a dominant species in Point Cooke along with sparse sea lettuce *Ulva* sp., brown algae *Dilophus marginatus* and *Dictyota dichotoma*, and thallose red algae such as *Gigartina* sp (Edmunds *et al.* 2011). Jawbone MS has low to moderate abundances of *Sargassum* spp, and filamentous brown algae Ectocarpales (Edmunds *et al.* 2011). Ricketts Point MS is dominated by *Sargassum-Caulerpa* assemblages, including *Caulerpa geminata* and *C. remotifolia*, *Sargassum spinuligerum*, and a mixture of smaller red and brown seaweeds. The reef in Ricketts Point MS generally has higher algae density than Jawbone or Point Cooke MSs (Edmunds *et al.* 2011). Sessile invertebrates in all MPAs include the hard coral *Plesiastrea versipora* and sponges (Edmunds *et al.* 2011).

Like the macroalgae there are substantial differences in species diversity and abundance in shallow subtidal reef invertebrate fauna communities of Port Phillip Heads MNP and the three MSs. Within Port Phillip Heads MNP there are four general invertebrate communities, corresponding to the four site groupings (Edmunds *et al.* 2010c). The biscuit star *Tosia australis* is the most abundant seastar on all the reefs in Port Phillip Heads MNP, although its numbers can be very variable (Edmunds *et al.* 2010c). Blacklip abalone *Haliotis rubra* are abundant on the exposed reef outside and inside the Heads (Edmunds *et al.* 2009b). Greenlip abalone *H. laevigata* are not as common as blacklip abalone *H. rubra* and are found on the inshore shallow reefs inside the Heads (Edmunds *et al.* 2009b). Inside the Heads the warrener *Turbo undulatus* and the seastar *Nectria ocellata* are common in Point Lonsdale (Edmunds *et al.* 2010c). Reefs both outside and inside the Heads in Point Lonsdale have low abundances of purple sea urchin *Heliocidaris erythrogramma* and feather star *Comanthus trichoptera* (Edmunds *et al.* 2009b). Inside the Heads in Point Nepean the warrener *T. undulatus* and cartrut shell *Dicathais orbita*, and feather star *C. trichoptera* are abundant along with moderate abundances of the purple sea urchin *H. erythrogramma* (Edmunds *et al.* 2010c). Popes Eye has high abundances of the featherstar *C. trichoptera*, low abundances of blacklip abalone *H. rubra*, and moderate to high abundances of the purple sea urchin *H. erythrogramma* (Edmunds *et al.* 2010c). No greenlip abalone *H.*

laevigata or warrener *T. undulatus* have been recorded at Popes Eye (Edmunds *et al.* 2009b).

Point Cooke MS subtidal reefs are dominated by echinoderms like the purple sea urchin *Heliocidaris erythrogramma* and seastars *Tosia australis*, *Meridiastra gunnii* and *Coscinasterias muricata* (Lindsay and Edmunds 2006; Edmunds *et al.* 2011). Black lip abalone *Haliotis rubra* and the granular seastar *Uniophora granifera* are also abundant (Edmunds *et al.* 2011). The mobile invertebrate assemblage in Jawbone MS is dominated by the sea urchin *Heliocidaris erythrogramma*, the seastars *Meridiastra gunnii*, *Meridiastra calcar* and *Coscinasterias muricata* and the blacklip abalone *Haliotis rubra* and to a lesser extent the biscuit star *Tosia australis* (Edmunds *et al.* 2011). There are relatively few mobile invertebrate species on the subtidal reef at Ricketts Point MS which is dominated by the purple sea urchin *Heliocidaris erythrogramma* (Edmunds *et al.* 2011). Other recorded species are the blacklip abalone *Haliotis rubra*, biscuit star *Tosia australis*, eleven-armed seastar *Coscinasterias muricata* and velvet star *Petricia vernicina* (Edmunds *et al.* 2011).

Over 71 species of fish are found on the shallow subtidal reefs of Port Phillip Heads MNP (Edmunds *et al.* 2009b). Inside the Heads both Lonsdale Bay and Nepean Bay have a relatively low abundance of fishes and the community structure is very variable over time (Edmunds *et al.* 2009b; Keough and Carnell 2009). Outside the Heads in Point Lonsdale, scalyfin *Parma victoriae* and senator wrasse *Pictilabrus laticlavius* are abundant. Also on the reef are herring cale *Odax cyanomelas*, blue-throated wrasse *Notolabrus tetricus* and the horseshoe leatherjacket *Meuschenia hippocrepis* (Edmunds *et al.* 2009b). The fish communities inside the Heads in Point Lonsdale and Point Nepean are similar, except for a lower abundance of scalyfin *P. victoriae* and senator wrasse *P. laticlavius*. Point Lonsdale also has a higher abundance of zebra fish *Girella zebra* and magpie perch *Cheilodactylus nigripes* than Point Nepean (Edmunds *et al.* 2009b). Popes Eye has a fish community that is distinct from elsewhere in the MNP (Edmunds *et al.* 2009b). Fishing has been banned since 1976 and the reef has higher species richness, as well as abundance of fish, including larger fish, than elsewhere in southern PPB (Edmunds *et al.* 2009b; Keough and Carnell 2009). Diversity is dominated by a high abundance of a few species, particularly hula fish *Trachinops caudimaculatus*, scalyfin *P. victoriae* and blue-throated wrasse *N. tetricus* (Edmunds *et al.* 2009b). Purple wrasse *N. fucicola*, magpie perch *C. nigripes*, horseshoe leatherjacket *M. hippocrepis* and herring cale *O. cyanomelas* are also abundant in Popes Eye (Edmunds *et al.* 2009b). Several species, including sea sweep *Scorpiis aequipinnis* and rosy wrasse *Pseudolabrus psittaculus* are rarely observed elsewhere in the MNP other than at Popes Eye (Edmunds *et al.* 2009b).

The number of fish species observed in the MSs ranges from 16 in Point Cooke MS to over 35 in Ricketts Point MS. All three MSs are dominated by the southern hula fish *T. caudimaculatus* (Jung *et al.* 2010; Edmunds *et al.* 2011). Southern goatfish *Upeneichthys vlaminghii* and little rock whiting *Neodax balteatus* are also common in the MSs but particularly abundant in Ricketts Point MS (Edmunds *et al.* 2011). Zebrafish *G. zebra*, globefish *Diodon nichthemerus*, horseshoe leatherjacket *Meuschenia hippocrepis* and dusky morwong *Dactylophora nigricans* are prominent large species found in low abundances in all three MSs (Edmunds *et al.* 2011). The moonlighter *Tilodon sexfasciatus* and banjo ray *Trygonorrhina fasciata* are found in Point Cooke and Ricketts Point MSs. Transient species such as Australian salmon *Arripis trutta* and snapper *Chrysophrys auratus* occur over the subtidal reefs in all the MPAs.

The deep (> 19 m) subtidal reef *E. radiata* kelp beds in Port Phillip Heads MNP are different to shallower *E. radiata* beds in the MNP; they have a lower abundance of understorey algae and mobile invertebrates, particularly seastars, and a different fish community (Edmunds 2007). The deep subtidal reef community in Port Phillip Heads MNP has a high abundance and diversity of sessile invertebrates, especially arborescent, encrusting and flabellate

sponges, gorgonian corals, bryozoans and hydroids (Edmunds *et al.* 2004a; Edmunds 2007). This includes distinctive species such as the hydroids *Solanderia fusca*, *Nemertesia procumbens*, *Halopteris glutinosa* and *Gymnangium superbum*, jewel anemone *Corynactis australis* and the bryozoan *Orthoscuticella ventricosa* (Edmunds 2007). It has a substantial proportion of the known sponge species from Victoria and Australia, and at least 115 species are endemic to the MNP (Edmunds 2007). Its sessile invertebrate community is quite distinct compared to deep subtidal reefs in The Arches MS and Twelve Apostles, Point Addis and Wilsons Promontory MNPs (Edmunds 2007). In particular sponges are more abundant, while algae and gorgonian coral fans *Pteronisis* sp are less abundant. Deep subtidal reef fish communities are diverse and dominated by barber perch *C. razor* and southern hulafish *T. caudimaculatus* (Edmunds *et al.* 2004a). Rosy wrasse *P. psittaculus*, silver sweep *Scorpius lineolata*, Australian mado *Atypichthys strigatus*, blue devil fish *Paraplesiops meleagris*, butterfly perch *Caesioperca lepidoptera*, jackass morwong *Nemadactylus macropterus*, gurnards Triglidae and goat fish Mullidae also occur (Plummer *et al.* 2003; Edmunds *et al.* 2004a).

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 11 species in Ricketts Point MS up to 58 in Port Phillip Heads MNP. The MPAs are also important for many migratory birds, from 7 species in Ricketts Point MS to 43 in Port Phillip Heads MNP. Numerous marine species are found at the limit of their distribution range within individual MPAs. In Port Phillip Heads MNP 104 species, including algae and invertebrates are believed to be at the edge of their distributional range, compared to 2 in Ricketts Point MS. Six are believed to be at the edge of their range in Point Cooke MS and 5 in Jawbone MS. Five invertebrates are believed to be endemic to Port Phillip Heads MNP and one to Ricketts Point MS.

Point Cooke, Jawbone and Ricketts Point MSs are generally too shallow to provide much habitat for conservation listed marine mammals although seals and dolphins have been seen in or near the MSs. In the deeper waters of Port Phillip Heads MNP the southern right *Eubalaena australis* and humpback whale *Megaptera novaeangliae*, have been sighted. The northwest corner of Popes Eye is a minor haul-out area for the *EPBC Act* listed Australian fur seal *Arctocephalus pusillus doriferus* (Edmunds *et al.* 2009b).

Specific threats to individual MPAs have been documented (Carey *et al.* 2007b). Generally invasive marine pest have been identified as posing a serious threat to all the MPAs as have the impact of sediment from dredging on seagrass, benthic fauna, birds and the water column. The lack of ecological knowledge and consequently inadequate monitoring and management is also recognized as a common threat. The MSs in the north of PPB are threatened by spills of oil or pollutants and increased nutrients from their urban catchments. Major oil spills from commercial shipping are also seen as a threat to Port Phillip Heads MNP. Damage through trampling poses a threat to the highly accessible intertidal reefs in the MSs. Disturbance of wildlife is also a threat, for example shore birds being disturbed by people or dogs in Jawbone MS. Illegal fishing is a threat in Point Cooke and Jawbone MSs. Measures to address or minimize these threats are included in the management plans for the MPAs.

The introduction of foreign species or marine pests, by recreational or commercial vessels, threatens the integrity of marine biodiversity and may also reduce the social and economic benefits derived from the marine environment. The introduced green shore crab *Carcinus maenas* occurs on the intertidal reefs of all the MPAs. The northern Pacific seastar *Asterias amurensis* is found in Swan Bay and Mud Islands in Port Phillip Heads MNP, and in Jawbone and Ricketts Point MS. The European fan worm *Sabella spallanzanii* is also established in Swan Bay, Point Cooke, Jawbone and sightings have been reported in Ricketts Point (yet to be confirmed by taxonomic experts). Broccoli weed *Codium fragile*

(*subsp. fragile*) is established in Swan Bay and Mud Islands in Port Phillip Heads MNP, and Jawbone and Ricketts Point MSs. The Invasive Japanese kelp *Undaria pinnatifida* is established on the subtidal reef in Point Cooke, Jawbone and Ricketts Point MSs, but not yet in Port Phillip Heads MNP. The red algae *Grateloupia turuturu* has also been recorded from Point Cooke MS. Another species of particular concern is the New Zealand screw shell *Maoricolpus roseus* which is established on subtidal soft sediment in eastern Bass Strait (Parks Victoria 2003). The potential for further invasions in the MPAs is high (Parks Victoria 2007a).

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 could be particularly vulnerable to climate change. Parks Victoria has 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 and intertidal reef monitoring occurs in all four MPAs in PPB. 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 and substrate mapping has been done for shallow waters in all MPAs. Most of our detailed knowledge about the flora and fauna of the MPAs is from the intertidal and shallow subtidal reef marine monitoring programs. Even with that we have limited knowledge of fish in the intertidal zone. Technological improvements have increased our ability to explore and describe deep habitats, as has been done for soft sediments and reefs in Point Lonsdale in Port Phillip Heads MNP (Edmunds 2007). A major gap in our understanding of the natural values of Victorian Embayments MPAs is the lack of knowledge about the habitat values and species associated with soft sediment seafloors 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.

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APPENDIX 1

Compilation of species from databases from:

- the Atlas of Victorian Wildlife (Fauna 100, records within 5km of all MPAs, excluding terrestrial areas)
- the first Marine Natural Values reports; (MAFRI MNV v1);
- MAVRIC (Monitoring and Assessment of Victoria's Rocky Intertidal Coast);
- PV intertidal reef monitoring program (IRMP 02-04);
- PV subtidal reef monitoring program (SRMP_All); and
- The Sea Search volunteer monitoring program (Point Cook and Ricketts Point MSs only).

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

Source	Habitat(s)	Port Phillip Heads MNP				Point Cook MS	Jawbone MS	Ricketts Pt MS
		Pope's Eye	Pt Lonsdale	Pt Nepean	Unspecified			
Fauna100_5kmSea	All				112	79	69	38
MAFRI distribution MNV v1	All				105	6	5	2
MAFRI endemic MNV v1	All				5			1
MAVRIC	Rocky Intertidal				71	32	10	31
IRMP 02-04	Rocky Intertidal		45			24	22	22
SRMP_All	Rocky Subtidal	123	211	155		30	28	62
Seasearch20090326	Rocky Intertidal					18		27

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. PPH, PE – Port Phillip Heads MNP, Pope’s Eye section; PPH, Lons – Port Phillip Heads MNP, Point Lonsdale section; PPH,Nep – Port Phillip Heads MNP, Point Lonsdale section; PPH, N/S – Port Phillip Heads MNP, Section not specified; PPH, Sum – Combined; PC – Point Cooke MS; Jaw – Jawbone MS; RP – Ricketts Point MS – The Arches MS; 12Ap – Twelve Apostles MNP.

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
Blue-green algae	Phormidiaceae	<i>Symploca</i> sp.	Blue-green alga		1			1		1	1
	Rivularaceae	<i>Rivularia firma</i>	Blue-green alga				1	1			
Total blue-green algae				0	1	0	1	2	0	1	1
Green algae	Bryopsidaceae	<i>Bryopsis macrailldii</i>	Green alga				1	1			
	Caulerpaceae	<i>Caulerpa annulata</i>	Green alga	1		1		1		1	1
		<i>Caulerpa brownii</i>	Green alga	1	1	1	1	1			
		<i>Caulerpa cactoides</i>	Green alga		1	1	1	1			
		<i>Caulerpa cliftonii</i>	Green alga				1	1			
		<i>Caulerpa flexilis</i>	Green alga	1	1	1		1			
		<i>Caulerpa flexilis</i> var. <i>muelleri</i>	Green alga		1	1		1			
		<i>Caulerpa geminata</i>	Bubbled Caulerpa	1	1	1	1	1			1
		<i>Caulerpa longifolia</i>	Green alga	1	1	1	1	1	1		1
		<i>Caulerpa obscura</i>	Green alga	1	1	1		1			
		<i>Caulerpa remotifolia</i>	Green alga		1			1	1		1
		<i>Caulerpa scalpelliformis</i>	Green alga	1	1	1		1			
		<i>Caulerpa simpliciuscula</i>	Green alga		1	1		1			1
		<i>Caulerpa trifaria</i>	Green alga	1	1	1		1			
		<i>Caulerpa vesiculifera</i>	Green alga			1		1			
	Cladophoraceae	<i>Abjohnia laetevirens</i>	Green alga		1	1		1			
		<i>Chaetomorpha</i> sp.	Green alga		1			1			
		<i>Cladophora prolifera</i>	Green alga	1	1	1		1	1	1	
		<i>Cladophora rugulosa</i>	Green alga				1	1			
		<i>Cladophora</i> sp.	Green alga		1			1	1		

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
	Codiaceae	<i>Codium duthieae</i>	Green alga		1	1		1			
		<i>Codium fragile</i>	Dead man's fingers								1
		<i>Codium galeatum</i>	Green alga		1			1			
		<i>Codium harveyi</i>	Green alga	1				1			
		<i>Codium lucasii</i>	Green alga	1		1		1			
		<i>Codium perrinae</i>	Green alga				1	1			
		<i>Codium pomoides</i>	Green alga		1	1	1	1			
		<i>Codium</i> sp.	Green alga	1	1			1		1	1
	Siphonocladaceae	<i>Dictyosphaeria sericea</i>	Green alga			1	1	1			
	Udoteaceae	<i>Avrainvillea clavatiramea</i>	Green alga				1	1			
		<i>Callipsygma wilsonis</i>	Green alga				1	1			
		<i>Chlorodesmis baculifera</i>	Green alga		1			1			
	Ulvaceae	<i>Enteromorpha compressa</i>	Green alga				1	1			
		<i>Enteromorpha intestinalis</i>	Green alga				1	1	1		
		<i>Enteromorpha</i> sp.	Green alga		1			1	1	1	1
		<i>Ulva</i> sp.	Sea lettuce	1	1	1		1	1	1	1
	Unknown Family	Unidentified filamentous green algae	Green alga		1			1		1	1
Total green algae				13	23	19	14	36	7	6	10
Brown algae	Alariaceae	<i>Ecklonia radiata</i>	Common kelp	1	1	1		1	1	1	1
	Chordariaceae	<i>Tinocladia australis</i>	Brown alga				1	1			
	Cladostephaceae	<i>Cladostephus spongiosus</i>	Brown alga		1	1	1	1			
	Cystoseiraceae	<i>Acrocarpia paniculata</i>	Brown alga		1	1		1			1
		<i>Carpoglossum confluens</i>	Brown alga		1	1		1			
		<i>Caulocystis cephalornithos</i>	Brown alga		1	1		1			1
		<i>Caulocystis uvifera</i>	Brown alga				1	1			1
		<i>Cystophora cuspidata</i>	Brown alga				1	1			
		<i>Cystophora cymodoceae</i>	Brown alga				1	1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Cystophora expansa</i>	Brown alga		1	1		1			
		<i>Cystophora monilifera</i>	Brown alga	1	1	1		1		1	1
		<i>Cystophora moniliformis</i>	Brown alga		1	1		1			1
		<i>Cystophora pectinata</i>	Brown alga		1			1			
		<i>Cystophora platylobium</i>	Brown alga		1	1		1			
		<i>Cystophora racemosa</i>	Brown alga				1	1			
		<i>Cystophora retorta</i>	Brown alga		1	1	1	1			
		<i>Cystophora retroflexa</i>	Brown alga		1	1		1			1
		<i>Cystophora siliquosa</i>	Brown alga		1	1		1			
		<i>Cystophora</i> sp.	Brown alga			1		1			
		<i>Cystophora subfarcinata</i>	Brown alga		1	1	1	1			1
		<i>Cystophora torulosa</i>	Brown alga				1	1			
	Dictyotaceae	<i>Chlanidophora microphylla</i>	Brown alga		1			1			
		<i>Dictyopteris acrostichoides</i>	Brown alga		1	1		1			
		<i>Dictyopteris muelleri</i>	Brown alga	1	1	1		1			
		<i>Dictyota dichotoma</i>	Brown alga	1	1	1		1	1	1	1
		<i>Dilophus gunnianus</i>	Brown alga		1			1			
		<i>Dilophus marginatus</i>	Brown alga						1		
		<i>Dilophus robustus</i>	Brown alga				1	1			
		<i>Distromium flabellatum</i>	Brown alga								1
		<i>Distromium</i> sp.	Brown alga		1			1			
		<i>Homeostrichus olsenii</i>	Brown alga		1			1			
		<i>Homeostrichus sinclairii</i>	Brown alga	1	1	1		1			
		<i>Homoeostrichus canaliculatus</i>	Brown alga				1	1			
		<i>Lobophora variegata</i>	Brown alga	1	1	1		1			
		<i>Lobospira bicuspidata</i>	Brown alga	1	1	1		1			1
		<i>Pachydictyon paniculatum</i>	Brown alga		1	1		1			
		<i>Pachydictyon</i> sp.	Brown alga		1			1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Padina fraseri</i>	Brown alga				1	1	1		
		<i>Padina</i> sp.	Brown alga								1
		<i>Zonaria angustata</i>	Brown alga		1	1	1	1			
		<i>Zonaria crenata</i>	Brown alga		1	1	1	1			
		<i>Zonaria</i> sp.	Brown alga		1	1		1			1
		<i>Zonaria spiralis</i>	Brown alga			1		1			
		<i>Zonaria turneriana</i>	Brown alga	1	1	1		1			1
	Durvillaeaceae	<i>Durvillaea potatorum</i>	Bull kelp		1			1			
	Ectocarpaceae	<i>Ectocarpus</i> sp.	Brown alga	1	1			1			
	Elachistaceae	<i>Elachista claytoniae</i>	Brown alga				1	1			
	Fucaceae	<i>Xiphophora chondrophylla</i>	Brown alga		1	1	1	1			
	Hormosiraceae	<i>Hormosira banksii</i>	Neptune's necklace		1		1	1	1		1
	Leathesiaceae	<i>Leathesia difformis</i>	Sea potato								1
	Lessoniaceae	<i>Macrocystis pyrifera</i>	Kelp	1	1	1		1			
	Notheiaceae	<i>Notheia anomala</i>	Brown alga		1		1	1			1
	Sargassaceae	<i>Sargassum decipiens</i>	Brown alga	1	1	1		1			
		<i>Sargassum fallax</i>	Brown alga	1	1	1		1		1	
		<i>Sargassum heteromorphum</i>	Brown alga		1			1			
		<i>Sargassum linearifolium</i>	Brown alga		1	1		1			
		<i>Sargassum sonderi</i>	Brown alga		1	1		1			
		<i>Sargassum</i> sp.	Brown alga	1	1	1		1	1	1	1
		<i>Sargassum spinuligerum</i>	Brown alga	1	1	1		1			1
		<i>Sargassum varians</i>	Brown alga		1	1		1			
		<i>Sargassum verruculosum</i>	Brown alga		1	1		1			1
		<i>Sargassum vestitum</i>	Brown alga	1	1	1		1			
	Scytosiphonaceae	<i>Colpomenia peregrina</i>	Brown alga			1		1			
		<i>Colpomenia sinuosa</i>	Globe algae			1	1	1			1
		<i>Colpomenia</i> sp.	Brown alga		1			1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
	Seirococcaceae	<i>Phyllospora comosa</i>	Brown alga		1	1		1			
		<i>Scytosiphon lomentaria</i>	Brown alga		1		1	1			1
		<i>Scytothalia dorycarpa</i>	Brown alga				1	1			
		<i>Seirococcus axillaris</i>	Brown alga		1	1		1			
	Sphacelariaceae	<i>Sphacelaria bracteata</i>	Brown alga				1	1			
		<i>Splachnidium rugosum</i>	Sausage weed								1
	Sporochnaceae	<i>Bellotia eriophorum</i>	Brown alga		1			1			
		<i>Carpomitra costata</i>	Brown alga	1	1			1			
		<i>Nereia lophocladia</i>	Brown alga				1	1			
		<i>Perithalia caudata</i>	Brown alga		1			1			
		<i>Sporochnus apodus</i>	Brown alga				1	1			
	Stypocaulaceae	<i>Halopteris gracilescens</i>	Brown alga				1	1			
		<i>Halopteris</i> sp.	Brown alga	1	1	1		1			
	Unknown Family	Unidentified brown algae	Brown alga	1	1	1		1			
		Unidentified brown turfing algae	Brown alga		1			1			1
		Unidentified filamentous brown algae	Brown alga	1				1	1	1	1
Total brown algae				19	56	43	25	76	7	6	25
Red algae	Acrotylaceae	<i>Amphiplexia hymenocladoides</i>	Red alga				1	1			
	Areschougiaceae	<i>Acrotylus australis</i>	Red alga	1	1	1		1			
		<i>Areschougia congesta</i>	Red alga	1	1	1		1			
		<i>Areschougia</i> sp.	Red alga	1	1	1		1			
		<i>Callophycus laxus</i>	Red alga	1	1			1			
		<i>Callophycus</i> sp.	Red alga		1			1			
		<i>Erythroclonium sonderi</i>	Red alga		1			1			
		<i>Erythroclonium</i> sp.	Red alga		1			1			
		<i>Melanema dumosum</i>	Red alga				1	1			
	Bonnemaisoniaceae	<i>Asparagopsis armata</i>	Red alga	1	1			1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Asparagopsis</i> sp.	Red alga	1	1			1			
		<i>Bonnemaisonia australis</i>	Red alga								1
		<i>Delisea hypneoides</i>	Red alga		1			1			
		<i>Delisea pulchra</i>	Red alga	1	1			1			
	Ceramiales	<i>Acrothamnionopsis eliseae</i>	Red alga				1	1			
		<i>Ballia ballioides</i>	Red alga				1	1			
		<i>Ballia callitricha</i>	Red alga	1	1	1		1			1
		<i>Ballia scoparia</i>	Red alga		1			1			
		<i>Bornetia tenuis</i>	Red alga							1	
		<i>Callithamnion caulescens</i>	Red alga				1	1			
		<i>Callithamnion pinnatum</i>	Red alga				1	1			
		<i>Ceramium flaccidum</i>	Red alga						1		
		<i>Ceramium repens</i>	Red alga				1	1			
		<i>Ceramium</i> sp.	Red alga								1
		<i>Crouania mucosa</i>	Red alga				1	1			
		<i>Dasythamniella dasyura</i>	Red alga				1	1			
		<i>Dasythamniella wollastoniana</i>	Red alga				1	1			
		<i>Diapse ptilota</i>	Red alga				1	1			
		<i>Drewiana nitella</i>	Red alga				1	1			
		<i>Elisiella arbuscula</i>	Red alga				1	1			
		<i>Elisiella dispar</i>	Red alga				1	1			
		<i>Euptilota articulata</i>	Red alga	1	1			1			
		<i>Griffithsia pulvinata</i>	Red alga				1	1			
		<i>Gymnothamnion nigrescens</i>	Red alga				1	1			
		<i>Hirsutithallia angustata</i>	Red alga				1	1			
		<i>Hirsutithallia formosa</i>	Red alga				1	1			
		<i>Hirsutithallia laricina</i>	Red alga				1	1			
		<i>Involucrana meredithiana</i>	Red alga				1	1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Macrothamnion acanthophorum</i>	Red alga				1	1			
		<i>Macrothamnion pectenellum</i>	Red alga				1	1			
		<i>Macrothamnion pellucidum</i>	Red alga				1	1			
		<i>Macrothamnion secundum</i>	Red alga				1	1			
		<i>Perichelia glomulifera</i>	Red alga				1	1			
		<i>Ptilocladia pulchra</i>	Red alga				1	1			
		<i>Rhipidothamnion secundum</i>	Red alga							1	
		<i>Rhodocallis elegans</i>	Red alga				1	1			
		<i>Shepleya wattsii</i>	Red alga				1	1			
		<i>Trithamnion eubryanii</i>	Red alga				1	1			
		<i>Wollastoniella myriophylloides</i>	Red alga				1	1			
		<i>Wrangelia nobilis</i>	Red alga		1			1			
	Champiaceae	<i>Champia</i> sp.	Red alga	1	1			1			
		<i>Champia viridis</i>	Red alga			1		1			
	Corallinaceae	<i>Amphiroa anceps</i>	Red alga	1	1	1		1			
		<i>Cheilosporum sagittatum</i>	Red alga	1	1	1		1			
		<i>Corallina officinalis</i>	Red alga		1			1	1		1
		<i>Haliptilon roseum</i>	Red alga	1	1	1		1			1
		<i>Lithothamnion indicum</i>	Red alga				1	1			
		<i>Martensia australis</i>	Red alga			1		1			
		<i>Metagoniolithon radiatum</i>	Red alga		1	1		1			
		Unidentified coralline algae	Red alga	1	1	1		1		1	
		Unidentified encrusting corallines	Red alga	1	1	1		1	1	1	1
		Unidentified erect corallines	Red alga		1			1			
	Cystocloniaceae	<i>Erythranaena ceramioides</i>	Red alga				1	1			
	Dasyaceae	<i>Heterosiphonia gunniana</i>	Red alga		1			1			
		<i>Heterosiphonia Lawrenciana</i>	Red alga				1	1			
		<i>Thuretia quercifolia</i>	Red alga		1			1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
	Delesseriaceae	<i>Hemineura frondosa</i>	Red alga	1	1			1			
	Gelidiaceae	<i>Capreolia implexa</i>	Red alga				1	1	1		1
		<i>Gelidiella mimima</i>	Red alga				1	1			
		<i>Gelidium asperum</i>	Red alga		1		1	1			
		<i>Gelidium australe</i>	Red alga	1	1	1		1			
		<i>Gelidium pusillum</i>	Red alga						1		1
		<i>Gelidium</i> sp.	Red alga	1	1			1			
		<i>Pterocladia capillacea</i>	Red alga	1	1	1		1	1		
		<i>Pterocladia lucida</i>	Red alga	1	1	1		1			
	Gigartinaceae	<i>Gigartina crassicaulis</i>	Red alga		1			1			
		<i>Gigartina muelleriana</i>	Red alga				1	1			
		<i>Gigartina pinnata</i>	Red alga				1	1			
		<i>Gigartina</i> sp.	Red alga		1			1	1		
		<i>Gigartina wahliae</i>	Red alga				1	1			
	Gracilariaceae	<i>Curdiea angustata</i>	Red alga		1			1			
		<i>Curdiea crassa</i>	Red alga				1	1			
		<i>Gracilaria secundata</i>	Red alga		1			1			
		<i>Melanthalia abscissa</i>	Red alga		1			1			
		<i>Melanthalia fastigiata</i>	Red alga		1			1			
		<i>Melanthalia obtusata</i>	Red alga	1	1	1		1			
	Halymeniaceae	<i>Cryptonemia digitata</i>	Red alga				1	1			
		<i>Cryptonemia nitophylloides</i>	Red alga				1	1			
		<i>Cryptonemia wilsoni</i>	Red alga				1	1			
		<i>Grateloupia filicina</i>	Red alga						1		
		<i>Halymenia plana</i>	Red alga		1			1			
		<i>Polyopes constrictus</i>	Red alga	1	1			1			
		<i>Thamnoclonium dichotomum</i>	Red alga	1	1			1			
	Hypneaceae	<i>Hypnea ramentacea</i>	Red alga	1	1	1		1			

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		<i>Hypnea</i> sp.	Red alga						1		
	Kallymeniaceae	<i>Callophyllis lambertii</i>	Red alga	1	1			1			
		<i>Callophyllis rangiferina</i>	Red alga	1	1	1		1	1		
		<i>Cirrularia nanus</i>	Red alga				1	1			
		<i>Hormophora australasica</i>	Red alga				1	1			
	Liagoraceae	<i>Liagora codii</i>	Red alga				1	1			
	Nemastomataceae	<i>Adelophycus corneus</i>	Red alga				1	1			
	Nizymeniaceae	<i>Nizymenia australis</i>	Red alga		1			1			
		<i>Stenocladia australis</i>	Red alga				1	1			
		<i>Stenocladia furcata</i>	Red alga				1	1			
	Peyssonneliaceae	<i>Peyssonelia novae-hollandiae</i>	Red alga		1			1			
		<i>Sonderopelta coriacea</i>	Red alga		1			1			
	Phacelocarpaceae	<i>Phacelocarpus alatus</i>	Red alga		1			1			
		<i>Phacelocarpus complanatus</i>	Red alga				1	1			
		<i>Phacelocarpus peperocarpus</i>	Red alga	1	1	1		1			
	Phylloporaceae	<i>Ahnfeltiopsis fastigata</i>	Red alga				1	1	1		
		<i>Stenogramma interrupta</i>	Red alga		1			1			
	Plocamiaceae	<i>Plocamium angustum</i>	Red alga	1	1	1		1			1
		<i>Plocamium cartilagineum</i>	Red alga	1	1	1		1			1
		<i>Plocamium costatum</i>	Red alga		1	1		1			
		<i>Plocamium dilatatum</i>	Red alga	1	1	1		1			
		<i>Plocamium leptophyllum</i>	Red alga	1	1	1		1			1
		<i>Plocamium mertensii</i>	Red alga		1	1		1			
		<i>Plocamium patagiatum</i>	Red alga		1			1			
		<i>Plocamium preissianum</i>	Red alga	1	1	1		1			
	Rhodomelaceae	<i>Dictymenia harveyana</i>	Red alga	1	1			1			
		<i>Dictymenia tridens</i>	Red alga		1			1			
		<i>Echinothamnion hystrix</i>	Red alga		1	1		1			

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		<i>Echinothamnion</i> sp.	Red alga		1			1			
		<i>Jeannerettia lobata</i>	Red alga	1	1			1			
		<i>Jeannerettia pedicellata</i>	Red alga		1			1			
		<i>Laurencia botryoides</i>	Red alga				1	1	1		1
		<i>Laurencia clavata</i>	Red alga		1			1			
		<i>Laurencia elata</i>	Red alga		1			1			
		<i>Laurencia filiformis</i>	Red alga	1	1	1	1	1			1
		<i>Laurencia</i> sp.	Red alga	1	1	1		1			
		<i>Lenormandia marginata</i>	Red alga		1			1			
		<i>Lenormandia muelleri</i>	Red alga		1			1			
		<i>Lenormandia smithiae</i>	Red alga		1			1			
	Rhodymeniaceae	<i>Botryocladia obovata</i>	Red alga	1	1	1		1			
		<i>Cordylecladia furcellata</i>	Red alga		1	1		1			
		<i>Erythrymenia minuta</i>	Red alga		1	1	1	1			
		<i>Faucheopsis cronata</i>	Red alga				1	1			
		<i>Hymenocladia chondricola</i>	Red alga		1			1			
		<i>Rhodymenia australis</i>	Red alga	1	1	1		1			
		<i>Rhodymenia leptophylla</i>	Red alga		1			1			
		<i>Rhodymenia obtusa</i>	Red alga		1	1		1			
		<i>Rhodymenia prolificans</i>	Red alga		1			1			
		<i>Rhodymenia</i> sp.	Red alga	1	1			1			
		<i>Webervanbossea splachnoides</i>	Red alga				1	1			
	Sarcodiaceae	<i>Sarcoidia marginata</i>	Red alga				1	1			
	Solieriaceae	<i>Solieria robusta</i>	Red alga		1			1	1		
	Unknown Family	<i>Chondria viridis</i>	misidentified red alga??	1	1			1			
		Unidentified filamentous red algae	Red alga	1	1	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	1

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
Total red algae				42	86	36	57	142	16	7	16
Lichens	Unknown Family	Lichen species	Lichen							1	1
Total lichens				0	0	0	0	0	0	1	1
Pondweeds	Zannichelliaceae	<i>Lepilaena cylindrocarpa</i>	Pondweed							1	
		<i>Lepilaena marina</i>	Pondweed						1		
Total pondweeds				0	0	0	0	0	1	1	0
Saltmarsh	Chenopodiaceae	<i>Sarcocornia quinqueflora</i>	Saltmarsh								1
Total saltmarsh				0	0	0	0	0	0	0	1
Seagrasses	Cymodoceaceae	<i>Amphibolis antarctica</i>	Seagrass		1	1	1	1			
	Posidoniaceae	<i>Posidonia australis</i>	Seagrass								1
	Zosteraceae	<i>Heterozostera nigricalis</i>	Seagrass		1	1		1		1	
		<i>Zostera muelleri</i>	Seagrass						1		1
Total seagrasses				0	2	2	1	2	1	1	2
Sponges	Unknown Family	Unidentified sponges	Sponge						1	1	1
Total sponges				0	0	0	0	0	1	1	1
Cnidaria	Actiniidae	<i>Actinia tenebrosa</i>	Anemone				1	1	1		1
		<i>Aulactinia veratra</i>	Anemone				1	1	1		1
		<i>Oulactis muscosa</i>	Anemone		1		1	1	1		
	Anthothelidae	<i>Erythropodium hicksoni</i>	Soft coral							1	1
	Faviidae	<i>Plesiastrea versipora</i>	Stony coral							1	1
	Sagartiidae	<i>Anthothoe albocincta</i>	Anemone						1		
	Unknown Family	Unidentified anemone	Anemone		1			1	1		
Total cnidarians				0	2	0	3	4	5	2	4
Polychaetes	Serpulidae	<i>Galeolaria caespitosa</i>	Tubeworm		1		1	1	1	1	1
Total polychaetes				0	1	0	1	1	1	1	1
Barnacles	Balanidae	<i>Elminius modestus</i>	Acorn barnacle						1		
	Chthamalidae	<i>Chamaesipho tasmanica</i>	Honeycomb barnacle				1	1			1

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Chthamalus antennatus</i>	Acorn barnacle				1	1			1
	Iblidae	<i>Ibla quadrivalvis</i>	Goose barnacle						1		1
	Tetraclitidae	<i>Tesseropora rosea</i>	Acorn barnacle				1	1			
		<i>Tetraclitella purpurascens</i>	Acorn barnacle				1	1		1	1
	Unknown Family	Unidentified barnacle	Barnacle							1	
Total barnacles				0	0	0	4	4	2	2	4
Decapod crustaceans											
	Alpheidae	<i>Athanopsis australis</i>	Snapping shrimp						1		1
	Axiidae	<i>Axiopsis werribee</i>	Ghost shrimp						1		
	Callinassidae	<i>Eucalliax tooradin</i>	Ghost shrimp				1	1			
	Galatheididae	<i>Munida subrugosa</i>	Squat lobster				1	1			
	Grapsidae	<i>Cyclograpsus audouinii</i>	Shore crab								1
		<i>Cyclograpsus granulatus</i>	Shore crab						1		1
		<i>Leptograpsodes octodentatus</i>	Shore crab						1		
	Lomisidae	<i>Lomis hirta</i>	Hairy stone crab						1		
	Mictyridae	<i>Mictyris platycheles</i>	Soldier crab						1		
	Penaeidae	<i>Penaeus plebejus</i>	Eastern king prawn							1	
	Portunidae	<i>Carcinus maenas</i>	European shore crab				1	1	1		1
		<i>Ovalipes catharus</i>	Swimming crab								1
	Rhynchocinetidae	<i>Rhynchocinetes kuiteri</i>	Hinge-back shrimp				1	1			
	Unknown Family	Unidentified crab	Crab		1			1			
Total decapod crustaceans				0	1	0	4	5	7	1	5
Chitons											
	Acanthochitonidae	<i>Acanthochitona gatliffi</i>	Chiton						1		
		<i>Acanthochitona retrojectus</i>	Chiton								1
		<i>Bassethullia glypta</i>	Chiton				1	1			
		<i>Leptoplax wilsoni</i>	Chiton				1	1			
	Ischnochitonidae	<i>Ischnochiton contractus</i>	Chiton				1	1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Ischnochiton torri</i>	Chiton				1	1			
		<i>Ischnochiton versicolor</i>	Chiton				1	1			
		<i>Ischnochiton wilsoni</i>	Chiton				1	1			
	Mopaliidae	<i>Plaxiphora albida</i>	Chiton				1	1	1		1
Total chitons				0	0	0	7	7	2	0	2
Gastropods	Anabathridae	<i>Pisinna nitida</i>	Sea snail				1	1			
	Batillariidae	<i>Zeacumantus diemenensis</i>	Mudwhelk								1
	Buccinidae	<i>Cominella eburnea</i>	Whelk						1		
		<i>Cominella lineolata</i>	Whelk		1		1	1	1		1
	Conidae	<i>Conus anemone</i>	Gastropod		1		1	1			
	Costellariidae	<i>Vexillum (Costellaria) pellucidum</i>	Gastropod				1	1			
	Eatoniellidae	<i>Eatoniella victoriae</i>	Gastropod				1	1			
	Fissurellidae	<i>Clypidina rugosa</i>	Keyhole limpet		1		1	1			
		<i>Diodora lineata</i>	Keyhole limpet				1	1			
		<i>Notomella candida</i>	Keyhole limpet								1
	Littorinidae	<i>Afrolittorina praetermissa</i>	Periwinkle				1	1			
		<i>Austrolittorina unifasciata</i>	Periwinkle				1	1		1	
		<i>Bembicium auratum</i>	Periwinkle						1		1
		<i>Bembicium melanostoma</i>	Periwinkle				1	1	1	1	1
		<i>Bembicium nanum</i>	Periwinkle		1		1	1		1	1
		<i>Bembicium sp.</i>	Periwinkle						1	1	1
		<i>Nodilittorina acutispira</i>	Periwinkle		1			1			
	Lottiidae	<i>Lottia mixta</i>	Limpet				1	1			
		<i>Notoacmea alta</i>	Limpet				1	1			
		<i>Notoacmea flammea</i>	Limpet				1	1	1		1
		<i>Notoacmea mayi</i>	Limpet		1			1		1	
		<i>Notoacmea petterdi</i>	Limpet		1		1	1			1
		<i>Patelloida alticostata</i>	Limpet		1		1	1	1	1	1

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Patelloida latistrigata</i>	Limpet				1	1			1
	Muricidae	<i>Dicathais orbita</i>	Gastropod		1		1	1			
		<i>Lepsiella reticulata</i>	Gastropod						1		
		<i>Lepsiella vinosa</i>	Gastropod		1		1	1	1	1	1
	Nacellidae	<i>Cellana tramoserica</i>	Limpet		1		1	1	1	1	1
	Naticidae	<i>Natica shorehami</i>	Moon snail				1	1			
	Neritidae	<i>Nerita atramentosa</i>	Nerite				1	1	1	1	1
	Onchidiidae	<i>Onchidella patelloides</i>	Pulmonate sea slug		1		1	1	1		
	Siphonariidae	<i>Siphonaria diemenensis</i>	Pulmonate limpet		1		1	1		1	1
		<i>Siphonaria funiculata</i>	Pulmonate limpet				1	1			
		<i>Siphonaria</i> sp.	Pulmonate limpet		1			1			
		<i>Siphonaria zelandica</i>	Pulmonate limpet				1	1			
	Trochidae	<i>Austrocochlea constricta</i>	Ribbed top shell		1		1	1	1	1	1
		<i>Austrocochlea porcata</i>	Top shell		1			1	1	1	1
		<i>Calliostoma armillata</i>	Top shell		1			1			
		<i>Chlorodiloma adelaidae</i>	Top shell				1	1	1		
		<i>Chlorodiloma odontis</i>	Top shell		1		1	1	1	1	1
		<i>Clanculus plebejus</i>	Top shell				1	1			
		<i>Diloma concamerata</i>	Wavy top shell							1	1
		<i>Fossarina legrandi</i>	Top shell				1	1			
		<i>Fossarina patula</i>	Top shell				1	1			
	Turbinidae	<i>Turbo undulatus</i>	Common warrener (Turban shell)		1		1	1	1	1	1
Total gastropods				0	19	0	33	38	17	15	20
Bivalves	Galeommatidae	<i>Mysella dromanaensis</i>	Bivalve				1	1			
	Mytilidae	<i>Austromytilus rostratus</i>	Beaked mussel		1		1	1	1		
		<i>Mytilus edulis</i>	Blue Mussel						1		1
		<i>Mytilus planulatus</i>	Mussel						1		

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		<i>Limnoperna pulex</i>	Mussel		1		1	1			1
	Pteriidae	<i>Electroma georgiana</i>	Common butterfly shell						1		
	Veneridae	<i>Venerupsis obesa</i>	Venus Shell				1	1			
Total bivalves				0	2	0	4	4	4	0	2
Sea slugs	UnknownFamily	Unidentified nudibranch	Nudibranch		1			1			
Total sea slugs				0	1	0	0	1	0	0	0
Echinoderms	Asterinidae	<i>Meridiastra calcar</i>	Sea Star								1
		<i>Patiriella calcar</i>	Sea Star						1		
		<i>Patiriella exigua</i>	Sea Star							1	
	Brissidae	<i>Eupatagus valenciennesii</i>	Heart Urchin				1	1			
	Chiridotidae	<i>Scoliorhapis</i> sp. MoV 1643	Sea Cucumber						1		
	Comasteridae	<i>Comatulella brachiolata</i>	Feather Star				1	1			
	Goniasteridae	<i>Tosia australis</i>	Sea Star						1		
	Phyllophoridae	<i>Thyone nigra</i>	Sea Cucumber				1	1			
Total echinoderms				0	0	0	3	3	3	1	1
Ascidian	Pyuridae	<i>Pyura stolonifera</i>	Cunjevoi				1	1			
Total ascidians				0	0	0	1	1	0	0	0
Fish	Aplodactylidae	<i>Aplodactylus arctidens</i>	Marblefish	1	1	1		1			
	Aracanidae	<i>Aracana aurita</i>	Shaw's Cowfish	1	1	1		1			
	Arripidae	<i>Arripis georgiana</i>	Australian Herring			1		1			
		<i>Arripis</i> sp.	Australian salmon species			1		1			
		<i>Arripis trutta</i>	Eastern Australian Salmon								1
	Berycidae	<i>Centroberyx gerrardi</i>	Bight Redfish				1	1			
	Bovichtidae	<i>Bovichtus angustifrons</i>	Dragonet		1			1		1	1
	Carangidae	<i>Pseudocaranx dentex</i>	White Trevally			1		1			
	Cheilodactylidae	<i>Cheilodactylus fuscus</i>	Red Morwong				1	1			
		<i>Cheilodactylus nigripes</i>	Magpie Perch	1	1	1		1			1

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Cheilodactylus spectabilis</i>	Banded Morwong		1	1		1			
		<i>Dactylophora nigricans</i>	Dusky Morwong	1	1	1		1	1	1	1
		<i>Nemadactylus valenciennesi</i>	Blue Morwong	1				1			
	Clinidae	<i>Heteroclinus mammoratus</i>	Short-tassel Weedfish				1	1			
		<i>Heteroclinus nasutus</i>	Largenose Weedfish				1	1			
			Unidentified weedfish								
		<i>Heteroclinus</i> sp.	species				1	1			
		<i>Heteroclinus tristis</i>	Longnose Weedfish			1		1			
	Clupeidae	<i>Sardinops neopilchardus</i>	Australian Pilchard	1		1		1			
	Dasyatididae	<i>Dasyatis brevicaudata</i>	Smooth Stingray	1		1		1			
	Dinolestidae	<i>Dinolestes lewini</i>	Longfin Pike	1	1	1		1			
		<i>Diodon nichthemerus</i>	Globefish	1	1	1		1	1	1	1
	Engraulidae	<i>Engraulis australis</i>	Australian Anchovy			1		1			
	Enoplosidae	<i>Enoplosus armatus</i>	Old Wife	1	1	1		1			1
	Girellidae	<i>Girella elevata</i>	Black Drummer		1	1		1			
		<i>Girella tricuspidata</i>	Luderick		1	1		1			
		<i>Girella zebra</i>	Zebrafish	1	1	1		1	1	1	1
	Gobiidae	<i>Nesogobius hinsbyi</i>	Hinsby's Goby				1	1			
		<i>Nesogobius</i> sp.	Goby species				1	1			
	Heterodontidae	<i>Heterodontus portusjacksoni</i>	Port Jackson Shark		1			1			
	Labridae	<i>Achoerodus gouldii</i>	Western Blue Groper			1		1			
		<i>Coris sandageri</i>	Eastern King Wrasse	1				1			
		<i>Dotalabrus aurantiacus</i>	Castelnau's Wrasse	1	1	1		1			
		<i>Eupetrichthys angustipes</i>	Snakeskin Wrasse		1			1			
		<i>Notolabrus fucicola</i>	Purple Wrasse	1	1	1		1			
		<i>Notolabrus parilus</i>	Brownspotted Wrasse				1	1			
		<i>Notolabrus tetricus</i>	Bluethroat Wrasse	1	1	1		1	1		
		<i>Pictilabrus laticlavus</i>	Senator Wrasse	1	1	1		1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Pseudolabrus psittaculus</i>	Rosy Wrasse	1	1			1			
	Latridae	<i>Latridopsis forsteri</i>	Bastard Trumpeter		1	1		1			
	Leptoscopidae	<i>Crapatalus munroi</i>	Pink Sandfish				1	1			
	Monacanthidae	<i>Acanthaluteres spilomelanurus</i>	Bridled Leatherjacket			1		1			
		<i>Acanthaluteres vittiger</i>	Toothbrush Leatherjacket	1	1	1		1		1	1
			Southern Pygmy								
		<i>Brachaluteres jacksonianus</i>	Leatherjacket		1			1	1		1
		<i>Eubalichthys bucephalus</i>	Black Reef Leatherjacket	1				1			
		<i>Eubalichthys gunnii</i>	Gunn's Leatherjacket	1	1	1		1			
		<i>Eubalichthys mosaicus</i>	Mosaic Leatherjacket			1		1			
		<i>Meuschenia australis</i>	Brownstriped Leatherjacket	1	1	1		1			
		<i>Meuschenia flavolineata</i>	Yellowstriped Leatherjacket	1	1	1		1			1
		<i>Meuschenia freycineti</i>	Sixspine leather jacket	1	1	1		1		1	1
		<i>Meuschenia galii</i>	Bluelined Leatherjacket	1	1			1			
		<i>Meuschenia hippocrepis</i>	Horseshoe Leatherjacket	1	1	1		1	1	1	1
		<i>Meuschenia scaber</i>	Velvet Leatherjacket	1				1			
			Stars-and-stripes								
		<i>Meuschenia venusta</i>	Leatherjacket	1	1	1		1			
		<i>Scobinichthys granulatus</i>	Rough Leatherjacket	1	1	1		1			1
	Moridae	<i>Pseudophycis bachus</i>	Red Cod	1				1			
	Mullidae	<i>Upeneichthys vlamingii</i>	Bluespotted Goatfish	1	1	1		1	1		1
	Myliobatidae	<i>Myliobatis australis</i>	Southern Eagle Ray		1	1		1			
	Neosebastidae	<i>Neosebastes scorpaenoides</i>	Common Gurnard Perch	1				1			
	Odacidae	<i>Haletta semifasciata</i>	Blue Weed-whiting			1		1			
		<i>Neoodax balteatus</i>	Little Weed Whiting			1		1	1	1	1
		<i>Odax acroptilus</i>	Rainbow Cale		1	1		1			
		<i>Odax cyanomelas</i>	Herring Cale	1	1	1		1			
		<i>Siphonognathus beddomei</i>	Pencil Weed Whiting		1			1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
	Odontaspidae	<i>Carcharias taurus</i>	Grey Nurse Shark							1	
	Parascyllidae	<i>Parascyllium variolatum</i>	Varied Carpetshark		1	1		1			
	Pempheridae	<i>Pempheris multiradiata</i>	Bigscale Bullseye	1	1	1		1			
	Pentacerotidae	<i>Parazanclistus hutchinsi</i>	Short Boarfish				1	1			
		<i>Paristiopterus labiosus</i>	Giant Boarfish				1	1			
		<i>Pentaceropsis recurvirostris</i>	Longsnout Boarfish	1	1	1		1			
	Platycephalidae	<i>Platycephalus bassensis</i>	Cliff Flathead								1
	Plesiopidae	<i>Paraplesiops meleagris</i>	Southern Blue Devil			1		1			
		<i>Trachinops caudimaculatus</i>	Southern Hulafish	1	1	1		1	1	1	1
	Pomacentridae	<i>Chromis hypsilepis</i>	Onespot Puller	1				1			
		<i>Parma microlepis</i>	White-ear			1		1			
		<i>Parma victoriae</i>	Scalyfin	1	1	1		1	1		1
	Rhinobatidae	<i>Trygonorrhina fasciata</i>	Southern Fiddler Ray		1			1	1		1
	Scorpididae	<i>Atypichthys strigatus</i>	Mado	1	1	1		1			
		<i>Scorpius aequipinnis</i>	Sea Sweep	1	1			1			1
		<i>Scorpius lineolata</i>	Silver Sweep	1	1	1		1			
		<i>Tilodon sexfasciatus</i>	Moonlighter	1	1	1		1	1		1
	Scyliorhinidae	<i>Cephaloscyllium laticeps</i>	Draughtboard Shark			1		1			
	Sepiidae	<i>Sepia apama</i>	Giant Cuttlefish	1	1			1			
	Serranidae	<i>Caesioperca lepidoptera</i>	Butterfly Perch	1				1			
		<i>Caesioperca rasor</i>	Barber Perch	1	1			1		1	
		<i>Lepidoperca pulchella</i>	Eastern Orange Perch				1	1			
		<i>Othos dentex</i>	Harlequin Fish				1	1			
	Sillaginidae	<i>Sillaginodes punctata</i>	King George Whiting	1		1		1			
	Sparidae	<i>Pagrus auratus</i>	Snapper								1
	Sygnathidae	<i>Phyllopteryx taeniolatus</i>	Common Seadragon		1			1			
		<i>Leptoichthys fistularius</i>	Brushtail Pipefish							1	
	Tetraodontidae	<i>Tetractenos glaber</i>	Smooth Toadfish	1	1	1		1	1		1

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
	Trachichthyidae	<i>Optivus</i> sp.	Roughy species				1	1			
	Tripterygiidae	<i>Apopterygion alta</i>	Tasselled Threefin				1	1			
	Urolophidae	<i>Urolophus paucimaculatus</i>	Sparsely-spotted Stingaree	1	1	1		1		1	
Total fish				47	50	54	15	89	13	13	23
Birds	Accipitridae	<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle				1	1	1	1	1
	Anatidae	<i>Cygnus atratus</i>	Black Swan				1	1	1	1	
	Anhingidae	<i>Anhinga novaehollandiae</i>	Australasian Darter				1	1			
	Ardeidae	<i>Ardea ibis</i>	Cattle Egret						1	1	
		<i>Ardea intermedia</i>	Intermediate Egret						1	1	
		<i>Ardea modesta</i>	Eastern Great Egret				1	1	1	1	
		<i>Ardea pacifica</i>	White-necked Heron				1	1	1	1	1
		<i>Botaurus poiciloptilus</i>	Australasian Bittern						1		
		<i>Ixobrychus minutus</i>	Little Bittern						1	1	
		<i>Nycticorax caledonicus</i>	Nankeen Night Heron				1	1	1	1	
	Charadriidae	<i>Charadrius bicinctus</i>	Double-banded Plover				1	1	1	1	
		<i>Charadrius hiaticula</i>	Ringed Plover				1	1			
		<i>Charadrius leschenaultii</i>	Greater Sand Plover				1	1			
		<i>Charadrius mongolus</i>	Lesser Sand Plover				1	1			
		<i>Charadrius ruficapillus</i>	Red-capped Plover				1	1	1	1	
		<i>Elseya melanops</i>	Black-fronted Dotterel				1	1	1	1	
		<i>Erythronyx cinctus</i>	Red-kneed Dotterel				1	1	1		1
		<i>Pluvialis fulva</i>	Pacific Golden Plover				1	1	1	1	
		<i>Pluvialis squatarola</i>	Grey Plover				1	1	1	1	
		<i>Thinornis rubricollis</i>	Hooded Plover				1	1			
		<i>Vanellus miles</i>	Masked Lapwing				1	1	1	1	1
	Ciconiiformes	<i>Egretta garzetta</i>	Little Egret				1	1	1	1	
		<i>Egretta novaehollandiae</i>	White-faced Heron				1	1	1	1	1
	Diomedeidae	<i>Thalassarche cauta</i>	Shy Albatross				1	1			

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Thalassarche chlororhynchos</i>	Yellow-nosed Albatross				1	1			
		<i>Thalassarche melanophris</i>	Black-browed Albatross				1	1			
	Gruidae	<i>Grus rubicunda</i>	Brolga				1	1			
	Haematopodidae	<i>Haematopus fuliginosus</i>	Sooty Oystercatcher				1	1	1	1	
		<i>Haematopus longirostris</i>	Pied Oystercatcher				1	1	1	1	
	Hydrobatidae	<i>Oceanites oceanicus</i>	Wilson's Storm Petrel				1	1			
		<i>Pelagodroma marina</i>	White-faced Storm-Petrel				1	1			
	Laridae	<i>Chlidonias hybridus</i>	Whiskered Tern				1	1	1	1	
		<i>Chlidonias leucopterus</i>	White-winged Black Tern				1	1	1	1	
		<i>Chroicocephalus novaehollandiae</i>	Silver Gull				1	1	1	1	1
		<i>Hydroprogne caspia</i>	Caspian Tern				1	1	1	1	
		<i>Larus dominicanus</i>	Kelp Gull				1	1			1
		<i>Larus pacificus</i>	Pacific Gull				1	1	1	1	1
		<i>Sterna bergii</i>	Crested Tern				1	1	1	1	1
		<i>Sterna hirundo</i>	Common Tern				1	1	1	1	1
		<i>Sterna striata</i>	White-fronted Tern				1	1			1
		<i>Sternula albifrons</i>	Little Tern				1	1	1	1	
		<i>Sternula nereis</i>	Fairy Tern				1	1	1	1	
	Meliphagidae	<i>Epthianura albifrons</i>	White fronted Chat				1	1	1	1	
	Pelecanidae	<i>Pelecanus conspicillatus</i>	Australian Pelican				1	1	1	1	1
	Phalacrocoracidae	<i>Microcarbo melanoleucos</i>	Little Pied Cormorant				1	1	1	1	1
		<i>Phalacrocorax carbo</i>	Great Cormorant				1	1	1	1	1
		<i>Phalacrocorax fuscescens</i>	Black-faced Cormorant				1	1		1	
		<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant				1	1	1	1	1
		<i>Phalacrocorax varius</i>	Pied Cormorant				1	1	1	1	1
	Podicipedidae	<i>Podiceps cristatus</i>	Grest Crested Grebe				1	1	1	1	1
		<i>Poliocephalus poliocephalus</i>	Hoary-headed Grebe				1	1	1	1	1
	Procellariidae	<i>Aphrodroma brevirostris</i>	Kerguelen Petrel								1

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Ardenna grisea</i>	Sooty Shearwater				1	1			1
		<i>Ardenna pacifica</i>	Wedge-tailed Shearwater				1	1			
		<i>Ardenna tenuirostris</i>	Short-tailed Shearwater				1	1	1	1	1
		<i>Daption capense</i>	Cape Petrel				1	1			
		<i>Fulmarus glacialisoides</i>	Southern Fulmar				1	1	1		
		<i>Macronectes halli</i>	Northern Giant Petrel				1	1			
		<i>Pachyptila belcheri</i>	Slender-billed Prion				1	1			
		<i>Pachyptila desolata</i>	Antarctic Prion				1	1			
		<i>Pachyptila salvini</i>	Salvin's Prion				1	1			
		<i>Pachyptila turtur</i>	Fairy Prion				1	1		1	
		<i>Pelecanoides urinatrix</i>	Common Diving-petrel				1	1	1		
		<i>Pterodroma lessonii</i>	White-headed Petrel				1	1			
		<i>Puffinus assimilis</i>	Little Shearwater				1	1			
		<i>Puffinus gavia</i>	Fluttering Shearwater				1	1	1	1	
	Psittacidae	<i>Neophema chrysogaster</i>	Orange-bellied Parrot				1	1	1	1	
		<i>Neophema chrysostoma</i>	Blue-winged Parrot				1	1	1	1	1
	Rallidae	<i>Fulica atra</i>	Eurasian Coot				1	1	1	1	
		<i>Gallinula ventralis</i>	Black-tailed native hen				1	1	1		1
		<i>Gallirallus philippensis</i>	Buff-banded Rail				1	1	1		
		<i>Porzana fluminea</i>	Australian Spotted Crake				1	1	1		
		<i>Porzana pusilla</i>	Baillon's Crake						1		
		<i>Porzana tabuensis</i>	Spotless Crake				1	1	1		
	Recurvirostridae	<i>Cladorhynchus leucocephalus</i>	Banded Stilt				1	1	1		
		<i>Himantopus himantopus</i>	Black-winged Stilt				1	1	1	1	1
		<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet				1	1	1		
	Rhinobatidae	<i>Tryngites subruficollis</i>	Buff-breasted Sandpiper						1		
	Rostratulidae	<i>Rostratula australis</i>	Australian Painted Snipe						1		
	Scolopacidae	<i>Actitis hypoleucos</i>	Common Sandpiper				1	1	1		

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
		<i>Arenaria interpres</i>	Ruddy Turnstone				1	1	1	1	1
		<i>Calidris acuminata</i>	Sharp-tailed Sandpiper				1	1	1	1	
		<i>Calidris alba</i>	Sanderling				1	1		1	
		<i>Calidris canutus</i>	Red Knot				1	1	1	1	
		<i>Calidris ferruginea</i>	Curlew Sandpiper				1	1	1	1	
		<i>Calidris melanotos</i>	Pectoral Sandpiper				1	1	1		
		<i>Calidris minuta</i>	Little Stint						1		
		<i>Calidris ruficollis</i>	Red-necked Stint				1	1	1	1	
		<i>Calidris subminuta</i>	Long-toed Stint						1		
		<i>Calidris tenuirostris</i>	Great Knot				1	1	1	1	
		<i>Gallinago hardwickii</i>	Latham's snipe				1	1	1	1	
		<i>Heteroscelus brevipes</i>	Grey-tailed Tattler				1	1		1	
		<i>Limicola falcinellus</i>	Broad-billed Sandpiper				1	1			
		<i>Limnodromus semipalmatus</i>	Asian Dowitcher				1	1			
		<i>Limosa lapponica</i>	Bar-tailed Godwit				1	1	1	1	
		<i>Limosa limosa</i>	Black-tailed Godwit				1	1	1	1	
		<i>Numenius madagascariensis</i>	Eastern Curlew				1	1	1	1	
		<i>Numenius phaeopus</i>	Whimbrel				1	1	1		
		<i>Phalaropus lobatus</i>	Red-necked Phalarope				1	1			
		<i>Tringa nebularia</i>	Common Greenshank				1	1	1	1	
		<i>Tringa stagnatilis</i>	Marsh Sandpiper				1	1	1		
		<i>Xenus cinereus</i>	Terek Sandpiper						1		
	Spheniscidae	<i>Eudyptula minor</i>	Little Penguin				1	1	1	1	
	Stercorariidae	<i>Stercorarius parasiticus</i>	Arctic Jaeger				1	1			1
		<i>Stercorarius pomarinus</i>	Pomarine Jaeger				1	1			
		<i>Stercorarius skua</i>	Great Skua				1	1			
	Sulidae	<i>Morus capensis</i>	Cape Gannet				1	1			
		<i>Morus serrator</i>	Australasian Gannet				1	1	1	1	1

Biotic group	Family	Species	Common Name	PPH PE	PPH Lons	PPH Nep	PPH N/S	PPH Sum	PC	Jaw	RP
	Threskiornithidae	<i>Sula leucogaster</i>	Brown Booby				1	1			
		<i>Platalea regia</i>	Royal Spoonbill				1	1	1	1	1
		<i>Plegadis falcinellus</i>	Glossy Ibis						1		1
		<i>Threskiornis molucca</i>	White Ibis				1	1	1	1	1
Total birds				0	0	0	100	100	77	60	30
Reptiles	Cheloniidae	<i>Caretta caretta</i>	Loggerhead Turtle				1	1			
Total reptiles				0	0	0	1	1	0	0	0
Mammals	Balaenidae	<i>Eubalaena australis</i>	Southern Right Whale				1	1		1	
	Balaenopteridae	<i>Balaenoptera acutorostrata</i>	Minke Whale				1	1			
		<i>Megaptera novaeangliae</i>	Humpback Whale				1	1	1	1	1
	Delphinidae	<i>Delphinus delphis</i>	Common Dolphin				1	1			1
		<i>Orcinus orca</i>	Killer Whale				1	1			
		<i>Tursiops truncatus</i>	Bottlenose Dolphin				1	1		1	1
	Otariidae	<i>Arctophoca forsteri</i>	New Zealand Fur-seal							1	1
		<i>Arctocephalus pusillus doriferus</i>	Australian Fur-seal				1	1		1	1
		<i>Arctophoca tropicalis</i>	Subantarctic Fur-seal						1	1	
	Phocidae	<i>Hydrurga leptonyx</i>	Leopard Seal				1	1		1	
		<i>Mirounga leonina</i>	Southern Elephant Seal				1	1		1	1
Total mammals				0	0	0	9	9	2	8	6

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. Port Phillip Heads MNP

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

Department of Primary Industries: Anthony Plummer, Liz Morris, Sean Blake, David Ball
Marine Natural Values Study. Victorian Marine National Parks and Sanctuaries.

Plummer, A., Morris, L., Blake, S. and Ball, D. (2003). Marine Natural Values Study, Victorian Marine National Parks and Sanctuaries. Parks Victoria Technical Series No. 1, Parks Victoria, Melbourne.

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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).

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University of Melbourne: Jan Carey, Mark Burgman
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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: 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.
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Bellgrove, A., McKenzie, P.F., McKenzie, J.L. and Sfiligoj, B.J. (2010). Restoration of the habitat-forming fucoid alga *Hormosira banksii* at effluent-affected sites: competitive exclusion by coralline turfs. *Marine Ecology Progress Series* 419: 47-56.

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Green, J.A., White, C.R., Bunce, A., Frappell, P.B. and Butler, P.J. (2009). Energetic consequences of plunge diving in gannets. *Endangered Species Research* 10: 269-279.

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- Yee, N. and Roberts, A. (2009). Queenscliff Harbour Redevelopment. Sediment and Water Quality Monitoring. Report Prepared by Elgin Associates for Compass Environmental.

* Department of Primary Industries (David Ball and Sean Blake) / Department of Sustainability and Environment have also mapped seagrass in Port Phillip Heads Marine National Park as part of the Seagrass Mapping of Port Phillip Bay.

2. Point Cooke 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.

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. 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: 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.

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., 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., 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.

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Edmunds, M., Stewart, K., Pritchard, K., and Zavallas, 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.

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.

Hart, S.P. and Edmunds, M. (2005). Parks Victoria Standard Operating Procedure: Biological Monitoring of Intertidal Reefs. Parks Victoria Technical Series No. 21. Parks Victoria, Melbourne.

Hart, S.P., Edmunds, M., Ingwersen, C. and Lindsay, M. (2005). Victorian Intertidal Reef Monitoring Program: The Intertidal Reef Biota of Northern Port Phillip Bay Marine Sanctuaries. Parks Victoria Technical Series No. 24. Parks Victoria, Melbourne.

Hart, S., Power, B., Edmunds, M., and Elias, J. (2003). Victorian Subtidal Reef Monitoring Program: The Reef Biota at Port Phillip Bay Marine Sanctuaries. Parks Victoria Technical Series No. 8. 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. (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.

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.

3. Jawbone 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.

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University of Melbourne: Rachael Bathgate, Mick Keough, Stephen Swearer
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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. (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.

4. Ricketts Point 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., Bunce, A., Gilmour, P. and McBurnie, J. (2005). Sea Search: Community-Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries - Seagrass Monitoring. Parks Victoria Technical Series No. 16. Parks Victoria, Melbourne.

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.

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Parks Victoria is responsible for managing the Victorian protected area network, which ranges from wilderness areas to metropolitan parks and includes both marine and terrestrial components.

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

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

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