

PARKS VICTORIA TECHNICAL SERIES

NUMBER 79

Marine Natural Values Study Vol 2: Marine Protected Areas of the Flinders and Twofold Shelf Bioregions

Jan Barton, Adam Pope and Steffan Howe

August 2012

State Government Victoria

Parks VICTORIA

Healthy Parks Healthy People®

First published 2012

Published by Parks Victoria
Level 10, 535 Bourke Street, Melbourne Victoria 3000

Authors:

Jan Barton – Research Fellow, Deakin University

Adam Pope – Research Fellow, Deakin University

Steffan Howe – Marine Science Manager, Parks Victoria

National Library of Australia
Cataloguing-in-publication data

Includes bibliography
ISSN 1448-4935

Citation

Barton, J., Pope, A. and S. Howe (2012) Marine Natural Values Study Vol 2: Marine Protected Areas of the Flinders and Twofold Shelf Bioregions. Parks Victoria Technical Series No. 79. Parks Victoria, Melbourne.

WOOD FIBRE FROM SUSTAINABLE FOREST
ECF ELEMENTAL CHLORINE FREE
EMS ENVIRONMENTAL MANAGEMENT SYSTEMS

Printed on environmentally friendly paper

Parks Victoria Technical Paper Series No. 79

Marine Natural Values Study (Vol 2)

Marine Protected Areas of the Flinders and Twofold Shelf Bioregions

Jan Barton, Adam Pope and Steffan Howe*

School of Life & Environmental Sciences
Deakin University
***Parks Victoria**

August 2012

EXECUTIVE SUMMARY

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

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

Wilsons Promontory MNP is the only MPA in the Flinders bioregion and is the largest MPA in Victoria. Ninety Mile Beach, Point Hicks and Cape Howe MNPs and Beware Reef MS are in the Twofold Shelf bioregion. Both bioregions have cool temperate biota with some warm-temperate species due to the influence of the East Australian Current (EAC). Long sandy beaches with granite headlands and promontories are typical of the coast in the bioregions. Shores in Flinders plunge steeply onto deep sandy sea floor. In Twofold Shelf the low carbonate sandy sediments slope off more gently to deep waters.

High resolution bathymetry mapping has increased our understanding of habitats in the shallow waters of all the MPAs, and for the whole of Point Hicks and Cape Howe MNPs. All the MPAs, except Ninety Mile Beach MNP, have both shallow and deep subtidal reef. All, except for Beware Reef, have extensive intertidal soft sediment habitat or beaches where wrack material contributes to the detrital cycle and is a significant source of food for many shore birds and invertebrates. Intertidal reef is not extensive in either bioregion and biota is a mix of cool and warm temperate species. All MPAs have subtidal soft sediment habitat, which can have very high numbers of invertebrate species living on and in it. Subtidal soft sediment and open water are the dominant habitat types in the MPAs.

Ongoing monitoring and focused research projects have described the flora and fauna of the shallow subtidal reefs in all the MPAs except Ninety Mile Beach MNP, which has limited (if any) reef habitat. Differences in wave exposure, depth and reef structure can result in different biotic assemblages, within and between MPAs. The shallow subtidal reefs in the MPAs differ in the composition of canopy forming macroalgae species, understorey and the associated invertebrate and fish assemblages. The canopy is usually dominated by crayweed *Phyllospora comosa,* with the contribution of common kelp *Ecklonia radiata* and bull kelp *Durvillaea potatorum* varying. Common to all the MPAs is the blacklip abalone *Haliotis rubra* and wrasse *spp*. The herbivorous, warm temperate sea urchin *Centrostephanus rodgersii* occurs in both bioregions and can remove all erect algae to create 'urchin barrens'. Warm temperate fish species such as the damsel fish, including the one-spot puller *Chromis hypsilepis* and white-ear damselfish *Parma microlepis,* are a feature of Twofold Shelf shallow subtidal reefs.

Wilsons Promontory MNP has two distinct shallow subtidal reef assemblages, high exposure in the west and south, and low exposure in the east. Point Hicks and Cape Howe MNP shallow subtidal reefs are highly exposed and have varied structure, providing a wide range of habitats. The shallow subtidal reef in the Beware Reef has seaweed, invertebrate and fish communities that are distinctly different to the other reefs in Twofold Shelf MPAs. The deep reefs in both the bioregions have a dense and often spectacular cover of epifauna, especially sponges, stalked ascidians, soft corals, sea anemones, zooanthids gorgonians and sea whips, and abundant fish life.

Subtidal soft sediment is a dominant habitat in all the MPAs but detailed knowledge of its flora and fauna is restricted to shallow waters, except for Point Hicks and Cape Howe MNPs. Sediments are predominantly inhabited by infauna (small crustaceans and worms that burrow into the sand), sponges and bottom-dwelling skates and rays. Deep water sediments in Point Hicks and Cape Howe MNPs have extensive beds of sessile invertebrates, predominately sponges and green algae *Caulerpa.*

Seagrass beds are found in sheltered bays, *Heterozostera* in Oberon Bay and *Amphibolis* and *Halophila* in Waterloo Bay in Wilsons Promontory MNP. Many species of fish are associated with these beds such as wide-bodied pipefish *Stigmatopora nigra*, spotted pipefish *S. argus*, slender weed whiting *Siphonognathus attenuatus* and weedfish *Heteroclinus* spp. and *Cristiceps* spp. Seagrass beds are not a feature of the Twofold Shelf bioregion.

All the MPAs support species of high conservation significance. They provide important feeding and roosting habitat for many threatened shore and sea birds, from 17 species in Beware Reef MS and up to 38 in Cape Howe MNP. They are also important for many migratory birds, from 7 species in Wilsons Promontory MNP to 24 in Cape Howe MNP. Numerous species are found at the limit of their distribution range within individual MPAs. In Wilsons Promontory MNP over 126 species, including algae, invertebrates and fish, are believed to be at the edge of their distributional range, whilst none are known from Ninety Mile Beach MNP. Fourteen are believed to be at the edge of their range in Point Hicks MNP, 17 in Beware Reef MS and 38 in Cape Howe MNP.

The humpback whale *Megaptera novaeangliae,* threatened southern right whale *Eubalaena australis* and threatened New Zealand fur seal *Arctophoca forsteri* are found in the waters of both bioregions. The southern right whale *E. australis* has been observed to calve in Cape Howe and Wilsons Promontory MNPs. Five listed marine reptiles: loggerhead turtle *Caretta caretta*, green turtle *Chelonia mydas*, Pacific ridley *Lepidochelys olivacea*, leatherback turtle *Dermochelys coriacea*, and yellow-bellied sea snake *Pelamis platurus* occur as warm water vagrants in the bioregions. The whale shark *Rhincodon typus* east coast range extends to Point Hicks MNP. The islands surrounded by Wilsons Promontory MNP, particularly Kanowna in the Anser Group, are breeding colonies of little penguins *Eudyptula minor*, Australian fur seals *A. pusillus doriferus*, and a small colony of New Zealand fur seals *A. forsteri*. The MNP is also a nationally significant area for the recovery of great white shark *Carcharodon carcharias* populations. In Ninety Mile Beach one species of crab, *Halicarcinus sp MoV746* and in Point Hicks one mollusc, the welk *Fax molleri*, are presumed to be endemic to the MNPs. Cape Howe MNP is an important foraging area for a significant breeding colony of little penguins *E. minor* from neighbouring Gabo Island. The state vulnerable New Zealand fur seal *A. forsteri* has also been recorded breeding in the MNP. The southern elephant seal *Mirounga leonina* has been recorded in Beware Reef MS.

The introduction of foreign species or marine pests, by recreational or commercial vessels, threatens the integrity of marine biodiversity. The New Zealand screw shell *Maoricolpus roseus* has been recorded in high densities on the subtidal sediment of Point Hicks MNP. The introduced green shore crab *Carcinus maenas* is presumed to occur on the intertidal

reefs of all the MPAs except Ninety Mile Beach MNP, which has no intertidal reef. Abalone viral ganglioneuritus has been slowly spreading on the west coast, killing a large percentage of abalone in infected areas from Discovery Bay MNP to Cape Otway. It could have serious ecological consequences for subtidal reef communities if it spreads into the Flinders and Twofold Shelf bioregions.

Recreational boating has also been identified as posing a threat to seagrass beds, soft sediments and shallow subtidal reefs through propeller scour or anchors. Disturbance of wildlife, shore birds by vehicles, people or dogs; or breeding colonies of seals by boats are also a threat in the MPAs, as is poaching of abalone or fish. Commercial vessels also pose a threat due to the risk of oil spills. Water quality in the MPAs may be threatened by increased nutrients and sediments from land use or waste discharge.

Climate change represents a serious threat but the specific ecological consequences are not well understood in temperate marine systems. Increased sea levels, water and air temperature, cloud cover, ultraviolet light exposure and frequency of extreme weather events are predicted. Changes in the chemical composition, circulation and productivity of the seas are also predicted. These predicted changes have the potential to impact all marine habitats, causing loss of habitats, decreases in productivity and reproduction and distribution of species. A number of species are at the limit of their distributional range in both bioregions and would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii* range increase is thought to be linked to climate change with the EAC extending further south.

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. Subtidal reef monitoring occurs in all MPAs in the bioregions except Ninety Mile Beach MNP. Intertidal reef monitoring is not conducted in either bioregion as this habitat is limited. Other statewide projects are currently underway to determine which MPAs are most at risk from introduced species, to document and photograph marine natural values, and to detect poaching.

Since declaration considerable advancement has been made in identifying and understanding the marine natural values of the Flinders and Twofold Shelf bioregions. There are still major gaps in our knowledge. Comprehensive knowledge of basic habitats, their distribution and extent, is limited to shallow waters except in Point Hicks and Cape Howe. Monitoring changes in flora and fauna over time is limited to shallow subtidal reef. There is limited knowledge of the bioregion's intertidal and subtidal soft sediment and open waters. Whilst general and individual threats to the MPAs have been identified we have limited knowledge of how those threats will affect marine natural values.

ACKNOWLEDGEMENTS

This project was undertaken for Parks Victoria and principally managed by Steffan Howe. We would also like to thank Tony Varcoe for his project management. Thank you to Parks Victoria's research partners who implemented many of the research projects cited in this report. Thank you to Anthony Boxshall who managed many of the earlier research partner projects cited in the report. Thank you to Richard Zavalas for creating the maps, Jacquomo Monk and Alex Rattray for GIS assistance and Margie Morrice for her fine editing. Thank you also to Matt Edmunds and Hugh Kirkman for their editorial comments. Thank you to all that generously made their photos available for this report.

CONTENTS

INDEX OF FIGURES AND TABLES

FIGURES

TABLES

ACRONYMS

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

1 Introduction

1.1 Victoria's Marine Protected Areas

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

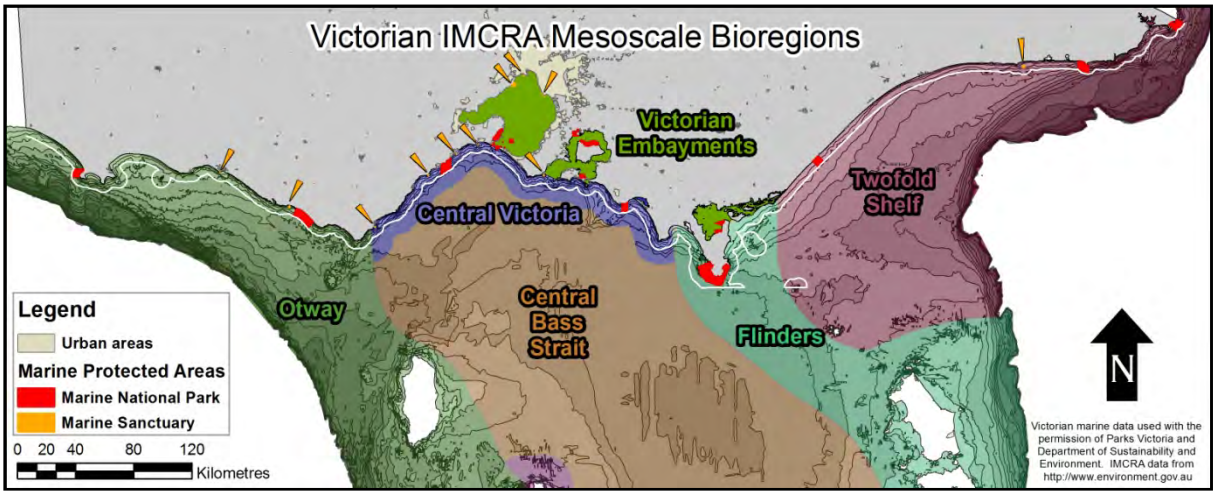


Figure 1. Locations of IMCRA mesoscale (*i.e.* 100-1000km) bioregions (IMCRA 2006 v4)

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

Sites for the Marine Protected Areas (MPAs) were chosen to be representative of the diversity of Victoria's marine environment (ECC 2000) and the 24 parks are spread across Victoria's five marine bioregions (Figure 1). More than one park and/or sanctuary was usually selected within each bioregion, to reflect as far as possible the range of habitats and biological communities within each, to incorporate the variability within habitats, and to insure against loss due to unforeseen or future catastrophic events (Parks Victoria 2003). These parks and sanctuaries now protect 5.3 % of Victoria's coastal waters, incorporating important marine habitats and species, significant natural features, cultural heritage and aesthetic values (Parks Victoria 2003). The MPAs are highly protected areas where no fishing, extractive or damaging activities are allowed but to which access is unrestricted. Recreation, tourism, education and research are encouraged and properly managed (Power and Boxshall 2007). 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 Flinders and Twofold Shelf bioregions and is one of a series of four reports covering Victoria's MPAs. It aims to give a comprehensive overview of the important natural values of each MPA that will assist in park management within the region. The report will also provide a resource for education and public recognition of the natural values of the MPAs in the Flinders and Twofold Shelf bioregions.

1.3 Structure

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

1.4 Methods

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

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

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

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

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

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

Species of conservation significance, particularly species distribution information, were derived from new research, monitoring and mapping reports. Species from the Atlas of Victorian Wildlife recorded near and within MPAs were included in the lists of species of conservation significance for each MPA. Constraints were made on the database searches

to ensure all records were for animals in the marine habitats in or near (*i.e.* within 5 km) individual MPAs. Aall 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 Flinders and Twofold Shelf bioregions Port (Appendix 1).

1.5 Flinders and Twofold Shelf Bioregions

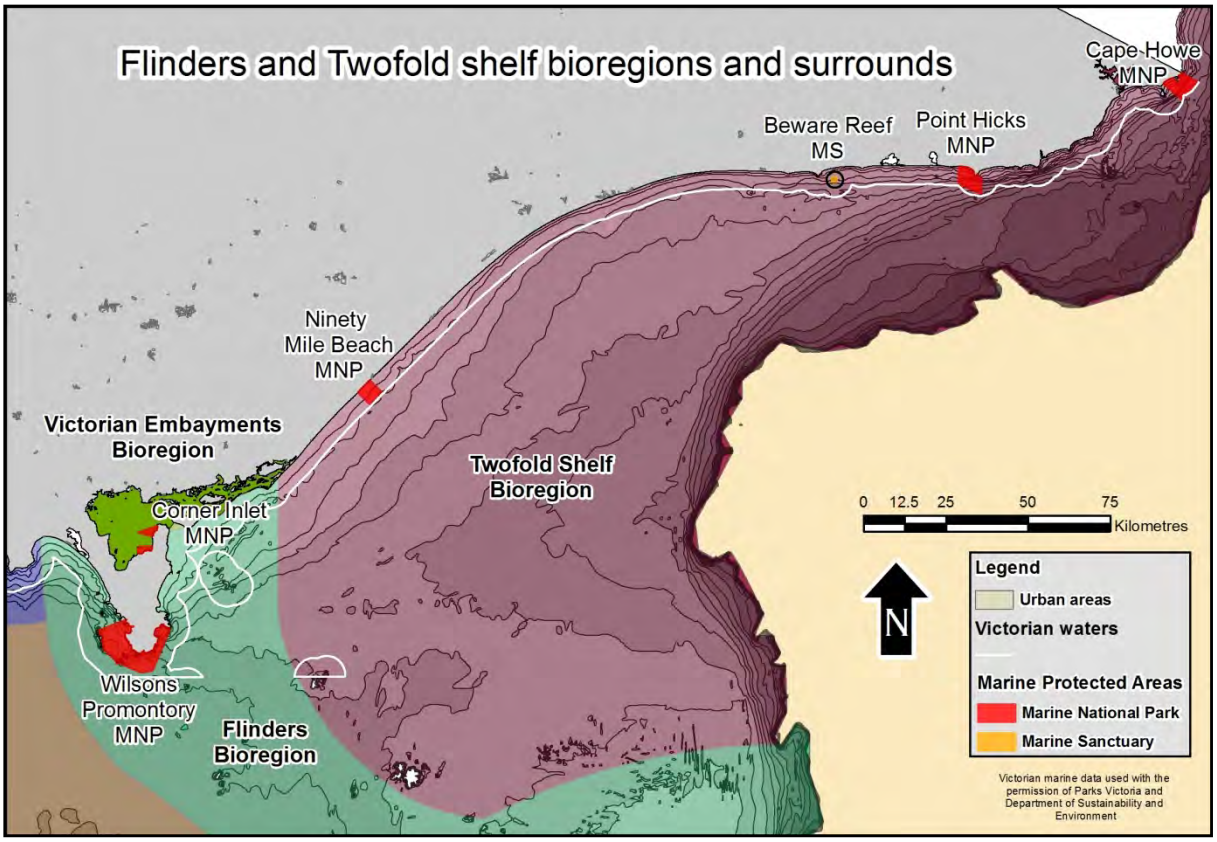


Figure 2. Eastern Victoria with IMCRA mesoscale bioregions, Marine National Parks and Marine Sanctuaries.

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 (Figure 2). 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 (Figure 3) 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).

Figure 3. Algal beds on subtidal reef at Wilsons Promontory Marine National Park in the Flinders bioregion

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 (Figure 2). 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. The continental shelf becomes broader and shallower in the west. Wave energy in this bioregion

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). Reefs are generally dominated by warm temperate species. The fauna is characterised by distinctive assemblages of reef fish, echinoderms, gastropods and bivalves. This bioregion is notable for the presence of species that also occur along the Southern NSW coast but not in central or western Victorian waters (IMCRA 2006). One such species is the large sea urchin *Centrostephanus rodgersii,* which removes macroalgae from shallow reefs creating a coralline algal encrusted barrens habitat on some reefs in the eastern part of the bioregion (Edmunds *et al.* 2007).

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 2006). Within the Central Victoria bioregion, there are two MNPs, Point Addis and Bunurong, and five MSs, Marengo Reef, Eagle Rock, Point Danger, Barwon Bluff and Mushroom Reef. It has a temperate climate with moist winters and warm summers. The shore is characterised by cliffs with sandy beaches and has the western-most occurrence of granites in its eastern region. Offshore gradients are steep in the east to very steep in the west (IMCRA 2006). It is relatively exposed to swells and weather from the south-west, but less so than the Otway bioregion (Parks Victoria 2003). Sea surface temperatures are representative of Bass Strait waters and wave energy is moderate (IMCRA 2006). Tides change from twice to four times a day from west to east (IMCRA 2006). The habitats include shallow near-shore reefs and sandy beaches along with large areas of subtidal sandy sediment and patchy, low profile subtidal reef. Reefs can be limestone, basalt, granite or mudstone (Parks Victoria 2003). The limestone reefs are usually offshore from a surf beach and readily erode to provide a complex habitat for a diverse array of macroalgae, sponges, bryozoans, corals and ascidians as well as mobile crevice dwellers (Parks Victoria 2003). The dominant biota of this region consists of a diverse mixture of species from all of the adjacent biogeographical provinces – western, eastern and southern temperate species – in addition to cosmopolitan southern Australian species (Parks Victoria 2003).

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

Figure 4. A common species in the park: butterfly perch *Caesioperca lepidoptera* at Wilsons Promontory Marine National Park.

2 Marine National Parks

2.1 Wilsons Promontory MNP – Flinders Bioregion

Wilsons Promontory MNP is the only Marine National Park in the Flinders bioregion, which also contains Wilsons Promontory Marine Park and Marine Reserve. Wilsons Promontory MNP is approximately 220 km south-east of Melbourne and surrounds the southernmost tip of Wilsons Promontory National Park. It extends offshore from high water mark along 44.6 km of coastline from the southern end of Norman Bay to Cape Wellington, and offshore to within 300 m of the Glennie Group of islands (Figure 6). The MNP surrounds the Anser Group of islands (Anser, Wattle and Kanowna Islands and Anderson Islets, part of Wilsons Promontory National Park) to the mean high water mark along 13.3 km of island coastline (Parks Victoria 2006g). The MNP adjoins Wilsons Promontory Marine Park which extends north along the west coast of Wilsons Promontory from Norman Bay. The Glennie Group of islands is surrounded by the Wilsons Promontory Marine Reserve and adjoins the MNP. The coastal water north of Cape Wellington along the east coast of Wilsons Promontory is also part of the Wilsons Promontory Marine Reserve and adjoins the MNP.

Aboriginal tradition indicates that the Wilsons Promontory MNP is part of the sacred *Country* known as Yiruk for the Gunai/Kurnai people and Wamoom for the Boon Wurrung people (Parks Victoria 2006f).

Important natural values of Wilsons Promontory MNP are its biological communities with distinct biogeographic patterns, including shallow subtidal reefs, deep subtidal reefs, intertidal rocky shores, sandy beaches, seagrass, subtidal soft substrates and expansive areas of open water (Parks Victoria 2006g). It has a wide range of habitat types, from low to high wave exposure. It has unusual granite habitats, with extensive heavy reefs with smooth surfaces, boulders and rubble and low profile reefs (Carey *et al.* 2007b). Its deep heavy reefs have a dense cover of epifauna, especially sponges, stalked ascidians and sea whips, and abundant fish life (Edmunds *et al.* 2009). Its soft sediment has diverse biotic assemblages. In some sheltered bays there are significant seagrass beds (*e.g. Amphibolis* and *Halophila* in Waterloo Bay, *Heterozostera* in Oberon Bay). Two important macroalgal communities have been identified, a *Phyllospora-Ecklonia* dominated macroalgal community, with fleshy red algae and some other brown species abundant, and a *Phyllospora* dominated macroalgal community, with *Ecklonia* and encrusting corallines abundant (Edmunds *et al.* 2007). The invertebrate communities generally have very abundant urchins *Heliocidaris erythrogramma*, blacklip abalone *Haliotis rubra* and feather stars *Cenolia trichoptera*. Two distinct invertebrate communities have been recognised, the south east invertebrate community typically has the seastar *Nectria macrobranchia* (Edmunds *et al.* 2007). The north west invertebrate community typically has the seastars *Patiriella brevispina* and *P. vernicina* (Edmunds *et al.* 2007). Wilsons Promontory MNP is considered to have relatively high species richness and high diversity indices along with higher than average abundances for most fish species compared to other areas in central Victoria (Edmunds *et al.* 2000). The fish communities are usually dominated by four species, the barber perch *Casioperca rasor*, blue-throated wrasse *Notolabrus tetricus*, purple wrasse *N. fucicola*, long-finned pike *Dinolestes lewini* and herring cale *Odax cyanomelax*. Fish communities include a western and eastern fish community, distinguished by the dominance of herring cale in the former (Edmunds *et al.* 2007).

Wilsons Promontory MNP is a nationally significant area for recovery of great white shark, *Carcharodon carcharias,* populations (Carey *et al.* 2007b). Wilsons Promontory MNP and the islands surrounded by the MNP provide important feeding and roosting habitat for several threatened bird species such as the hooded plover *Thinornis rubricollis*, whitebellied sea-eagle *Haliaeetus leucogaster* and Caspian tern *Hydroprogne caspia* which are listed

under the *Flora and Fauna Guarantee* (*FFG*) *Act* (1998). The MNP protects feeding areas for species of national environmental significance under the *Commonwealth Environment Protection and Biodiversity Conservation* (*EPBC*) *Act* (1999) and species that are listed under the China–Australia Migratory Bird Agreement (CAMBA) and the Japan–Australia Migratory Bird Agreement (JAMBA) (Parks Victoria 2006g). The islands, particularly Kanowna in the Anser Group, are breeding colonies of little penguins *Eudyptula minor*, Australian fur seals *Arctocephalus pusillus doriferus*, and a small colony of New Zealand fur seals *Arctophoca forsteri* (Carey *et al.* 2007b). The conservation listed southern right *Eubalaena australis* and humpback whales *Megaptera novaeangliae,* killer whale *Orcinus orca* and leatherback *Dermochelys coriacea* and green turtles *Chelonia mydas* use the MNP waters. The bottlenose dolphin *Tursiops truncates*, common dolphin *Delphinus delphis* and leopard seal *Hydrurga leptonyx* have been observed in the waters in and around the park. One hundred and twenty-six species of marine flora and fauna are believed to be at their eastern or western distributional limits within the planning area.

Serious threats to the Wilsons Promontory MNP include limited ecological knowledge of important processes. Serious threats to the Wilsons Promontory MNP include limited ecological knowledge of important processes. Invasive marine pests; nutrients from sewage; propeller scour; major oil spills; boat disturbance of seal colonies; inadequate management; 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 Wilsons Promontory MNP (Parks Victoria 2006g). Ongoing intertidal and subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Wilsons Promontory MNP.

2.1.1 PHYSICAL PARAMETERS & PROCESSES

Wilsons Promontory MNP is 15,580 hectares in size which makes it the largest of the 24 Marine National Parks and Sanctuaries in Victoria (Figure 6, Table 1). Its shoreline geology is dominated by a massif of Devonian granite forming the southern part of the Promontory itself. The area includes numerous geological and landform features of national geological and geomorphological significance (Figure 8, Bird 1993). Within the MNP, Cleft Island in the Anser Group is listed as having State geological significance. Just outside the MNP the numerous sheets of granites at Norman Point are also listed while the sea caves of Great Glennie Island are of regional significance. Wilsons Promontory's smooth-walled granite cliffs plunge abruptly to the sea-floor and its sandy beaches slope gradually to depths of 30 to 70 m within 3 km offshore (Figure 6). Over 90 % of the MNP is > 20 m depth (Table 1). Water depth reaches 30 m around many headlands (Oberon Point to South East Point), and 75 m further offshore between the Anser Group and Forty Foot Rocks (Parks Victoria 2006g). The MNP is less exposed to swells than other parts of the Victorian coast, but is subject to strong current flows and high winds (Parks Victoria 2006g). These winds can create substantial surface waves, affect local currents and cause turbidity. Strong and complex tidal patterns occur in the MNP (Parks Victoria 2006g). The western coast of the MNP is generally subject to a south-west swell, and the eastern coast to a south-east swell (Parks Victoria 2006g). The only major current in the MNP area is the very weak termination of the East Australian Current (Parks Victoria 2006g). Wilsons Promontory is significant in that it marks the boundary between the warmer waters of the eastern Australian coast and the colder waters of central and western Victoria. Surface water temperatures cool and are comparable to sea temperatures in Tasmanian waters (Parks Victoria 2006g). The tides are mostly semi-diurnal with a marked diurnal inequality (*i.e.* two low tides of different height, and two high tides of different height, within a 24-hour period) (Parks Victoria 2006g). Numerous small estuaries run directly into the MNP (Table 1).

Table 1. Physical attributes of the Wilsons Promontory Marine National Park.

Park Name	**Wilsons Promontory**
Conservation status	Marine National Park
Biophysical Region	Flinders
Size	15580 ha (ranked 1st of 24)
Length of coastline	~ 44.6 km
Shoreline geology	granite
Area with depth:	
Less than 10m	575 ha
Comprising: <5 m (high res)	*(274 ha)*
5-10 m (high res)	*(228 ha)*
*0 - 10 m (low res)**	*(73 ha)*
0-20 m (coarse)*	30 ha
10-20 m	715 ha
20-30 m	1227 ha
30-40 m	1845 ha
40-50 m	4465 ha
50-60m	2526 ha
60-70m	1519 ha
70-80m	2675 ha
Mean tidal variation - spring	1.8 m
Mean tidal variation - neap	1.4 m
Mean water temp - summer	17.5°C
Mean water temp - winter	13°C
Adjacent catchment	Conservation
Discharges into MNP	Growler, Frasers, Roaring Meg, Picnic, Ferr, First Bridge, Freshwater and numerous intermittent Creeks
Nearest major estuary (distance & direction)	Growlers discharges directly into MNP Tidal 1.3 km North on the west shore Sealers 8.2 km North on the east shore

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

Figure 5. Hermit crab (probably *Strigopagurus strigimanus*) in Wilsons Promontory Marine National Park. Photo by Julian Finn Museum of Victoria.

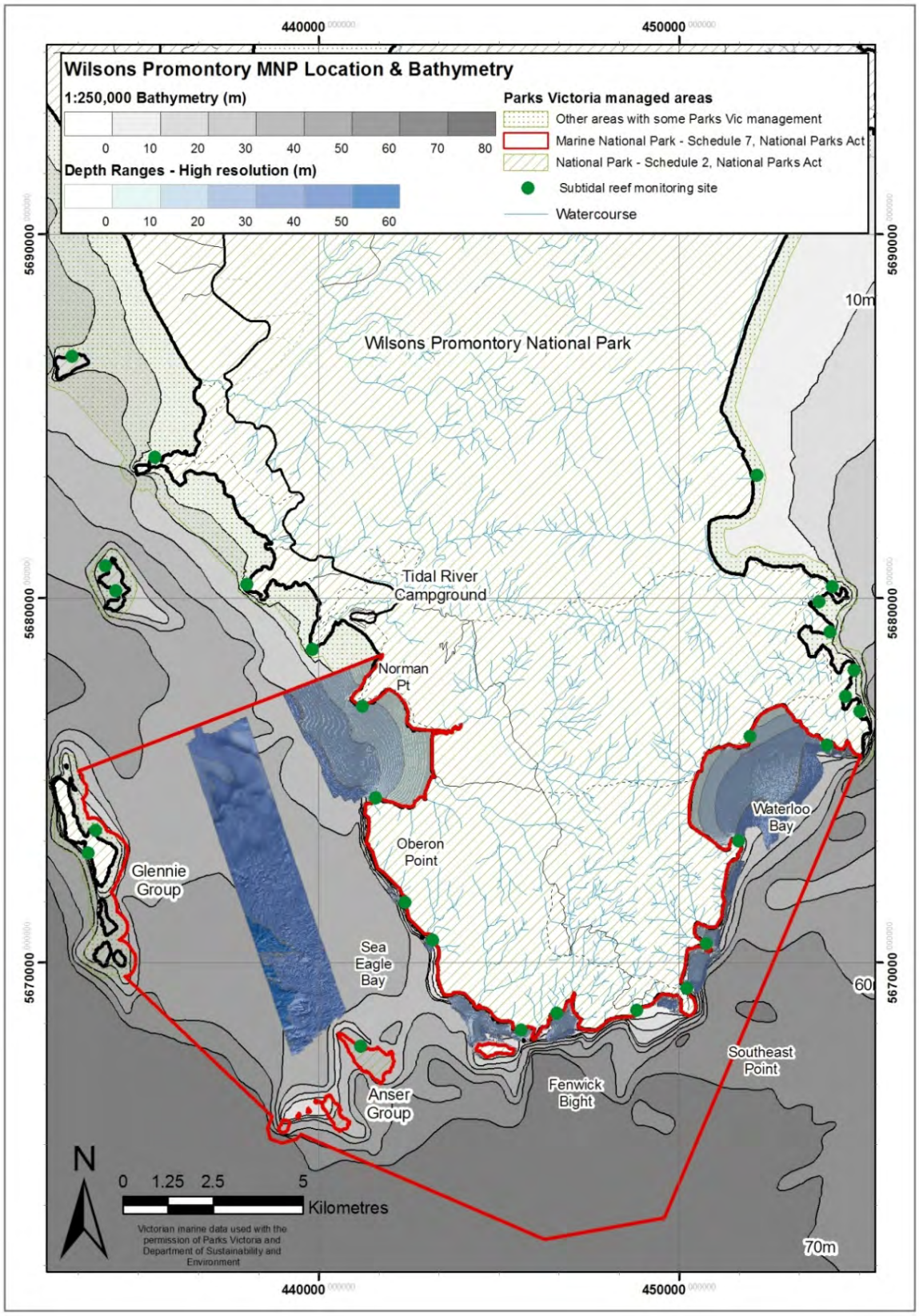


Figure 6. Location map of Wilsons Promontory Marine National Park with high resolution and 1:250,000 bathymetry. Subtidal reef monitoring sites inside and outside the MNP are shown, there are no intertidal monitoring sites.

2.1.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. The main habitats present in Wilsons Promontory MNP include some intertidal soft sediment and reef, extensive subtidal soft sediment and reef, and open ocean (Figure 8). LiDAR mapping of the coastline has been done but it is limited by depth to shallow habitats in Oberon and Norman Bays on the west side of Wilsons Promontory MNP, in Waterloo Bay on the east side of the park and some areas around the tip of Wilsons Promontory (Figure 6). This represents a very small proportion of the park, the surveys found heavy reef with some low profile reef. No modelling of habitats has been done, so unlike other parks, we do not have a good understanding of the distribution and extent of basic habitats within the MNP. The majority of the Wilsons Promontory MNP substrate has been mapped as soft sediment, but this may change with additional more detailed acoustic mapping. The subtidal sand plains extend to at least 20 m depth and are composed of both coarse and fine calcarenite sediments Plummer *et al.* (2003).

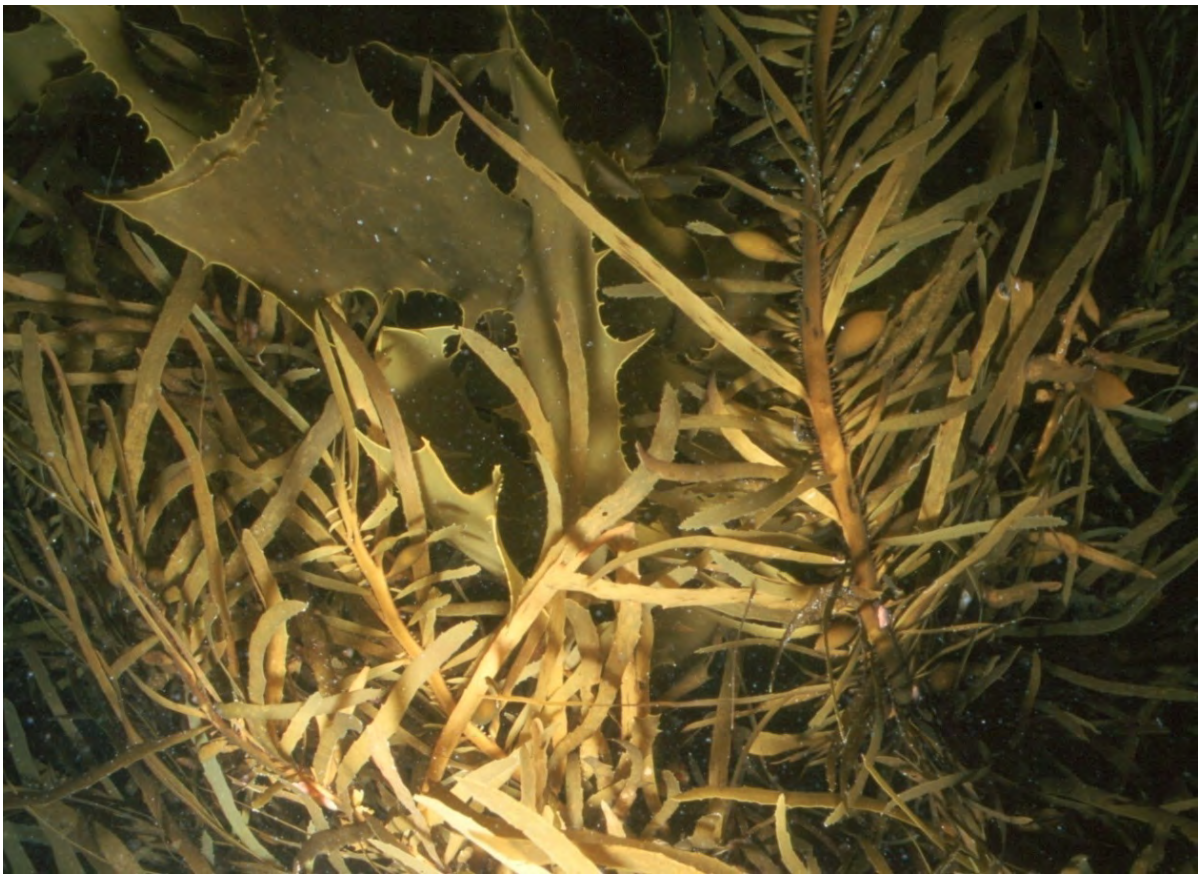


Figure 7. Crayweed *Phyllospora comosa* in Wilsons Promontory Marine National Park

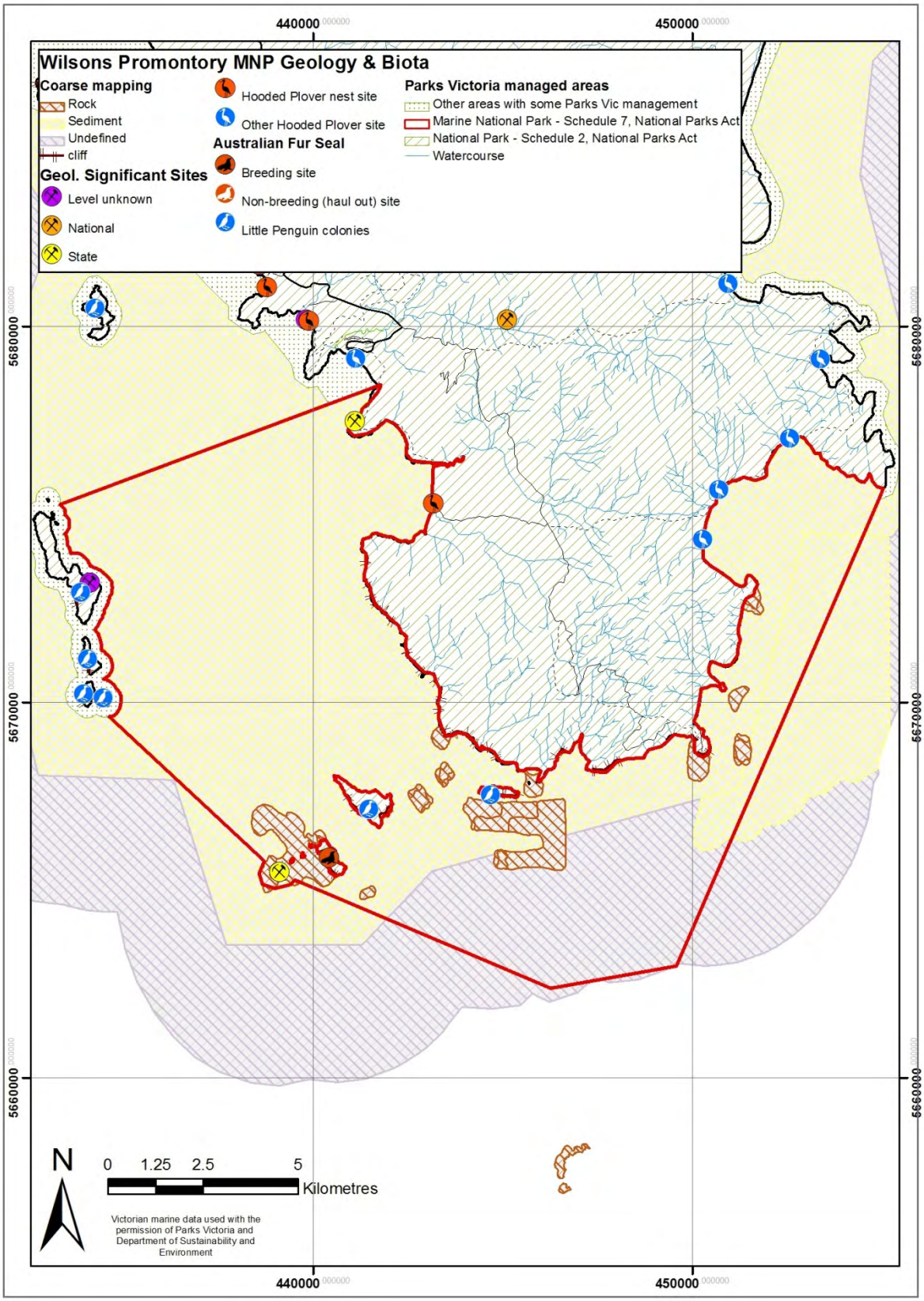


Figure 8. Substrate and biota mapping of Wilsons Promontory Marine National Park.

2.1.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al*. (2003) there have been several monitoring, mapping surveys and research projects conducted in Wilsons Promontory MNP (Edmunds *et al.* 2007; Edmunds *et al.* 2009). The new data for fish abundances, distributions or interactions is generally limited to shallow subtidal reef habitats (Colton and Swearer 2009; Colton and Swearer 2010), with some research focussing on deeper reefs (Edmunds *et al.* 2009). Important locations for some birds and mammals are shown in Figure 8. Surveys in the MNP found red algae dominate the diversity of macrophytes, gastropods and echinoderms the invertebrates and fish the vertebrates in Wilsons Promontory MNP (Table 2, Appendix 1). There is no new information on the ecological communities of sandy beaches and intertidal soft sediments and there is presently no information available for water column assemblages.

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

Biotic group	Number of species
Macrophytes	**145**
Green algae	16
Brown algae	49
Red algae	79
Seagrasses	1
Invertebrates	**121**
Cnidaria	3
Polychaetes	1
Barnacles	5
Decapod	12
Sea spiders	3
Chitons	6
Gastropods	43
Bivalves	5
Sea slugs	7
Cephalopods	2
Echinoderms	38
Vertebrates	**195**
Ascidians	1
Fish	137
Birds	60
Reptiles	3
Mammals	9

Intertidal

Soft sediment

The major areas of intertidal soft sediment in the MNP are in Oberon Bay and Waterloo Bay (Figure 8). Flora is restricted to macroalgae drift and macroalgal epiphytes. Beach-washed materials in sandy beach habitats are a significant source of food for scavenging birds, and contribute to the detrital cycle that nourishes many of the invertebrates, such as bivalves, living in the sand (Weston 2003; Parks Victoria 2006g). Norman Bay just north of the Park boundary may provide an indication of the likely fauna of similar areas within the MNP (Plummer *et al.* 2003). Norman Bay features fine intertidal sand and has impoverished infauna with fewer than ten macroinvertebrate species recorded. The soldier crab *Mictyris longicarpus* is the dominant invertebrate reaching very high densities at mid-tide level. The moon shells *Polinices conicus* and *P. sordidus* are also common (Plummer *et al.* 2003).

No specific data for fish on intertidal sandy beaches in the MNP are available. As reported in Plummer *et al*. (2003) fish such as mullets, hardyheads and Australian salmon *Arripis trutta* are offshore of sandy beaches and usually mobile and transient. Hooded Plovers *Thinornis rubricollis*, endangered in Victoria, are thought to prefer wide beaches with beach-washed macroalgae like Oberon Bay (Weston 2003).

Reef

Intertidal reef biota is exposed to large changes in physical conditions such as temperature, water cover and wave exposure. Intertidal rocky reefs in the MNP are generally steep boulder-fields. There is great spatial and temporal variability in the life histories of the organisms and the environmental processes in intertidal reef habitats (Underwood and Chapman 2004). The recruitment of new biota onto the reef, from the plankton, strongly influences the ecological patterns for individual species and assemblages. Interactions between biota on the reef also influence biota distribution. Some mobile species of animals, particularly chitons, brittlestars, opisthobranchs and gastropods are predominately found under boulders (Underwood and Chapman 2004). Space on which to live and food itself are often resources in short supply on intertidal reefs (Underwood and Chapman 2004). There is no intertidal reef monitoring program in Wilsons Promontory MNP.

The intertidal rocky shore at Wilsons Promontory MNP is not as diverse as some other locations in Victoria, probably due to the weathering patterns of the granite which result in less varied and protected microhabitats for invertebrates (Plummer *et al.* 2003). The steep aspect of the large granite boulders at Wilsons Promontory MNP mean that the intertidal zone is often only as wide as the tidal range which limits the substrate available (Plummer *et al.* 2003).

Macroalgae and Aggregating Sessile Invertebrates

Dominated by steep granite boulders, the intertidal rocky shore provides habitat for lichens, various brown algae, chitons and ascidians (Parks Victoria 2006g). Two lichens, *Lichina confinis* and the orange lichen *Gasparinnia murorum* (which is rare elsewhere in Victoria) dominate the region above the high water mark which is exposed to wind-blown spray and water droplets (Plummer *et al.* 2003). The mussel *Brachidontes rostratus,* the barnacles *Chthamalus antennatus*, *Chamaesipho columna, Catomerus polymerus and Austromegabalanus nigrescens*, the anemone *Actinia tenebrosa* and the globular cyanobacteria *Rivularia firma* are common in the mid-intertidal (Plummer *et al.* 2003). The small brown algae *Splachnidium rugosum* occurs only in summer when it can form a conspicuous band. Near the low water mark encrusting calcareous red algae, the ascidian *Pyura stolonifera* and medium sized brown algae *Cystophora* sp. can be common. Further down the shore the large brown algae *Durvillaea potatorum* is dominant at Wilsons Promontory MNP in comparison to other regions of Victoria. Also dominant in the surge zone

exposed only by low spring tides are the browns *Ecklonia radiata* and *Phyllospora comosa* along with coralline red algae (Plummer *et al.* 2003).

Mobile Invertebrates

Above the high water mark in amongst the lichen are the dominant invertebrate periwinkle gastropods *Nodilittorina unifasciata* and *N. praetermiss.* They can only be found on Bass Strait coasts, including Tasmania (Plummer *et al.* 2003). In amongst the mussels and barnacles are the limpets *Cellana solida*, *C. tramoserica*, *Notoacmea alta*, *N. mayi*, *N. petteridi*, *Patelloida victoriana*, and *P. latistrigata*. The predatory gastropods *Diacthais orbita* and *Lepsiella vinosa* are also common and feed on the mussels and barnacles. Near low-water mark the gastropods *Diacthais orbita* and *Turbo undulatus*, chitons of the genus *Plaxiphora* spp. and the limpet *Patella peroni* are common. Both the chitons and limpets extend into the surge zone. Shore birds such as the sooty oystercatcher frequent the intertidal reefs.

Fish

Intertidal fish communities have not been surveyed at Wilsons Promontory MNP. The steep rocky intertidal zone in the MNP supports only small and cryptic fishes such as the blenny *Parablennius tasmanianus* and dragonet *Bovichtus angustifrons* (Plummer *et al.* 2003).

Subtidal

Soft sediment

There are some shallow and extensive deep sandy beds within the Wilsons Promontory MNP and these are predominantly inhabited by infauna (small crustaceans and worms that burrow into the sand) and bottom-dwelling skates and rays (Parks Victoria 2003).

Drift algae and algae attached to shells and debris are common on soft sediments. Seagrass beds of *Halophila ovalis* and *Heterozostera nigricaulis* are restricted to sheltered waters, in particular Waterloo and Oberon Bays (Plummer *et al.* 2003). Cover of *H. ovalis* is generally sparse and is often replaced by *H. nigricaulis* in deeper waters. Extensive meadows of *H. nigricaulis* were recorded down to a depth of 21 m in Oberon Bay. *Posidonia australis* has been recorded just outside the Marine National Park in shallow water at Great Glennie Island and Norman Bay (Plummer *et al.* 2003). Seagrass can support numerous algal epiphytes, sessile invertebrates such as bryozoans, hydroids and sponges and mobile invertebrates such as molluscs, isopods, crabs (Figure 5) and amphipods. No specific seagrass surveys have been undertaken in the MNP. From Norman Bay just to the north of the Marine National Park at Wilsons Promontory, the unusual octocoral *Pseudogorgia godeffroyi* was recorded on two occasions at a depth of 13 m in seagrass communities. This species was previously only recorded between 30 - 64 m deep on sand swept by currents (Plummer *et al.* 2003). A variety of fish have been recorded on seagrass and associated sand substrate including the southern goatfish *Upeneichthys vlamingii*, silverbelly *Parequula melbournensis*, wide-bodied pipefish *Stigmatopora nigra*, spotted pipefish *S. argus*, slender weed whiting *Siphonognathus attenuatus*, blue throated wrasse *Notolabrus tetricus*, gobies *Nesogobius* spp., weedfish *Heteroclinus* spp. and *Cristiceps* spp. and toothbrush leatherjackets *Acanthaluteres vittiger* (Plummer *et al.* 2003).

The demersal fish fauna of subtidal soft sediment environments at Wilsons Promontory MNP are typical of much of the shallower parts of Bass Strait (Plummer *et al.* 2003). The most common benthic fish is the sparsely spotted stingaree *Urolophus paucimaculatus*, but other elasmobranches including Tasmanian numbfish *Narcine tasmaniensis*, banded stingaree *Urolophus cruciatus*, angel shark *Squatina australis* and shortnose sawshark *Pristiophorus nudipinnis* are also common. Boney fishes including sand flathead *Platycephalus bassensis*,

silver trevally *Pseudocaranx dentex*, prickly toadfish *Contusus brevicaudus* and several leatherjackets are common (Plummer *et al.* 2003).

Depth and sediment affect the distribution of benthic invertebrates along the Victorian coast. Coleman *et al*. (2007), and Heislers and Parry (2007) found that species richness was greater at 40 metres compared to 10 or 20 metres depth. Their coastal survey of benthic fauna included the benthos of Wilsons Promontory MNP. One transect off Oberon Bay on the west coast and one off Waterloo Bay on the east sampled the soft sediment with two 0.1 m^2 grab samples in 10, 20 and 40 m of water depth. The grab samples contained between 39 to 734 individuals and 16 to 71 species consisting mainly of crustaceans including amphipods, cumaceans, isopods and ostracods and polychaetes (Coleman *et al.* 2007; Heislers and Parry 2007). The sediment was generally fine sand with some medium sand (Heislers and Parry 2007).

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). 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

Diversity and species composition varies with location within the Wilson Promontory MNP. Central Waterloo Bay on the east coast and other areas to the north-east of the MNP are identified as having high macrophyte species diversity and richness (Edmunds *et al*. 2000). The macrophyte population in the southern part of the MNP is of low diversity, predominantly because a dense canopy is comprised of only one to three species with a sparse understorey (Edmunds *et al*. 2000). These three species (*Phyllospora comosa*, *Ecklonia radiata* and *Seirococcus axillaris*; Figures 7 and 9) form distinct algal assemblages: a *Phyllospora* dominated, an *Ecklonia-Seirococcus* dominated (Figure 9); and mixed brown algae (Edmunds *et al.* 2003; Edmunds *et al.* 2007). The species richness and diversity of the macroalgal communities is lowest at the exposed western and south-western sites, where the canopy is predominantly *Phyllospora* with a reduced cover of understorey species (Edmunds *et al.* 2007). Relatively large variations in community structure were observed between surveys at Oberon Point, Roaring Meg Bight and Fenwick Point (Edmunds *et al.* 2007).

The *Phyllospora* dominated assemblage is the most common, present at all MNP sites (Edmunds *et al.* 2007). This assemblage consists of a canopy of predominantly *Phyllospora comosa* (> 30% cover) and a lesser proportion of *Ecklonia radiata*. The associated understorey has a sparse cover of thallose red algae, with much of the underlying rock covered by encrusting corallines. Common understorey species included *Phacelocarpus peperocarpus*, *Plocamium angustum*, *P. dilatatum*, *Pterocladia lucida*, *Ballia callitricha*, *Haliptilon roseum* and *Melanthalia obtusata*. At sites in the south-west of the MNP, South Norman Point, Oberon Point and Sea Eagle Bay, *Phyllospora* cover has increased since the inception of the monitoring program. *Phyllospora* has higher abundances, and *Ecklonia* proportionately less so, at the most exposed sites, particularly Sea Eagle Bay and West Landing. At slightly less exposed sites, *Ecklonia* has a greater proportion of cover in the canopy, particularly Oberon Point, East Landing and Fenwick Point (Edmunds *et al.* 2007).

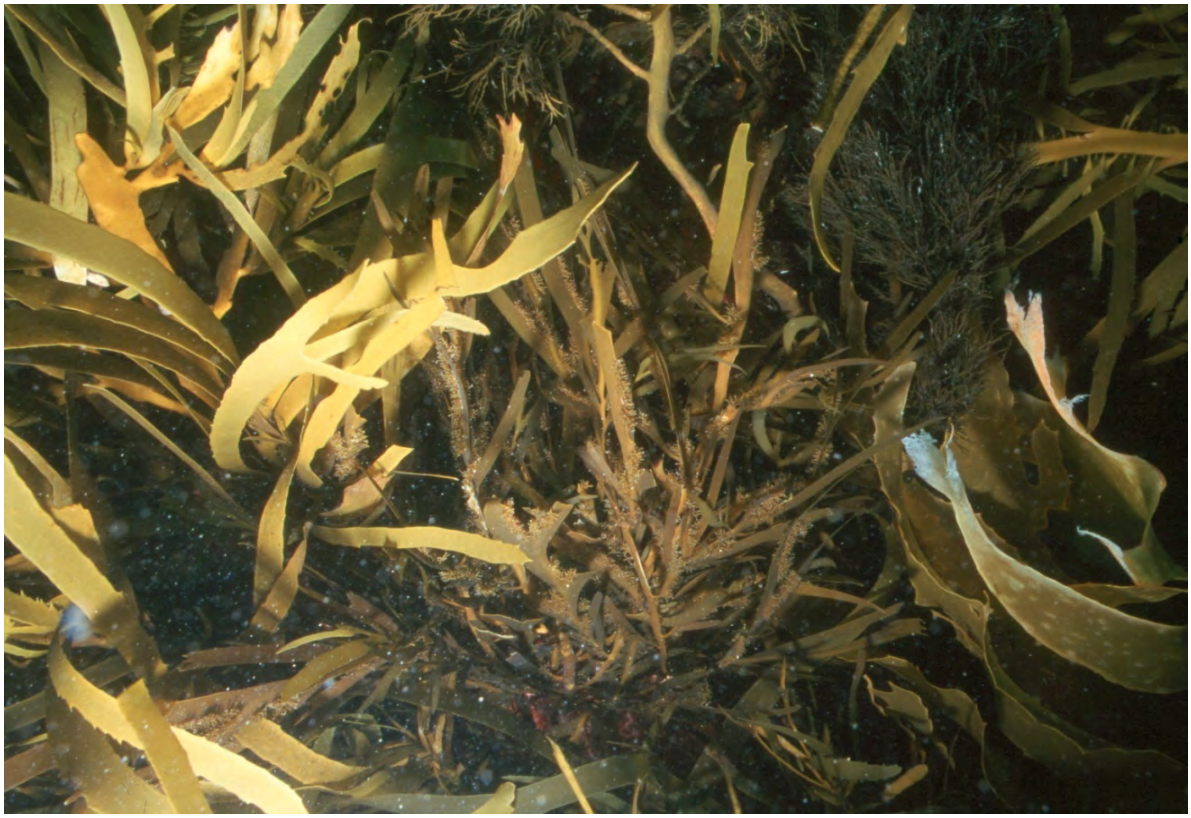


Figure 9. *Seirococcus axillarus* (centre of frame) with *Ecklonia radiata* in Wilsons Promontory Marine National Park.

In the *Ecklonia-Seirococcus* dominated assemblage *Ecklonia radiata* and *Seirococcus axillaris* comprised the dominant proportion of the canopy cover at moderately sheltered Waterloo Bay (Edmunds *et al.* 2007). *Phyllospora comosa* was also present at this site, but contributed less than 20 % of the canopy cover. Thallose understorey algae were a greater component of the assemblage, with 50 – 70 % cover compared with less than 30 % cover for the *Phyllospora* assemblage. The understorey composition is similar to the *Phyllospora* assemblage but with reduced abundance of *Ballia callitricha* and the erect coralline *Haliptilon roseum*, with smaller brown species more prevalent. These brown species included *Sargassum verruculosum*, *Sargassum sonderi*, *Perithalia cordata* and *Acrocarpia paniculata* (Edmunds *et al.* 2007).

At some sites, *i.e.* North Anser Island, East Landing, Fenwick Point and North Waterloo, both *Ecklonia* and *Phyllospora* are abundant (Edmunds *et al.* 2007). At Oberon Point and East Landing, there has been a gradual decrease in abundance of *Ecklonia radiata* since monitoring began in 1999. *Seirococcus axillaris* was generally most abundant at Oberon Point. An increase in the percent cover of *Plocamium angustum* has been observed at North Anser Island and Roaring Meg during recent surveys (Edmunds *et al.* 2007).

The sessile flora and fauna of five sites on deep subtidal reefs within Wilsons Promontory MNP have been video surveyed by remote operated vehicle (ROV, Edmunds *et al.* 2009). Wilsons Promontory MNP deep reefs (up to 50 m) are smooth granite of varying steepness (Edmunds *et al.* 2009). Eight taxa of algae and 47 taxa of sessile invertebrates were identified (Appendix 1). The most abundant taxa, sponges, could not be identified beyond morphotype from the survey method used, but less than half of Victoria's sponges have been formally described. The deep reefs in Wilsons Promontory MNP were characterized by the presence of gorgonian corals *Pteronisis* sp and *Acabaria* sp and the seawhip *Primnoella australasia.* The abundance of the sessile flora and fauna is variable (Edmunds *et al.* 2009; Figure 10). Particularly the deep turf cover, seawhip *Primnoella australasia,* encrusting

ruffled grey sponge, encrusting sponges, gorgonian fan *Pteronisis* sp., thallose red algae, encrusting ruffled yellow sponge, unidentified aboresecent bryozoans, lace bryozoans *Triphyllozoon moniliferum* and hard bryozoans (Edmunds *et al.* 2009).

Invertebrate fauna

The invertebrate species richness typically ranged from 10–20 species, with the common invertebrate assemblages appearing to differ according to the exposure at the different sites (Edmunds *et al.* 2007). Assemblage structure at the more sheltered sites, Roaring Meg Bight, Fenwick Point and Central Waterloo Bay, consist of a high abundance of the sea urchin *Heliocidaris erythrogramma* and moderate abundances of blacklip abalone *Haliotis rubra* and the featherstar *Cenolia trichoptera*. The sea stars *Nectria ocellata*, *Nectria macrobrachia* and *Plectaster decanus* are also common. At more exposed sites, South Norman Point, North of Sea Eagle Bay and Sea Eagle Bay, *Haliotis rubra* is more dominant in abundance and *Heliocidaris erythrogramma* is relatively less abundant. *Nectria macrobrachia* and *Plectaster decanus* is also less abundant at sheltered sites. The warrener *Turbo undulatus* tends to be more abundant at exposed sites. South Norman Point and North of Sea Eagle has moderate to high abundances of *Haliotis rubra*, but has comparatively low abundances of *Heliocidaris erythrogramma* and *Cenolia trichoptera*. The Fenwick Point and Central Waterloo Bay sites had high abundances of *Heliocidaris erythrogramma* and low abundances of *Cenolia trichoptera* and *Haliotis rubra* (Edmunds *et al.* 2007*)*. The abundance of these invertebrates is higher than found in the adjacent Central bioregion (Edmunds *et al.* 2000).

Over the ten SRMP surveys, the urchin *Centrostephanus rodgersii* has been recorded in low abundance at East Landing and just outside the MNP at Glennie Island (Edmunds *et al.* 2007). When in high densities *C. rodgersii* causes community shifts from macrophyte dominated reefs to urchin barrens. This species is of particular interest as in recent years it has increased its range down the east coast of Australia to Tasmania, causing major losses in macrophyte reef communities. Wilsons Promontory appears to be a western satellite site for the urchin as it is found in high abundance in the Twofold Shelf bioregion on the east coast of Victoria, but not the Bunurong Marine Park on the central coast (Edmunds *et al.* 2007).

Two pycnogonid species (*Stylopallene dorsospinum* and *Achelia transfugoides*) have been found on subtidal reefs and were new records for Victoria (O'Hara 2000). The bryozoan fauna near Lighthouse and Waterloo Bay is composed of large colonies of *Canda arachnoides, Amathia plumosa, Amathia woodsii*, *Orthoscuticella*, *Euthyroides episcopalis* and *Triphyllozoon munitum* attached either to rock, *Ecklonia radiata* holdfasts or *Ecklonia radiata* fronds (O'Hara 2000).

Fish

The fish fauna of Wilsons Promontory is composed primarily of wide-ranging cool temperate species endemic to Southern Australian, with a much smaller proportion of warmer-water temperate species towards the southern limits of their range (Plummer *et al.* 2003). Wilsons Promontory MNP is considered to have relatively high species richness and high diversity indices along with higher than average abundances for most fish species compared to other central Victorian areas (Edmunds *et al.* 2000). Notable are the colony of old wives *Enoplosus armatus* (Figure 11) at Oberon Bay, sea dragons of Tongue Point, the large bastard trumpeter *Latriopsis forsteri* of South Point, and the exceptionally high abundances of planktivorous fishes (Edmunds 2003). Species richness of fishes at Wilsons Promontory MNP is between 15 and 25 at most sites (Edmunds *et al.* 2007). The common fish species are: the barber perch *Caesioperca rasor*; blue-throated wrasse *Notolabrus tetricus*; purple wrasse *Notolabrus fucicola;* southern hulafish *Trachinops caudimaculatus;* silver sweep *Scorpis lineolata;* and magpie perch *Cheilodactylus nigripes*. Other common species

included: the toothbrush leatherjacket *Acanthaluteres vittiger*; herring cale *Odax cyanomelas*; butterfly perch *Caesioperca Lepidoptera* (Figure 4)*;* sea sweep *Scorpis aequipinnis;* and mado *Atypichthys strigatus*.

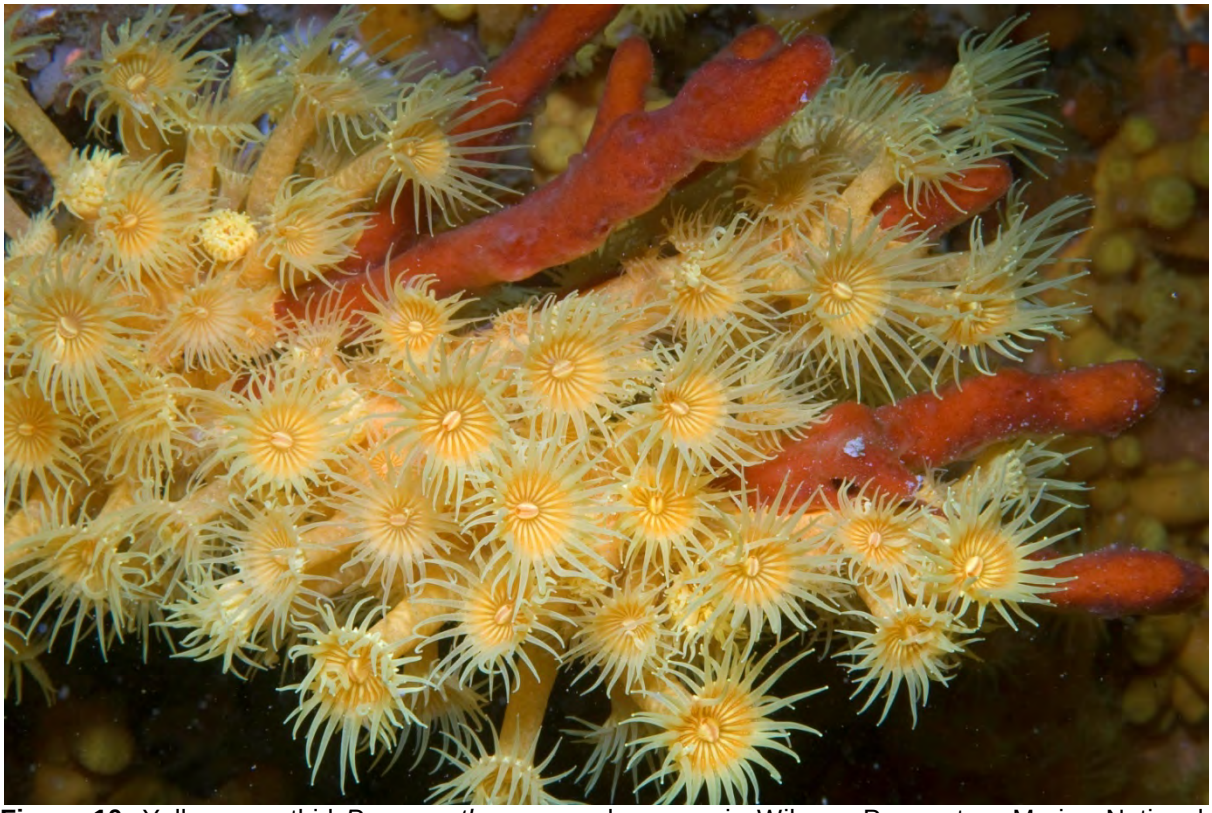


Figure 10. Yellow zoanthid *Parazoanthus* sp. and sponge in Wilsons Promontory Marine National Park. Photo by Julian Finn, Museum of Victoria.

Water column

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

2.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora

No threatened marine flora has been recorded in the park (Parks Victoria 2006g).

Fish

Many fish found in streams and rivers in terrestrial Wilsons Promontory National Park, have marine larval stages that would pass through and probably feed in the MNP. This would include the critically endangered Australian mudfish, and the state and nationally vulnerable Australian grayling (Table 3). Other fish recorded in or near the MNP are the broad-finned galaxias *Galaxias brevipinnis*, spotted galaxias *G. truttaceus*, pouched lamprey *Geotria australis* and short-headed lamprey *Mordacia mordax.* Great white sharks *Carcharodon carcharias* are often sighted around the islands of Wilsons Promontory MNP and park is a nationally significant area for recovery of great white shark populations (Carey *et al.* 2007b). The eastern blue groper *Achoerodus viridis* is present in low numbers in Wilsons Promontory MNP. It is thought to be threatened by over fishing and a temporary protection from all fishing was introduced in April 2011.

Table 3. Conservation listed fish records from Wilsons Promontory Marine National Park and surrounds.

		Victorian listing		National listing
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**
Australian mudfish	*Neochanna cleaveri*	L	CR	
Australian grayling	*Prototroctes maraena*	L	VU	VU

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

Birds

Twenty-five conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Wilsons Promontory MNP (Table 4). Twenty-two are recognised as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Five birds are listed at both the state and national level, including the southern giant-petrel which is nationally recognised as endangered. The soft-plumaged petrel is listed as vulnerable at the national level *EPBC Act 1999*. Seven birds are recognised internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA).

A pair of hooded plovers has been recorded as breeding in the MNP on the beach at Oberon Bay. Hooded plovers also nest outside the MNP at Picnic and Squeaky Beaches. They have been observed but do not nest at Norman Beach and on the beaches of Waterloo Bay. The hooded plover is endemic to Southern Australia and is recognised as endangered in Victoria and listed as vulnerable nationally. Hooded plovers feed and nest on the beach or in the nearby dunes of high energy ocean beaches (Wescott 2002). Beach-washed seaweed is an important habitat and food source of the wide variety of invertebrates they eat (Wescott 2002). They nest in solitary pairs and defend their breeding territories from August to March. There is a high mortality of eggs and chicks caused by disturbance from humans and dogs, and predation by foxes and cats (Wescott 2002).

There are two breeding colonies of little penguins within the boundaries of the Wilsons Promontory MNP, one on Anser Island (400 breeding pairs) and one on Wattle Island (500 breeding pairs). Breeding colonies of little penguins are also on the Glennie Group and Norman Island outside the MNP. These birds are a protected species under the *Wildlife Act 1975*. Little penguins nest from May to January with adults foraging within 20 km of the colony while feeding chicks. Outside of the breeding season they may travel larger distances from their colonies to feed, mainly keeping within 15 km of the coast.

Three of the islands within the MNP, Wattle, Kanowna and Anser are of state significance for shorebird habitat (Plummer *et al.* 2003). Species recorded include the crested tern, sooty oystercatcher, silver gull, Pacific gull (the only Victorian breeding site for this species), short-tailed shearwater, fairy prion and common diving-petrel (Plummer *et al.* 2003). Similar species are recorded on the islands of the Glennie Group to the west of the MNP (Plummer *et al.* 2003).

Table 4. Conservation listed shorebird and seabird records from Wilsons Promontory Marine National Park and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
Australasian bittern	*Botaurus poiciloptilus*	L	EN			
eastern reef egret	*Egretta sacra*	L	EN			
fairy tern	*Sternula nereis*	L	EN			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
common diving-petrel	*Pelecanoides urinatrix*		NT			
Pacific gull	*Larus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
white-fronted tern	*Sterna striata*		NT			
hardhead	*Aythya australis*		VU			
white-faced storm-petrel	*Pelagodroma marina*		VU			
hooded plover	*Thinornis rubricollis*	L	VU			
eastern curlew	*Numenius madagascariensis*		NT		C	J
Latham's snipe	*Gallinago hardwickii*		NT		C	J
sanderling	*Calidris alba*		NT		C	J
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
southern giant-petrel	*Macronectes giganteus*	L	VU	EN		
black-browed albatross	*Thalassarche melanophris*		VU	VU		
fairy prion	*Pachyptila turtur*		VU	VU		
shy albatross	*Thalassarche cauta*	L	VU	VU		
yellow-nosed albatross	*Thalassarche chlororhynchos*	L	VU	VU		
soft-plumaged petrel	*Pterodroma mollis*			VU		
common tern	*Sterna hirundo*				C	J
short-tailed shearwater	*Ardenna tenuirostris*					J

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

Marine mammals and reptiles

The southern right whale *Eubalaena australis* and humpback whale *Megaptera novaeangliae* have been recorded in or near the Wilsons Promontory MNP (Table 5). The southern right whale *E. australis* is listed as critically endangered in Victorian waters and endangered nationally. The humpback whale *M. novaeangliae* is listed as vulnerable at the state and national level. Both species have been observed to calf in the MNP. These two whales along with the killer whale *Orcinus orca* are migratory listed species under the Bonn convention. The state vulnerable New Zealand fur seal *Arctophoca forsteri* has been recorded as breeding on Kanowna Island and presumably feeds in the MNP. The state and nationally listed leatherback turtle *Dermochelys coriacea* and the nationally vulnerable green turtle *Chelonia mydas* have both been recorded from the MNP. Three other marine reptiles occur as vagrants along the eastern Victorian coast: loggerhead turtle *Caretta caretta*, Pacific ridley *Lepidochelys olivacea*, yellow-bellied sea snake *Pelamis platurus* and probably use the waters of the MNP (Plummer *et al.* 2003). The bottlenose dolphin *Tursiops truncatus*, common dolphin *Delphinus delphis*, and leopard seal *Hydrurga leptonyx* have been observed in the waters in and around the park. The Australian fur seal *Arctocephalus pusillus doriferus* feeds in the MNP and breeds on the islands surrounded by the park, with a particularly large breeding colony on Kanowna Island (Littnan *et al.* 2007, Arnould & Kirkwood 2008, Tripovich *et al.* 2009, Deacon & Arnould 2009, Gibbons & Arnould 2008, Tripovich *et al* 2006, Spence-Bailey *et al.* 2007). Numbers are concentrated in breeding areas from October to December.

Table 5. Conservation listed marine mammal and reptile records from Wilsons Promontory Marine National Park and surrounds.

		Victorian listing		National listing	International convention
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**Bonn**
southern right whale	*Eubalaena australis*	L	CR	EN	L
humpback whale	*Megaptera novaeangliae*	L	VU	VU	L
New Zealand fur seal	*Arctophoca forsteri*		VU	L	
Australian fur seal	*Arctocephalus pusillus doriferus*			L	
killer whale	*Orcinus orca*			L	L
leatherback turtle	*Dermochelys coriacea*	L	CR	VU	L
green turtle	*Chelonia mydas*			VU	L

L = listed, M = listed Migratory, VU = vulnerable, EN = endangered, CR = critically endangered

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that Wilsons MNP had four molluscs presumed to be endemic to the park (O'Hara and Barmby 2000; O'Hara 2002; Table 6).

Table 6. Marine invertebrates presumed to be endemic to the Wilsons Promontory Marine National Park (O'Hara and Barmby 2000; O'Hara 2002)

Phylum	Order	Family	Species
Mollusca	Gastropoda	Cyclostrematidae	*Liotella vercoi*
Mollusca	Gastropoda	Cystiscidae	*Cystiscus halli*
Mollusca	Polyplacophora	Eulimidae	*Eulima styliformis*
Mollusca	Polyplacophora	Eulimidae	*Eulima victoriae*

One hundred and twenty-six biota have been recorded or presumed to be at their distributional limit in Wilsons Promontory MNP (O'Hara 2002). Sixty biota have been recorded as being at the easterly limit of their distribution in Wilsons Promontory MNP, including thirty-five algae, two shrimps, three sea stars, three sea urchins, and seventeen fish. Forty-two biota are presumed to be at their easterly limit of distribution, including sixteen algae, the seagrass *Amphibolis antarctica*, three chiton, two marine snail, one shrimp, one brittle star, one feather star and seventeen fish. Eighteen biota have been recorded as being at their western limit of distribution in Wilsons Promontory MNP, including one alga, three sea urchins, and fourteen fish. One shrimp, two brittle stars and the fish black sole are presumed to be at their western limit of distribution. One marine snail and the fish flathead congollis are presumed to be at their northern limit of distribution (O'Hara 2002). The distributional limits of the biota listed in Table 7 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 7. Marine species at their distribution limits in Wilsons Promontory Marine National Park (O'Hara 2002).

Order	Family	Species	Common name	Dist. code
Caulerpales	Caulerpaceae	*Caulerpa annulata*	green algae	RE
Caulerpales	Caulerpaceae	*Caulerpa brownii*	green algae	RE
Caulerpales	Caulerpaceae	*Caulerpa longifolia*	green algae	RE
Caulerpales	Caulerpaceae	*Caulerpa obscura*	green algae	RE
Caulerpales	Caulerpaceae	*Caulerpa simpliciuscula*	green algae	RE
Caulerpales	Caulerpaceae	*Caulerpa trifaria*	green algae	RE
Caulerpales	Caulerpaceae	*Caulerpa vesiculifera*	green algae	RE
Derbesiales	Bryopsidaceae	*Bryopsis gemellipara*	green algae	RE
Dictyotales	Dictyotaceae	*Chlanidophora microphylla*	brown algae	PE
Dictyotales	Dictyotaceae	*Dictyopteris acrostichoides*	brown algae	RW
Dictyotales	Dictyotaceae	*Dictyota diemensis*	brown algae	RE
Dictyotales	Dictyotaceae	*Distromium flabellatum*	brown algae	PE
Dictyotales	Dictyotaceae	*Pachydictyon polycladum*	brown algae	PE
Dictyotales	Dictyotaceae	*Zonaria spiralis*	brown algae	RE
Fucales	Cystoseiraceae	*Carpoglossum confluens*	brown algae	PE
Fucales	Cystoseiraceae	*Cystophora congesta*	brown algae	PE
Fucales	Cystoseiraceae	*Cystophora grevillei*	brown algae	RE
Fucales	Cystoseiraceae	*Cystophora siliquosa*	brown algae	RE
Fucales	Cystoseiraceae	*Cystophora subfarcinata*	brown algae	RE
Fucales	Fucaceae	*Xiphophora chondrophylla*	brown algae	RE
Fucales	Sargassaceae	*Sargassum decipiens*	brown algae	RE
Fucales	Sargassaceae	*Sargassum sonderi*	brown algae	RE
Fucales	Sargassaceae	*Sargassum spinuligerum*	brown algae	RE
Fucales	Seirococcaceae	*Seirococcus axillaris*	brown algae	RE
Sphacelariales	Stypocaulaceae	*Halopteris funicularis*	brown algae	RE
Sporochnales	Sporochnaceae	*Perithalia caudata*	brown algae	PE
Bonnemaisoniales	Bonnemaisoniaceae	*Ptilonia australasica*	red algae	RE
Ceramiales	Ceramiaceae	*Acrothamnion pressii*	red algae	PE
Ceramiales	Ceramiaceae	*Dasyphila preissii*	red algae	PE
Ceramiales	Ceramiaceae	*Griffithsia teges*	red algae	RE
Ceramiales	Ceramiaceae	*Heterothamnion muelleri*	red algae	PE
Ceramiales	Ceramiaceae	*Pterothamnion nodiferum*	red algae	RE
Ceramiales	Dasyaceae	*Dasya ceramioides*	red algae	RE
Ceramiales	Dasyaceae	*Thuretia australasica*	red algae	PE
Corallinales	Corallinaceae	*Lithophyllum chamberlainianum*	red algae	PE
Corallinales	Corallinaceae	*Mastophoropsis*	red algae	RE

Order	Family	Species	Common name	Dist. code
		canaliculata		
Corallinales	Corallinaceae	*Metagoniolithon radiatum*	red algae	RE
Corallinales	Corallinaceae	*Metagoniolithon stelliferum*	red algae	RE
Corallinales	Corallinaceae	*Metamastophora flabellata*	red algae	RE
Gelidiales	Gelidiaceae	*Gelidium asperum*	red algae	RE
Gigartinales	Areschougiaceae	*Areschougia congesta*	red algae	RE
Gigartinales	Areschougiaceae	*Callophycus laxus*	red algae	RE
Gigartinales	Cystocloniaceae	*Austroclonium charoides*	red algae	PE
Gigartinales	Nizymeniaceae	*Nizymenia australis*	red algae	RE
Gigartinales	Phacelocarpaceae	*Phacelocarpus alatus*	red algae	RE
Gigartinales	Phyllophoraceae	*Ahnfeltiopsis fastigiata*	red algae	PE
Gigartinales	Phyllophoraceae	*Sterogramme leptophylla*	red algae	PE
Gigartinales	Plocamiaceae	*Plocamium pressianum*	red algae	PE
Gracilariales	Gracilariaceae	*Melanthalia concinna*	red algae	RE
Gracilariales	Gracilariaceae	*Melanthalia obtusata*	red algae	RE
Rhodymeniales	Rhodymeniaceae	*Cordylecladia furcellata*	red algae	RE
Rhodymeniales	Rhodymeniaceae	*Hymenocladia chondricola*	red algae	PE
Potamogetonales	Cymodoceaceae	*Amphibolis antarctica*	seagrass	PE
Caridea	Alpheidae	*Alpheus australosulcatus*	shrimp	RE
Caridea	Crangonidae	*Aegaeon lacazei*	shrimp	PW
Caridea	Hippolytidae	*Tozeuma elongatum*	shrimp	RE
Caridea	Rhynchocinetidae	*Rhynchocinetes kuiteri*	shrimp	PE
Gastropoda	Anabathridae	*Pisinna columnaria*	marine snail	PN
Gastropoda	Anabathridae	*Pisinna frenchiensis*	marine snail	PE
Gastropoda	Anabathridae	*Pisinna tumida tumida*	marine snail	PE
Polyplacophora	Acanthochitonidae	*Notoplax speciosa*	chiton	PE
Polyplacophora	Ischnochitonidae	*Ischnochiton elongatus*	chiton	PE
Polyplacophora	Ischnochitonidae	*Ischnochiton variegatus*	chiton	PE
Asteroidea	Asterinidae	*Nepanthia troughtoni*	seastar	RE
Asteroidea	Oreasteridae	*Nectria macrobrachia*	seastar	RE
Asteroidea	Oreasteridae	*Nectria multispina*	seastar	RE
Crinoidea	Antedonidae	*Euantedon paucicirra*	feather star	PE
Echinoidea	Brissidae	*Spatagobrissus incus*	sea urchin	RW
Echinoidea	Cidaridae	*Goniocidaris impressa*	sea urchin	RE
Echinoidea	Diadematidae	*Centrostephanus rodgersii*	sea urchin	RW
Echinoidea	Spatangidae	*Spatangus luetkeni*	sea urchin	RW
Echinoidea	Temnopleuridae	*Holopneustes porosissimus*	sea urchin	RE
Echinoidea	Temnopleuridae	*Microcyphus compsus*	sea urchin	RE
Ophiuroidea	Amphiuridae	*Amphiura (Amphiura) dolia*	brittle star	PW
Ophiuroidea	Ophiotrichidae	*Ophiothrix (Placophiothrix) spongicola*	brittle star	PW
Ophiuroidea	Ophiuridae	*Ophioplocus bispinosus*	brittle star	PE
Clupeiformes	Engraulididae	*Herklotisichtchys castelnaui*	sprat	RW
Gobiesociformes	Gobiesocidae	*Genus A sp 2*	brown spotted spiny clingfish	RW
Orectolobiformes	Parascyllidae	*Parascyllium variolatum*	varied catshark	PE
Perciformes	Apogonidae	*Vincentia conspersa*	southern cardinal fish	RE
Perciformes	Bovichtidae	*Pesudaphritis sp*	flathead congolli	PN
Perciformes	Callanthiidae	*Callanthias allporti*	rosy perch	RW
Perciformes	Carangidae	*Trachurus novaezelandiae*	yellow tail horse mackeral	RW
Perciformes	Cheilodactylidae	*Nemadactylus douglassii*	blue morwong	RW
Perciformes	Chironemidae	*Chironemus georgianus*	tasselled kelpfish	RE
Perciformes	Clinidae	*Heteroclinus adelaide*	Adelaide	RE

Order	Family	Species	Common name	Dist. code
			weedfish	
Perciformes	Clinidae	*Heteroclinus eckloniae*	kelp weedfish	RE
Perciformes	Clinidae	*Heteroclinus johnstoni*	Johnstons weedfish	RE
Perciformes	Clinidae	*Heteroclinus macrophthalmus*	large eye weedfish	RE
Perciformes	Clinidae	*Heteroclinus puellarum*	little weedfish	RE
Perciformes	Clinidae	*Ophiclinops varius*	variegated snakeblenny	PE
Perciformes	Clinidae	*Ophiclinus gabrieli*	frosted snakeblenny	PE
Perciformes	Girellidae	*Girella elevata*	black drummer	RW
Perciformes	Gobiidae	*Gobiopterus semivestitus*	glass goby	RW
Perciformes	Labridae	*Achoerodus viridis*	eastern blue groper	RW
Perciformes	Labridae	*Dotalabrus aurantiacus*	pretty polly	RE
Perciformes	Mullidae	*Upeneichthys vlamingii*	red mullet	PE
Perciformes	Odacidae	*Siphonognathus attenuatus*	slender weed whiting	RE
Perciformes	Odacidae	*Siphonognathus beddomei*	pencil weed whiting	RE
Perciformes	Odacidae	*Siphonognathus caninus*	sharpnose weed whiting	RE
Scorpaeniformes	Pataecidae	*Aetapcus maculatus*	warty prowfish	RE

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

In a study assessing the conservation of reef fishes in Victoria Colton and Swearer (2009; 2010) observed 63 species of fish found around the points of Squeaky Beach, Norman and Oberon Bays. They regard seven, as species of concern as they are numerically and spatially rare at the state level (Table 8). *Sphyraena novaehollandiae*, *Latris lineate* and *Dactylophora nigricans* are targeted by fishing threat outside MPAs (Colton and Swearer 2010).

Table 8. Reef fishes of conservation concern recorded near Squeaky Beach, Norman Bay and Oberon Bay (Colton and Swearer, 2009; 2010). Species in bold are targeted for fishing outside MPAs.

Family	Species	Common name
Sphyraenidae	*Sphyraena novaehollandiae*	Australian barracuda or snook,
Pentacerotidae	*Pentaceropsis recurvirostris*	longsnout boarfish
Monacanthidae	*Scobinichthys granulates*	rough leatherjacket
Latrididae	*Latris lineate*	striped trumpeter
Hexanchidae	*Notorynchus cepedianus*	broadnose sevengill shark
Cheilodactylidae	*Dactylophora nigricans*	dusky morwong
Aracanidae	*Aracana ornata*	onate cowfish

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). Six hazards with the potential to be extreme were identified by Carey *et al*. (2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Exotic species and pathogens introduced via ballast water or recreational boating, affecting biodiversity by competing with local species (potentially all park);
2. Nutrients from untreated sewage affecting subtidal rocky reef near South East Point light station or from seepage from settling ponds at Tidal River affecting marine habitats and communities of Norman Bay (intertidal and shallow subtidal reef and soft sediments);
3. Propeller scour affecting seagrass beds and bare mudflats (subtidal soft sediments);
4. Major oil or chemical spill from vessel damaging penguins, seals and rocky intertidal habitat (intertidal reef and soft sediment, marine mammals and birds);
5. Presence of boats affecting breeding colonies of seals on Kanowna Is by increasing pup mortality (pups crushed/drowned when colony disturbed) and disruption to the social order (bulls losing territory on beach when colony disturbed) (marine mammals); and
6. High profile of MNPs leading to reduced management and/or environmental focus on surrounding marine areas, to the subsequent detriment of the MNPs (potentially all park).

The introduction of marine pests threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). One introduced species or marine pest has been recorded from the south-east of Wilsons Promontory MNP, the bryozoan *Bugula neritina* (O'Hara and Barmby 2000*)*. It is thought that the introduced green shore crab *Carcinus maenas* is also found within the MNP. The New Zealand seastar *Astrostole scabra* and screw shell *Maoricolpus roseus* have been reported in Point Hicks and Cape Howe MNPs. The Northern Pacific seastar *Asterias amurensis* was found at nearby Anderson Inlet in 2004-05 (Parks Victoria 2006b), at San Remo in 2011, and most recently in 2012 in Tidal River in the Wilsons Promontory National Park. In each case there has been a coordinated effort to eradicate these populations. Other species of particular concern include the European fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile* ssp. *fragile* (Parks Victoria 2003).

A virus affecting abalone called abalone viral ganglioneuritus has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area and has been confirmed from Discovery Bay MNP to near Cape Otway (DPI 2009). It is not in the Wilsons Promontory MNP but its spread into the park could have serious long term ecological consequences for rocky reef communities (DPI 2009).

Climate change represents a serious threat to marine ecosystems (McLeod *et al.* 2009) but specific ecological consequences of accelerating climate change are not well understood in marine systems, particularly in temperate systems. Climate change is predicted to increase water temperature, alter chemical composition (salinity, acidity and carbonate saturation), change circulation and productivity, increase frequencies of extreme weather events and exposure to damaging ultraviolet light (UVB), and increase air temperature, cloud cover and sea levels (conservatively 80 cm by 2100; CSIRO-BoM 2007; Fine and Franklin 2007; VCC

2008; McLeod *et al.* 2009). A combined increase in cloud cover and sea level could result in decreased light availability potentially changing benthic flora. Increased storm surges and ocean current changes also have the potential to change the distribution of fauna and flora and could result in loss of habitats (CSIRO-BoM 2007). Intertidal communities will face increased desiccation, storm wave exposure and habitat shift. Changes in the relationship between climate and annual life-history events may force major change in functional groups and consequent ecosystem function (Fine and Franklin 2007). Climate change is also anticipated to modify species recruitment and habitat connectivity, species interactions and disturbance regimes in the marine environment (CSIRO-BoM 2007; Fine and Franklin 2007). A large number of species are at the eastern or northern limit of their distributional range at Wilsons Promontory and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in Wilsons Promontory MNP, has increased its range down the east coast of Australia to Tasmania and that increase is thought to be linked to climate change with the EAC extending further south (Banks *et al.* 2010).

Measures to address or minimise these hazards form part of the management plan for Wilsons Promontory MNP (Parks Victoria 2006g). For example research has been conducted into the disruption of boat approach on seal colonies on Kanowna Island (Kirkwood *et al.* 2003; Patkin 2005) and management actions have been implemented to minimise these disruptions (Parks Victoria 2006g). 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 11. Old wife *Enoplosius armatus* over a *Phyllospora* bed in Wilsons Promontory Marine National Park.

2.1.6 CURRENT RESEARCH AND MONITORING

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. The research relevant to Wilsons Promontory 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 9 and Appendix 2).

Wilsons Promontory MNP does not have an ongoing intertidal reef monitoring program as it has limited intertidal reef area with relatively low human pressure. The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003) in and around the Wilsons Promontory MNP began in 1999. Since that time sites in the MNP and reference sites outside of the MNP (Figure 6) have been surveyed over ten census events (Edmunds *et al.* 2003; Lindsay and Edmunds 2006; Edmunds *et al.* 2007). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than ten metres (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water. Over 230 different species of biota have been observed during the SRMP in, and around, Wilsons Promontory MNP (Appendix 1).

Preliminary analysis of the SRMP subtidal reef monitoring data to 2006 by Keough and Carnell (2009) has assessed changes in the park since declaration by comparing subtidal reef MNP sites to reference sites outside of the MNP (Figure 6). Limitations to the preliminary analysis were the relatively short time since declaration (four years) and the corresponding small data set (Keough and Carnell 2009). Preliminary analysis found there were no significant differences in overall species richness and abundance between MNP and reference sites post-declaration of the MNP (Keough and Carnell 2009). The seastar *Patiriella brevispina* showed a convergence in abundance between MNP and non-MNP sites since declaration (Keough and Carnell 2009). The toothbrush leatherjacket *Acanthaluteres vittiger*, showed a general increase since the declaration, with a slightly greater abundance in MNP sites. Herring cale *Odax cyanomelas* also showed an effect of MNP, with a decrease in abundance in MNP sites. Magpie perch *Cheilodactylus nigripes*, blue-throated wrasse *Notolabrus tetricus* and silver sweep *Scorpis lineolata* showed differences between east and west coasts of Wilsons Promontory MNP that was unrelated to the MNP. Purple wrasse *Notolabrus fucicola* displayed an increase in the difference between MNP and non-MNP sites since declaration on the west coast, but not on the east coast (Keough and Carnell 2009).

Table 9. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Wilsons Promontory Marine National Park.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Malcolm Lindsay, Stephen Swearer, Mick Keough Developing tools for assessing ecological performance of marine protected areas.
Deakin University: Julia Back, John Arnould The physiological and behavioural response of Australian fur seals to boat disturbance: developing guidelines for boat-based eco-tourism.
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:*** Gerry Quinn, Jan Barton, Adam Pope 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.
Deakin University: John Arnould Support for research on Kanowna Island in Wilsons Prom National Park and Marine National Park.
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.
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

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). Because Wilsons Promontory MNP had minimal pressure before declaration a clear effect of the declaration might not be detected at all as any recovery may be relatively small. The major benefit of declaration in this case would be to ensure protection of the MNP area against future threats to biodiversity and natural processes. A targeted analysis of monitoring data in relation to conservation outcomes for the park will be done by 2013. The major directions for monitoring include implementing an expanded and improved monitoring program following a review of the major findings taking into account knowledge generated since park declaration (Keough *et al.* 2007; Power and Boxshall 2007; Keough and Carnell 2009).

The sessile flora and fauna of five sites on deep subtidal reefs within Wilsons Promontory MNP have been video surveyed by remote operated vehicle (ROV, Edmunds *et al.* 2009). The surveys were carried out for comparison to the biota in Port Phillip Heads as part of the

impact and recovery assessment for the Port Phillip Heads Channel Deepening Project. Five sites within Wilsons Promontory MNP, West Kanowna Is, Roaring Meg East, Southeast Landing, Church Rocks and Waterloo Bay North were surveyed in 2002 and again 2009 with the exception of Kanowna Is (Edmunds *et al.* 2009). Two more surveys are scheduled in 2013 and 2019.

Other ongoing research in Wilsons Promontory MNP include research being conducted by John Arnolds Deakin University research team focussing on the ecology of fur seal and seabird species on islands around Wilsons Promontory, in particular, Kanowna Island. Research includes the response of fur seal colonies to boats, the feeding ecology of fur seals, little penguins and other seabirds.

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 (Figure 12), and using semi-quantitative methods to determine spatial and temporal changes across the system in response to threats, including marine pests and climate change. Jan Carey, University of Melbourne, is conducting research focussing on marine pest species which may impact on park values, and the MPAs which are most at risk of invasion. This will help prioritise Parks Victoria surveillance monitoring efforts to MPAs where there is greatest potential for successful management.

2.1.7 KNOWLEDGE GAPS

Only a very small proportion of Wilsons Promontory MNP has been mapped for detailed bathymetry or substrates. No modelling of the habitats has been done so there is not an understanding of the distribution and extent of basic habitats within the MNP. No new surveys exist for the ecological communities of sandy beaches, intertidal soft sediments, with little new data on fish abundances, distributions or interactions except in shallow subtidal reef habitats. No information exists at present for water column assemblages. Major threats have been identified for Wilsons Promontory MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.

Figure 12. Red Velvetfish *Gnathanacanthus goetzeei* in Wilsons Promontory Marine National Park. Photo by Mark Norman, Museum of Victoria.

2.2 Ninety Mile Beach MNP - Twofold Shelf Bioregion

Ninety Mile Beach Marine National Park (Figure 13) is one of three MNPs in the Twofold Shelf Bioregion, which also contains Point Hicks and Cape Howe. Beware Reef Marine Sanctuary is the other Marine Protected Area in the bioregion. Ninety Mile Beach MNP is approximately 260 km east of Melbourne, 40 km south of Sale, and immediately south-west of the small town of Seaspray. It extends offshore for approximately five kilometres (three nautical miles) to the limit of Victorian waters from the high water mark along 5 km of coastline (Figure 14). Ninety Mile Beach MNP is relatively inaccessible from the land, except through private property, but is readily accessible by boat from Seaspray. It includes areas between the high and low water mark that were formerly part of McLoughlins Beach – Seaspray Coastal Reserve, reserved under the *Crown Lands (Reserves) Act 1978 (Vic.)*. Ninety Mile Beach MNP protects approximately 4 % of the Ninety Mile Beach coastline (Parks Victoria 2006e). Lake Denison, on the coast adjacent to the MNP is regionally geologically significant as an example of lake, barrier, bluff and lagoon channel evolution (Figure 14). McGaurans Beach, Merriman Creek and near Seaspray are also recognised as geologically significant.

Aboriginal tradition indicates that the Ninety Mile Beach MNP is part of the *Country* of the Gunai/Kurnai people (Parks Victoria 2006d).

Important natural values of Ninety Mile Beach MNP are its soft sediment habitat both intertidal and subtidal, and its water column that provides habitat for a diversity of marine flora and fauna species, including sessile invertebrates, algae, fish and transient whales (Parks Victoria 2006e). The MNP has extensive subtidal sandy sediments. Clumps of ascidians (mainly *Pyura australis*) occur on the sand (ECC 2000). Subtidal low calcarenite rocky reefs may occur along Ninety Mile Beach but preliminary mapping has not located the reefs within the MNP, although they may have been covered by sand (ECC 2000; Carey *et al.* 2007b; Edmunds *et al.* 2010a). Reefs in the area are dominated by invertebrates (70% coverage) and have sparse floral communities of small red algae (ECC 2000). Invertebrates include sponges, ascidians, and smaller bryozoans and hydroids (ECC 2000; Carey *et al.* 2007b).

A large endemic southern Australian seastar *Coscinasterias muricata* occurs along this coast in large numbers as well as an unusual soft coral *Pseudogorgia godeffroyi* (ECC 2000). Aggregations of juvenile white shark *Carcharodon carcharias*, snapper *Pagrus auratus*, Australian salmon *Arripis sp.,* long-finned pike *Dinolestes lewini* and short-finned pike *Sphyraena novaehollandiae* occur in the MNP (ECC 2000).

Ninety Mile Beach MNP provides important feeding and roosting habitat for several threatened bird species such as the great knot *Calidris tenuiros*, fairy tern *Sternula nereis* and little egret *Egretta garzetta*, which are listed under the *Flora and Fauna Guarantee* (*FFG*) Act (1998) and as endangered in Victoria. The MNP protects feeding areas for the fairy prion *Pachyptila turtur* which is of national environmental significance under the *Commonwealth Environment Protection and Biodiversity Conservation* (*EPBC*) *Act* (1999) and twenty species that are listed under the Japan–Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA, Parks Victoria 2006e). The threatened southern right whale *Eubalaena australis* and New Zealand fur seal *Arctophoca forsteri* use the MNP waters. Although not recorded, the leatherback turtle *Dermochelys coriacea* probably also occurs in the MNP. One species of crab, *Halicarcinus sp MoV746* is presumed to be endemic to the MNP. No marine flora or fauna are believed to be at their distributional limits within the MNP.

Serious threats to the Ninety Mile Beach MNP include limited ecological knowledge of important processes. Human disturbance of shorebirds, invasive marine pests; benthic

fishing adjacent to the MNP, introduced pathogens via fish bait; 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 Ninety Mile Beach MNP (Parks Victoria 2006d). Specific research aims to increase ecological knowledge about the natural values of, and threats to Ninety Mile Beach MNP.

Figure 13. Intertidal soft sediment of Ninety Mile Beach Marine National Park

2.2.1 PHYSICAL PARAMETERS & PROCESSES

Ninety Mile Beach MNP is 2650 hectares in size which makes it the 9th largest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 10, Figure 14). The shoreline geology is quartzose sands (Bird 1993). Subtidal soft sediment is recent Holocene sand (< 10 000 years ago) consisting of a mixture of fine and medium sand with some silt, gravelly sand and shell, with a low carbonate content of 14 to 19 % (ECC 2000). The MNP is off shore from Ninety Mile Beach, a large NE-SW orientated beach that extends from Corner Inlet to Red Bluff, broken only by the artificial entrance at Lakes Entrance, and is part of a major barrier system that fronts the Gippsland Lakes. The coast adjacent to Ninety Mile Beach MNP has a narrow single dune barrier unlike the broader, three barrier systems to the east. The beach is steep faced and high energy (Parks Victoria 2006e). The MNP is on the Gippsland Shelf which is one of the most extensive areas of shallow water on the Victorian coast. The seafloor of the park drops away to 25 metres in depth and the majority of the park is between 15 to 20 metres depth.

Surface water temperatures average 18 °C in the summer and 13 °C in the winter. The MNP is influenced by the warmer waters of East Gippsland and the cooler waters of Bass Strait. Consequently the area has some of the flora and fauna of both areas (ECC 2000). Tidal currents run parallel to the coast and follow a semi-diurnal pattern (Parks Victoria 2006e).

Tidal variation is 0.9 metres for spring tides and 0.6 metres for neap tides (Plummer *et al.* 2003). Strong tidal currents (2 to 2.5 knots) are characteristic of this area (ECC 2000). The area is protected from south-westerly swells by Tasmania but is strongly influenced by south-easterly and easterly swells heights of 1.0 – 1.5 m, with maximum heights varying between 1.9 and 2.7 m (LCC 1993). The combination of these tidal currents and high energy swells result in well-mixed coastal waters (ECC 2000). Wave action is the main source of beach erosion in the park (Parks Victoria 2006e). Wind patterns also influence hydrodynamics, with south-westerly winds dominating in winter, resulting in an overall north-easterly movement of water and sand along the coast (ECC 2000).

Three waterways and one saline waste water outfall discharge into the sea in the vicinity of the park (Parks Victoria 2006e). Merriman Creek discharges intermittently into the sea approximately 500 m north-east of the park, and the overflow from Lake Dennison, locally known as 'The Fisheries', very occasionally discharges approximately three kilometres to the south-west of the park boundary (Parks Victoria 2006e). Mason Creek runs directly into the park (Table 10). The saline water outfall is associated with electricity production from the Latrobe Valley and discharges 4 km south-west of the MNP at McGaurans Beach (Parks Victoria 2006e).

Table 10. Physical attributes of the Ninety Mile Beach Marine National Park.

Park Name	**Ninety Mile Beach**
Conservation status	Marine National Park
Biophysical Region	Twofold Shelf
Size	2650 ha (ranked 9th of 24)
Length of adjacent coastline	~ 5 km
Shoreline geology	Quartzose sands
Area with depth:	
< 5 m	136 ha
5 - 10 m	168 ha
10 - 20 m	2085 ha
20 - 30 m	261 ha
Mean tidal variation - spring	0.9 m
Mean tidal variation - neap	0.6 m
Mean water temp - summer	18 ^{o}C
Mean water temp - winter	13 ^{o}C
Adjacent catchment	Agricultural, Urban
Discharges into MNP	Mason Creek and drain.
Nearest major estuary (distance & direction)	Merriman Creek 5.5 km northeast of MNP

2.2.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. The main habitats present in Ninety Mile Beach MNP (Figure 15) include intertidal soft sediment, extensive subtidal soft sediment, and the water column (Parks Victoria 2006e).

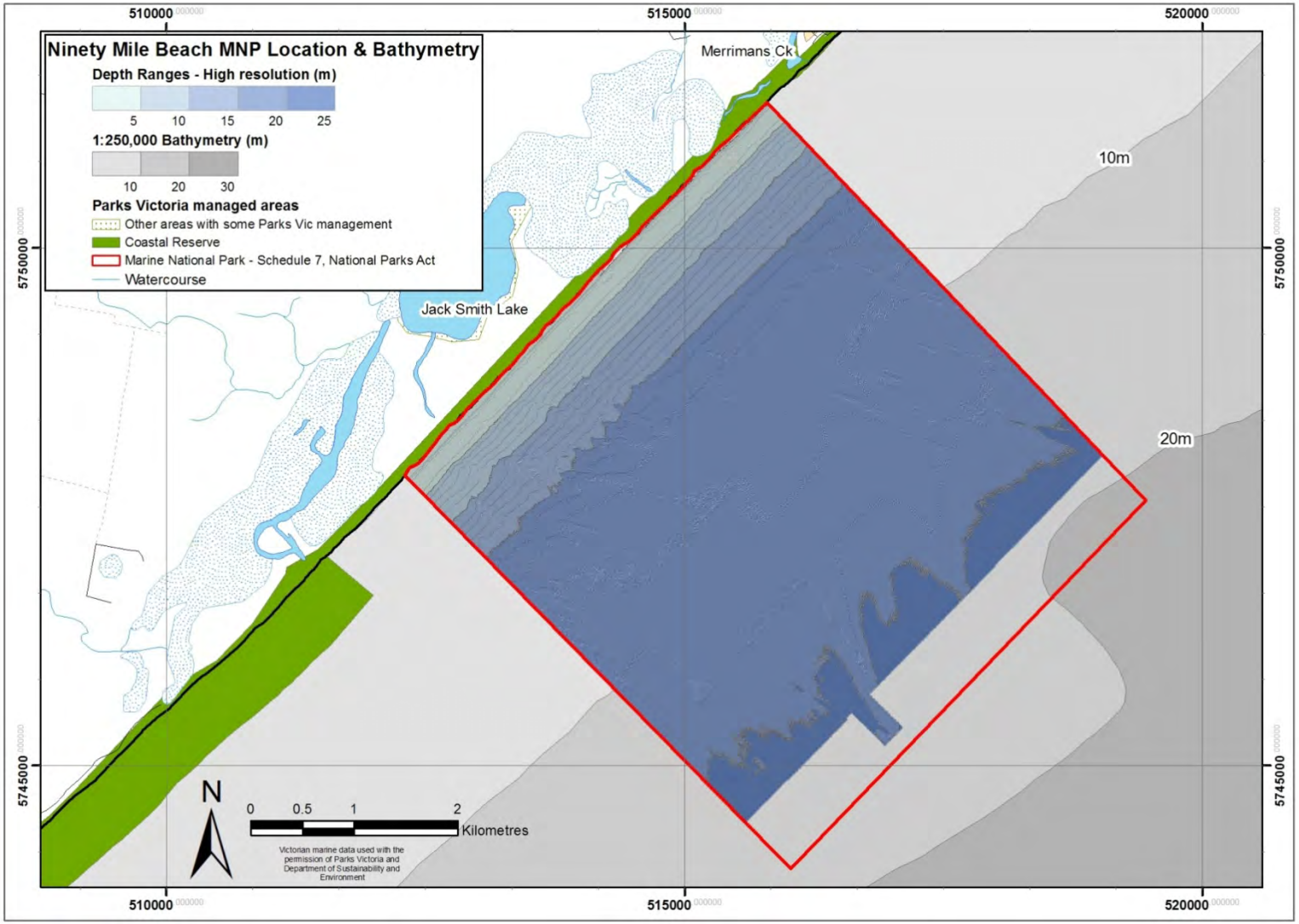


Figure 14. Location map of Ninety Mile Beach Marine National Park with 1:250,000 bathymetry. Subtidal reef monitoring sites inside and outside the MNP are shown, there are no monitoring sites.

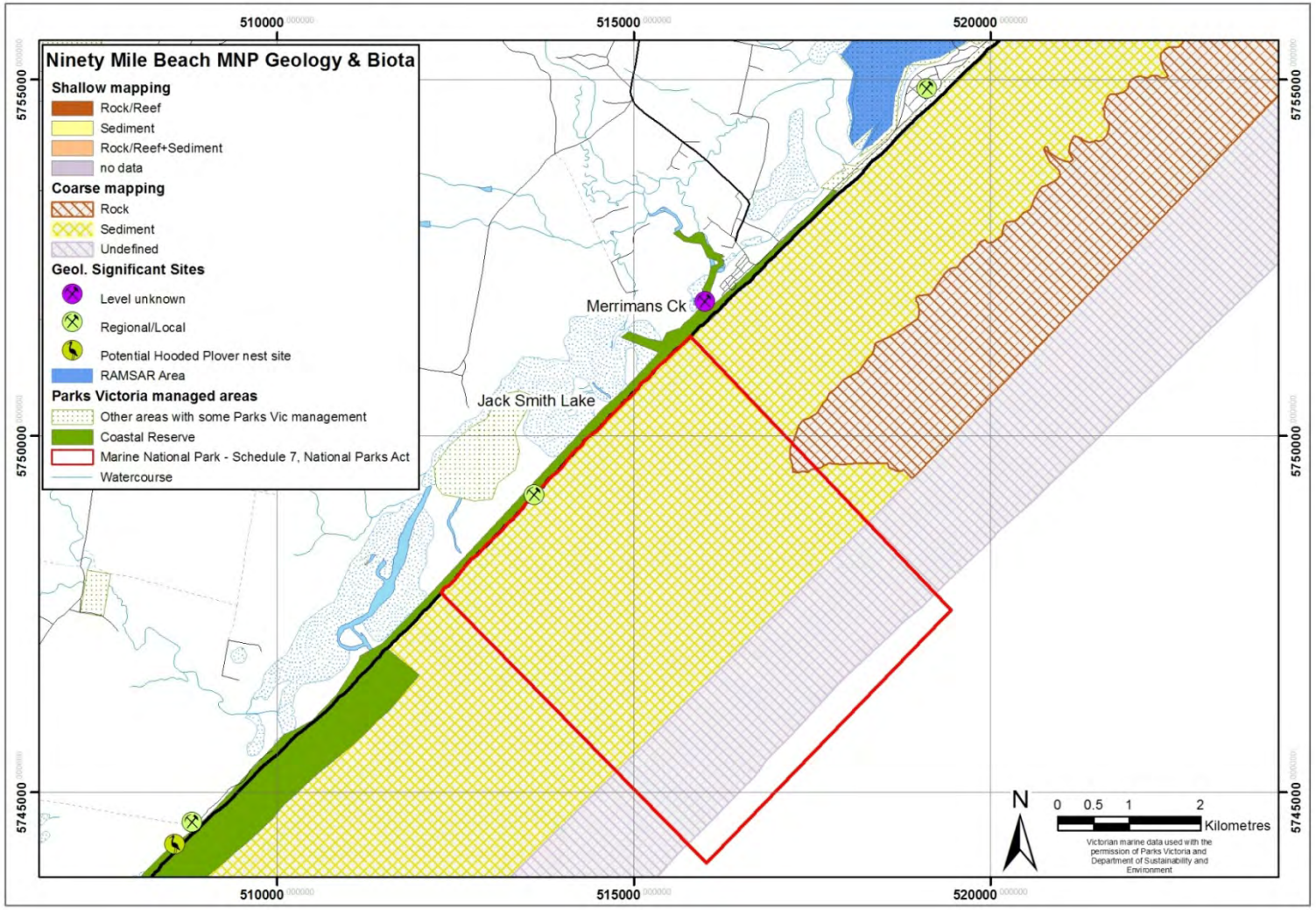


Figure 15. Location of habitat types based on coarse geology mapping. Geological and biological sites of significance for Ninety Mile Beach Marine National Park also indicated.

2.2.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) there has been limited further research or mapping surveys in Ninety Mile Beach MNP. There has been broadscale bathymetric mapping, with the intertidal and shallow subtidal areas mapped by aerial LiDAR surveys. There have been no surveys of the pelagic habitats.

No new surveys of biota have been done in the MNP since declaration. Our knowledge of biota found in Ninety Mile Beach MNP is limited to large fauna such as birds and mammals (Appendix 1). Forty-nine species of birds and over six species of marine mammals have been recorded in or in the immediate surrounds of the MNP.

Intertidal

Soft sediment

The intertidal soft sediment is in the north of Ninety Mile Beach MNP as a high-energy steep-faced, coarse-grained sandy beach fronting an extensive dune barrier system. The intertidal sand communities at McGaurans and Woodside Beaches to the west of the MNP are species-poor (LCC 1993). Between 1983 and 1990 eight surveys were conducted at these beaches and found low biodiversity (nine species per sample) and dominated by isopods, with bivalves, polychaetes, amphipods and insect larvae (LCC 1993). Bivalves (such as pipis) and worms are known to occur in the sand in the lower intertidal area (LCC 1993).The abundance of beach infauna was also low (5 to 102 m^2), with invertebrate populations on both beaches being extremely variable, fluctuating considerably between years. This is typical of these types of beaches.

Flora is restricted to macroalgae drift and macroalgal epiphytes. Beach-washed materials in sandy beach habitats are a significant source of food for scavenging birds, and contribute to the detrital cycle that nourishes many of the invertebrates, such as bivalves, living in the sand.

Reef

There is no intertidal rocky reef in the Ninety Mile Beach MNP.

Subtidal

Soft sediment

Invertebrate species diversity of subtidal soft sediment in the Orbost region at the eastern end of Ninety Mile Beach is regarded as one of the most biologically diverse marine environments in the world (Coleman *et al.* 1997). Invertebrate diversity in East Gippsland was therefore higher compared to the rest of the Victorian coastline and was generally greater with depth (Coleman *et al.* 2007; Heislers and Parry 2007). A transect east of the MNP was sampled with 0.1 m^2 grab samples in 10 and 40 m of water depth. The shallow sediment was fine sand and deep was medium sand (Coleman *et al.* 2007). The grab samples contained between 260 to 430 individuals and 36 to 72 species (Coleman *et al.* 2007). Crustaceans were the dominant taxa in both depth classes, representing more than 13 of the 21 most abundant families (Heislers and Parry 2007). Ten families were common in both depth classes (Heislers and Parry 2007). These organisms live in or on the sand and their ecological relationships are poorly known, except that they are a key component of the local food web and that their population dynamics are extremely variable (Parks Victoria 2006e).

No information on nearshore fish is available from within the MNP, but recreational fishing guides indicate that Seaspray Beach, (just east of the MNP), is known for populations of Australian salmon *Arripis* sp*.,* snapper *Pagrus auratus*, tailor *Pomatomus saltatrix* and

flathead (Plummer *et al.* 2003). Newborn pups of gummy sharks *Mustelus antarcticus* inhabit shallow inshore areas and there is some evidence to suggest that the inshore sandy areas east of Wilsons Promontory, including Ninety Mile Beach MNP, may be important feeding areas for gummy shark pups (Plummer *et al.* 2003).

Reef

Subtidal low calcarenite rocky reefs occur along Ninety Mile Beach but preliminary mapping has not located the reefs within the MNP, although they may have been covered by sand (ECC 2000; Carey *et al.* 2007b; Edmunds *et al.* 2010a). Reefs in the area are dominated by invertebrates (70 % coverage) and have sparse floral communities of small red algae (ECC 2000). Invertebrates include sponges, ascidians, and smaller bryozoans and hydroids.

Water column

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

2.2.4 SPECIES OF CONSERVATION SIGNIFICANCE

The approach of managing MNPs for their marine ecological communities, rather than threatened species, is also likely to protect and enhance threatened species populations (Power and Boxshall 2007). Whole-of-habitat management may also result in the protection of species not yet identified because of their rarity or cryptic nature (Power and Boxshall 2007). There are no listed sites of biological significance in the MNP.

Flora

No conservation listed marine flora has been recorded in Ninety Mile Beach MNP (Parks Victoria 2006e).

Fish

No conservation listed fish have been recorded at Ninety Mile Beach MNP or its immediate surrounds.

Birds

Twenty-eight conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Ninety Mile Beach MNP (Table 11). Nineteen are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Three, the great knot *Calidris tenuiros*, fairy tern *Sternula nereis* and little egret *Egretta garzetta* are regarded as endangered. One bird the fairy prion *Pachyptila turtur* is listed as vulnerable at both the state and national level. Twenty birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or

Japan (JAMBA). Hooded plovers *Thinornis rubricollis* are thought to nest outside of the MNP at McLoughlins Beach in the Seaspray Coastal Reserve (Figure 15).

Table 11. Conservation listed shorebird and seabird records from Ninety Mile Beach Marine National Park and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
fairy prion	*Pachyptila turtur*		VU	VU		J
great knot	*Calidris tenuirostris*	L	EN		C	J
eastern great egret	*Ardea modesta*	L	VU		C	J
little tern	*Sternula albifrons*	L	VU		C	J
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
fairy tern	*Sternula nereis*	L	EN			
little egret	*Egretta garzetta*	L	EN			
hooded plover	*Thinornis rubricollis*	L	VU			
Pacific golden plover	*Pluvialis fulva*		NT		C	J
red knot	*Calidris canutus*		NT		C	J
Latham's snipe	*Gallinago hardwickii*		NT		C	J
grey plover	*Pluvialis squatarola*		NT		C	J
white-winged black tern	*Chlidonias leucopterus*		NT		C	J
red-necked stint	*Calidris ruficollis*				C	J
curlew sandpiper	*Calidris ferruginea*				C	J
bar-tailed godwit	*Limosa lapponica*				C	J
sharp-tailed sandpiper	*Calidris acuminata*				C	J
common greenshank	*Tringa nebularia*				C	J
sooty shearwater	*Ardenna grisea*				C	J
common tern	*Sterna hirundo*				C	J
marsh sandpiper	*Tringa stagnatilis*				C	J
short-tailed shearwater	*Ardenna tenuirostris*					J
royal spoonbill	*Platalea regia*		VU			
Pacific gull	*Larus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
nankeen night heron	*Nycticorax caledonicus*		NT			
white-fronted tern	*Sterna striata*		NT			

Marine mammals and reptiles

The marine mammals recorded in the MNP are transient and include the southern right whale *Eubalaena australis* that is listed as critically endangered in Victorian waters and endangered nationally, Australian fur seals *Arctocephalus pusillus doriferus* and the state vulnerable New Zealand fur seals *Arctophoca forsteri* (Table 12). Five listed marine reptiles occur as vagrants along the eastern Victorian coast and probably occur in the waters of the MNP include the loggerhead turtle *Caretta caretta*, green turtle *Chelonia mydas*, Pacific ridley *Lepidochelys olivacea*, leatherback turtle *Dermochelys coriacea*, and yellow-bellied sea snake *Pelamis platurus* (Plummer *et al.* 2003).

Table 12. Conservation listed marine mammal and reptile records from Ninety Mile Beach Marine National Park and surrounds.

		Victorian listing		National listing	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**AROTS**
southern right whale	*Eubalaena australis*	L	CR	EN	EN
New Zealand fur seal	*Arctophoca forsteri*		VU	L	
Australian fur seals	*Arctocephalus pusillus doriferus*			L	

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

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that the Brachyura crab *Halicarcinus* sp. *MoV746* was presumed to be endemic to the Ninety Mile Beach area including the MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000). No biota have been recorded or presumed to be at their distributional limit in Ninety Mile Beach MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000; Plummer *et al.* 2003).

2.2.5 MAJOR THREATS

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 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). Four hazards with the potential to be extreme were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Visitor activities on shore within the park (*e.g.* dune buggies, dogs off-lead) affecting the feeding and roosting of shorebirds (intertidal soft sediment);
2. Introduction of exotic marine species via ballast water or hull fouling, recreational boating, or natural dispersal from adjacent waters, and resulting in displacement of native species (all of park especially soft sediment);
3. Trawling or scallop dredging affecting subtidal soft sediment and reef (*i.e.* benthic) habitats (subtidal soft sediment); and
4. Introduction of pathogens via fish bait or berley for either commercial or recreational fishing (but probably largely recreational) affecting local species (all of park especially soft sediment).

Native vegetation has been largely removed from the dunes behind the beach and replaced with Marram Grass (Parks Victoria 2006e; Figure 16). This has contributed to the formation of a high, single-ridge dune along Ninety Mile Beach which is more susceptible to wind and wave erosion. The changing dune structure has resulted in a beach face that is frequently

inundated by wave action right up to the dune base, reducing the beach's suitability for shore-nesting birds (Parks Victoria 2006e). Illegal vehicle access on and through the dunes has contributed to blowouts in areas adjacent to the park (Parks Victoria 2006e).

Figure 16. Steep dunes bordering Ninety Mile Beach Marine National Park

The introduction of marine pests threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). No known introduced species have been recorded in the MNP (Parks Victoria 2006e). Because of the park's inaccessibility and associated difficulty in conducting regular, detailed surveys, incursions of marine pests are unlikely to be detected until they are fully established and beyond potential control (Parks Victoria 2006e). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). Species of particular concern include the Northern Pacific seastar *Asterias amurensis*, European fanworm *Sabella spallanzanii*, broccoli weed *Codium fragile (subsp. fragile)* and screw shell *Maoricolpus roseus* (Parks Victoria 2003).

The screw shell has been recorded south-east of Ninety Mile Beach MNP in Point Hicks MNP and Corner Inlet (Parks Victoria 2006e; Heislers and Parry 2007; Holmes *et al.* 2007a). It is a 5 cm long gastropod introduced to Tasmania from New Zealand in the 1920s (Bax *et al.* 2003). It has now spread out to the 80 m depth contour off the eastern Victorian and New South Wales coasts (Patil *et al.* 2004). The dense beds of this invasive species change the benthic structure with unknown (and unexamined) effects on ecosystem services (Patil *et al.* 2004). In Point Hicks MNP where this invasive species was most abundant, the diversity of infauna was reduced, suggesting that this exotic species poses a serious threat to the high diversity of infauna that is characteristic of much of Bass Strait (Heislers and Parry 2007).

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

Measures to address or minimise these hazards form part of the management plan for Ninety Mile Beach MNP (Parks Victoria 2006e). Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

2.2.6 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 Ninety Mile Beach MNP has been published in Parks Victoria's Technical Series available on Parks Victoria's website (http://www.parkweb.vic.gov.au). As most research in the MNP has been carried out under permits issued by DSE, the permit database was also used to identify relevant projects for this report (see Table 13 and Appendix 2).

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. The University of Melbourne is also investigating and assessing water quality issues affecting natural values in all MPAs.

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

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

2.2.7 KNOWLEDGE GAPS

No new surveys exist for the ecological communities of sandy beaches, intertidal or subtidal soft sediments. There is little data on fish abundances, distributions or interactions. No information exists at present for water column communities. Major threats have been identified for Ninety Mile Beach MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.

2.3 Point Hicks MNP – Twofold Shelf Bioregion

Point Hicks is one of three Marine National Parks in the Twofold Shelf bioregion, which also contains Ninety Mile Beach and Cape Howe MNP. Other conservation areas are Gippsland Lakes and Cape Conran Coastal Parks. Point Hicks MNP is approximately 450 km east of Melbourne, 68 km east of Orborst and 25 km south-east of Cann River. It adjoins Point Hicks Lighthouse Reserve and the Croajingolong National Park. It extends offshore to state limits from high water mark along 9.6 km of coastline from two kilometres east of Clinton Rocks to Stable Bay (Figure 17). It includes Whaleback Rock and Sensation Reef. Point Hicks MNP is accessible by a short walk from Point Hicks Road, or less readily by boat (Parks Victoria 2006f). The reef directly below Point Hicks (formerly known as Cape Everard), Whaleback Rock and Satisfaction Reef are the best-known geological features of the park (Parks Victoria 2006f). The area of coast between Point Hicks and Thurra River is a site of State geological and/or geomorphological significance because of its important dune stratigraphic sequence.

Aboriginal tradition indicates that the Point Hicks MNP is part of the *Country* of the Bidawal people and Gunai/Kurnai people and that other Aboriginal people including the Monero-Ngarigo people also have an association with the coastal region of this area (Parks Victoria 2006e).

Important natural values of Point Hicks MNP are its granite intertidal and shallow and deep subtidal rocky reefs, sandy shores and open oceans that provide habitat for a diversity of marine flora and fauna species, including sessile invertebrates, algae, fish and transient whales (Parks Victoria 2006f). Shallow rocky reef habitats have varied forms, from flat platform reefs bordered by sand, pinnacles and bombies, gutters, large boulders rising to six metres to clusters of smaller rocks and stones (ECC 2000; Carey *et al.* 2007b; Edmunds *et al.* 2010a). They are highly exposed, which is reflected in the types of kelp habitats present (Edmunds *et al.* 2010a). Deep subtidal reef characteristics have not been fully described (Edmunds *et al.* 2010a). The MNP also has extensive subtidal soft sediments of variable grainsize, with a low carbonate content (Carey *et al.* 2007b). Very high faunal species richness, including intertidal and shallow subtidal invertebrates have been recorded in the MNP (ECC 2000). Eastern temperate and southern cosmopolitan species co-occur, as a result of the mixing of warm eastern and cool southern waters (Parks Victoria 2006f). The marine flora and fauna of the subtidal reefs are spectacular with colourful and diverse sessile invertebrates (Carey *et al.* 2007b). A notable feature are the front reefs and Whaleback Rock, which have high relief gutters of 1 - 15 m and a high area of sessile invertebrate habitat on the vertical walls (O'Hara 2000).

An important characteristic of Point Hicks MNP is its canopy forming algae and small understorey algae (ECC 2000; Carey *et al.* 2007b). The stands of canopy forming algae are generally a mixture of crayweed *Phyllospora comosa* and common kelp *Ecklonia radiata*, with the proportions of these two species varying according to the habitat, depth and location (Williams *et al.* 2007; Edmunds *et al.* 2010b). The reef beneath the canopy varies from encrusting and erect sponges to small fleshy red algae (Parks Victoria 2003). The *Phyllospora* invertebrate community includes relatively high abundances of the predatory whelk *Cabestana spengleri* and the seastar *Patiriella calcar,* and moderate abundances of blacklip abalone *Haliotis rubra* and the red bait crab *Plagusia chabrus* (Parks Victoria 2003; Edmunds *et al.* 2005; Williams *et al.* 2007). The herbivorous sea urchin *Centrostephanus rodgersii* can remove all erect algae to create 'urchin barrens' on the reefs in the MNP (Williams *et al.* 2007).

Fish assemblages at Point Hicks MNP are a mixture of cool southern and warm eastern species. They are dominated by large numbers blue throat wrasse *Notolabrus tetricus* and

purple wrasse *Notolabrus fucicola* (Edmunds *et al.* 2010b). Other fish species include the banded morwong *Cheilodactylus spectabilis,* sea sweep *Scorpis aequipinnis,* Maori wrasse *Ophthalmolepis lineolata*, one-spot puller *Chromis hypsilepis* and white-ear damselfish *Parma microlepis* (Parks Victoria 2003). The eastern blue grouper *Achoerodus viridis* is also a prominent species, but present in low numbers (Parks Victoria 2003).

Point Hicks MNP provides important feeding and roosting habitat for several threatened bird species such as the hooded plover *Thinornis rubricollis*, little egret *Egretta garzetta* and fairy tern *Sternula nereis* which are listed under the *Flora and Fauna Guarantee* (*FFG*) Act (1998). The latter two are regarded as endangered. The MNP protects feeding areas for species of national environmental significance under the *Commonwealth Environment Protection and Biodiversity Conservation* (*EPBC*) *Act* (1999) and species that are listed under the Japan–Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA, Parks Victoria 2006f). The conservation listed southern right *Eubalaena australis* and humpback whale *Megaptera novaeangliae,* killer whale *Orcinus orca* and whale shark *Rhincodon typus* use the MNP waters. The leopard seal *Hydrurga leptonyx* have been observed in the waters in and around the MNP. Although not recorded the leatherback turtle *Dermochelys coriacea* probably also occurs in the MNP. Eleven species of marine flora and fauna are believed to be at their eastern or western distributional limits within the MNP.

Serious threats to the Point Hicks MNP include limited ecological knowledge of important processes. Invasive marine pests from commercial and recreational boats; poaching of abalone; 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 Point Hicks MNP (Parks Victoria 2006f). Ongoing intertidal and subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Point Hicks MNP.

2.3.1 PHYSICAL PARAMETERS & PROCESSES

Point Hicks MNP is 3810 hectares in size which makes it the 5th largest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 14, Figure 17). Point Hicks promontory is granite with a wide rocky and bouldery shore, which includes some metamorphic outcrops west of the lighthouse (Bird 1993). Sandy beaches flank the headland backed by extensive dunes (Figure 18). The seabed has a relatively steep gradient with reef descending into deeper water relatively close to shore (Ball and Blake 2007). The subtidal reef consists of granite slopes, boulders and outcrops (Williams *et al.* 2007). The seafloor of the park drops away rapidly to 88 metres in depth (Holmes *et al.* 2007a). Greater than 80% of the MNP is >20 m depth. Prevailing winds and swells are generally from the south-west and north-east (Parks Victoria 2006f). Most of the subtidal reef in Point Hicks MNP is highly exposed to westerly swell and seas (Williams *et al.* 2007). The coastline is influenced by high energy waves and twice daily tides. Tidal variation is 0.9 metres for spring tides and 0.6 metres for neap tides (Plummer *et al.* 2003). Surface water temperatures average 19° C in the summer and 14 °C in the winter. The MNP is influenced by both cool southern waters and the warm East Australian Current. The continental slope is quite close and cold-water upwellings are frequent (Williams *et al.* 2007). These upwellings provide nutrients to the inshore ecosystems, contributing to high productivity (Williams *et al.* 2007). No estuaries or intermittent creeks run directly into the park (Table 14).

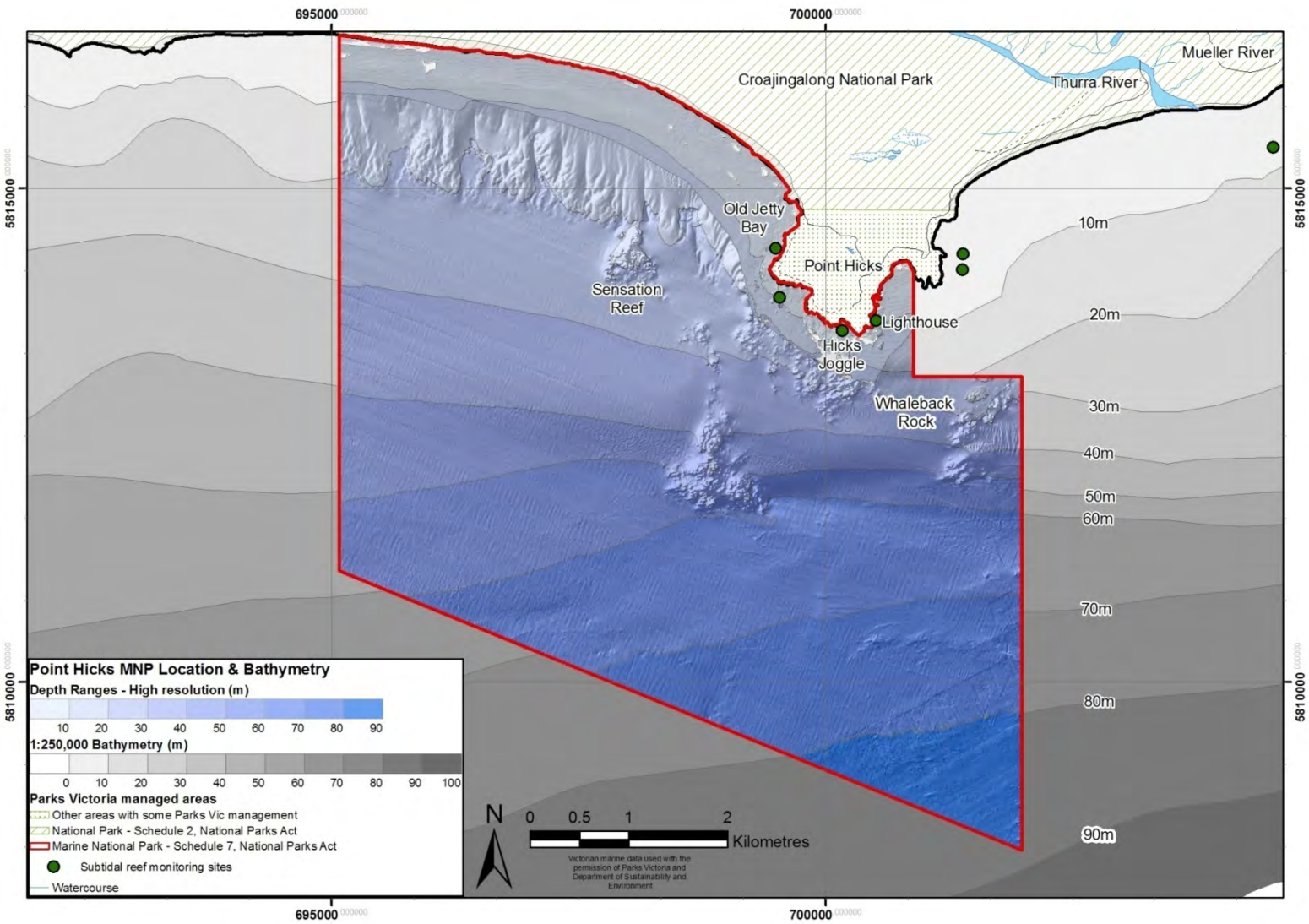


Figure 17. Location map of Point Hicks Marine National Park with high resolution bathymetry. Subtidal reef monitoring sites inside and outside the MNP are shown, there are no intertidal monitoring sites.

Table 14. Physical attributes of the Point Hicks Marine National Park.

Park Name	Point Hicks
Conservation status	Marine National Park
Biophysical Region	Twofold Shelf
Size	3810 ha (ranked 5th of 24)
Length of coastline	~ 9.6 km
Shoreline geology	Granite and sand
Area with depth:	
0 - 10 m	307 ha
Comprising <5 m (high res)	*(159 ha)*
5 – 10 m (high res)	*(138 ha)*
*0 – 10 m (low res)**	*(10 ha)*
10-20 m	372 ha
20-30 m	583 ha
30-40 m	530 ha
40-50 m	366 ha
50-60 m	425 ha
60-70 m	597 ha
70-80 m	441 ha
80-90 m	168 ha
Mean tidal variation - spring	0.9 m
Mean tidal variation - neap	0.6 m
Mean water temp - summer	19
Mean water temp - winter	14
Adjacent catchment	Croajingolong National Park
Discharges into MNP	None
Nearest major estuary (distance & direction)	Tamboon Inlet 6.4 km west Thurra 3.2 km east Mueller 4.3 km east

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

2.3.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. The main habitats present in Point Hicks MNP include some intertidal soft sediment and reef, extensive subtidal soft sediment, subtidal reef, and the water column (Parks Victoria 2006f). The majority of the intertidal and subtidal habitat of the Point Hicks MNP has been mapped by remote sensing and detailed acoustic surveys. The intertidal and shallow subtidal (to 22 m) habitats were mapped from 2004 aerial photography (Figure 18) and satellite imagery (Ball and Blake 2007). The shallow subtidal habitat was ground truthed by underwater video in 2005. In 2004/2005 the deep (> 10 m) subtidal substrate and biota was surveyed and mapped acoustically (Figure 19 & Figure 20) by Holmes *et al.* (2007a). Underwater video transects allowed the substrate and biota to be predictively modelled for the areas not surveyed.

The coast of Point Hicks MNP is mostly bare sandy sediment with a band of high profile reef extending from a narrow intertidal rock platform around the base of Point Hicks itself (Figure 17 and 18). The majority of the intertidal habitat is sandy beach fronting an extensive dune system in the west of the MNP (Ball and Blake 2007). The subtidal reef is mostly continuous close to shore, becoming more patchy moving offshore (Ball and Blake 2007). It consists of granite slopes, boulders, rock gullies and outcrops (Williams *et al.* 2007). Some areas of boulders and cobble are interspersed with sand (Williams *et al.* 2007). The main biotic habitat is tall crayweed *Phyllospora comosa* and common kelp *Ecklonia radiate* (Williams *et al.* 2007). Underneath this canopy there is a highly diverse cover of fleshy red thallose algae (Williams *et al.* 2007). Giant kelp *Macrocystis pyrifera* can also occur adding to the vertical habitat structure (Williams *et al.* 2007).

The majority of the subtidal sediment (Figure 19) is flat medium sand or coarse gravel made up of shells or shell fragments (Holmes *et al.* 2007a). Sediment as mapped by Holmes *et al.* (2007a) covered 33 sq. km and reef outcrops in nearshore shallower water < 55 m, covered 1 sq. km. Nearly half of the mapped sediment had no identifiable biota living on it. The rest has sparse macroalgae *Caulerpa* and sessile invertebrates (*e.g.* Figure 22) predominately sponges (Holmes *et al.* 2007a). Sessile invertebrates are common from approximately 30 m depth (Figure 20), and sparse *Caulerpa* is modelled as present over an extensive band at moderate water depths (Holmes *et al.* 2007a).

Figure 18. Aerial view of the coast of Point Hicks Marine National Park (QASCO 20/01/04). Photography ortho-rectified by PIRVic. Figure from Ball and Blake (2007).

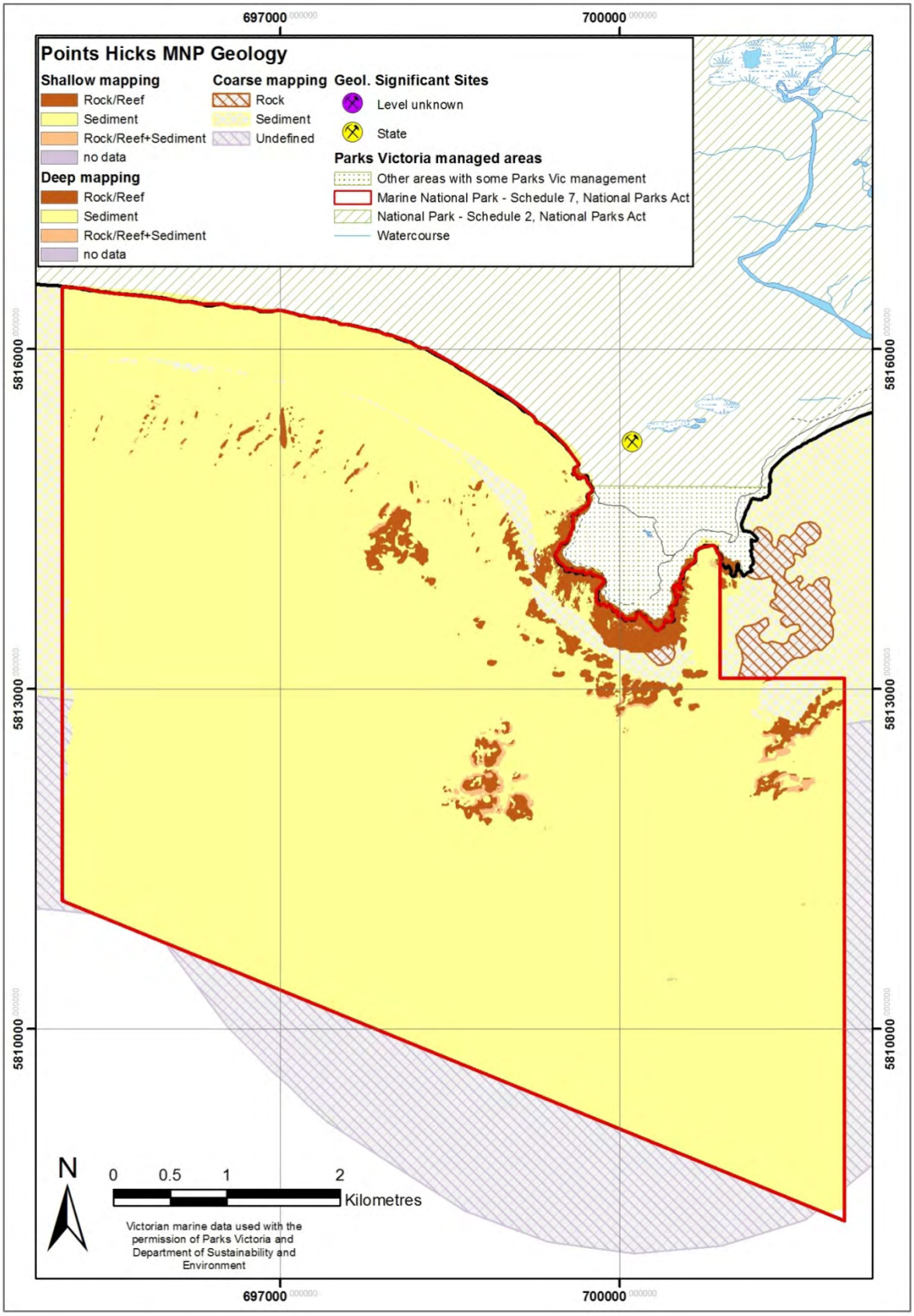


Figure 19. Substrate mapping of Point Hicks Marine National Park showing sites of geological significance.

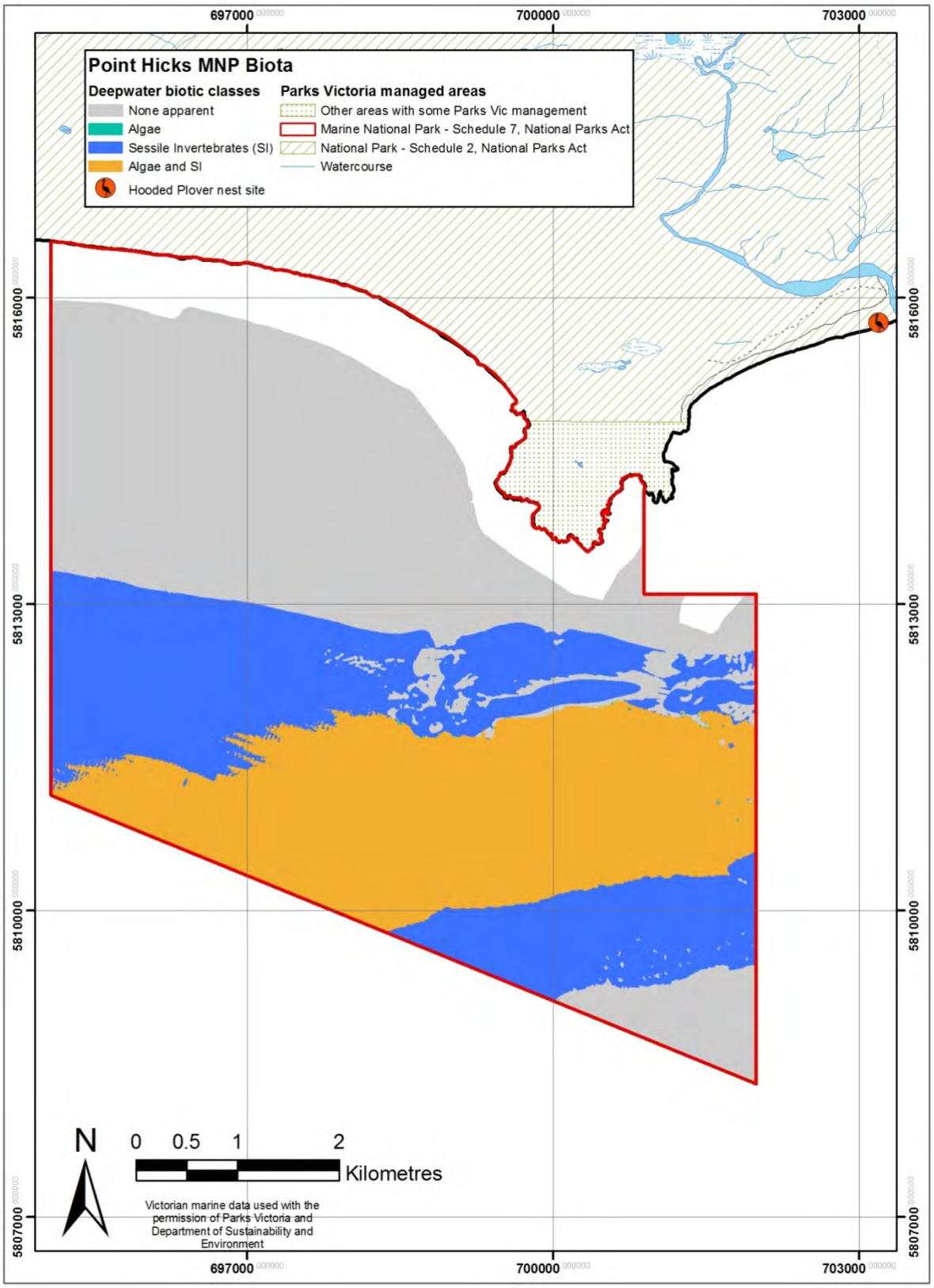


Figure 20. Biota mapping of Point Hicks Marine National Park showing sites of biological significance.

Figure 21. Sponge garden in Point Hicks Marine National Park. Photo by Mark Norman Museum of Victoria.

2.3.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in extensive monitoring and mapping surveys in Point Hicks MNP. There has been broadscale habitat mapping, with the intertidal and shallow subtidal areas mapped from aerial and satellite imagery (Ball and Blake 2007) and the deep subtidal areas with hydroacoustic surveys (Holmes *et al.* 2007a). There have been four SRMP surveys of the shallow subtidal reef biota of Cape Howe which are summarised by Williams *et al.* (2007) and Edmunds *et al.* (2010b). Additional funding has allowed samples from deep subtidal soft sediment surveyed in the MNP in 1998 to be processed and identified (Heislers and Parry 2007). There have still been no surveys of sandy beaches, the biota of intertidal reefs or the pelagic habitats. Important locations for some birds and mammals are shown in Figure 20. Surveys in the MNP found red and brown algae dominate the diversity of macrophytes, gastropods and echinoderms the invertebrates and fish and birds the vertebrates in Point Hicks MNP (Table 15, Appendix 1).

Table 15. Summary of the number of species in major biotic groups from surveys in Point Hicks Marine National Park.

Biotic group	Number of species
Macrophytes	**43**
Green algae	3
Brown algae	20
Red algae	19
Seagrasses	1
Invertebrates	**43**
Sponges	0
Cnidaria	0
Polychaetes	0
Barnacles	0
Decapod crustaceans	4
Sea spiders	0
Chitons	2
Gastropods	22
Bivalves	0
Sea slugs	1
Cephalopods	0
Echinoderms	14
Vertebrates	**106**
Fish	46
Birds	54
Reptiles	1
Mammals	5

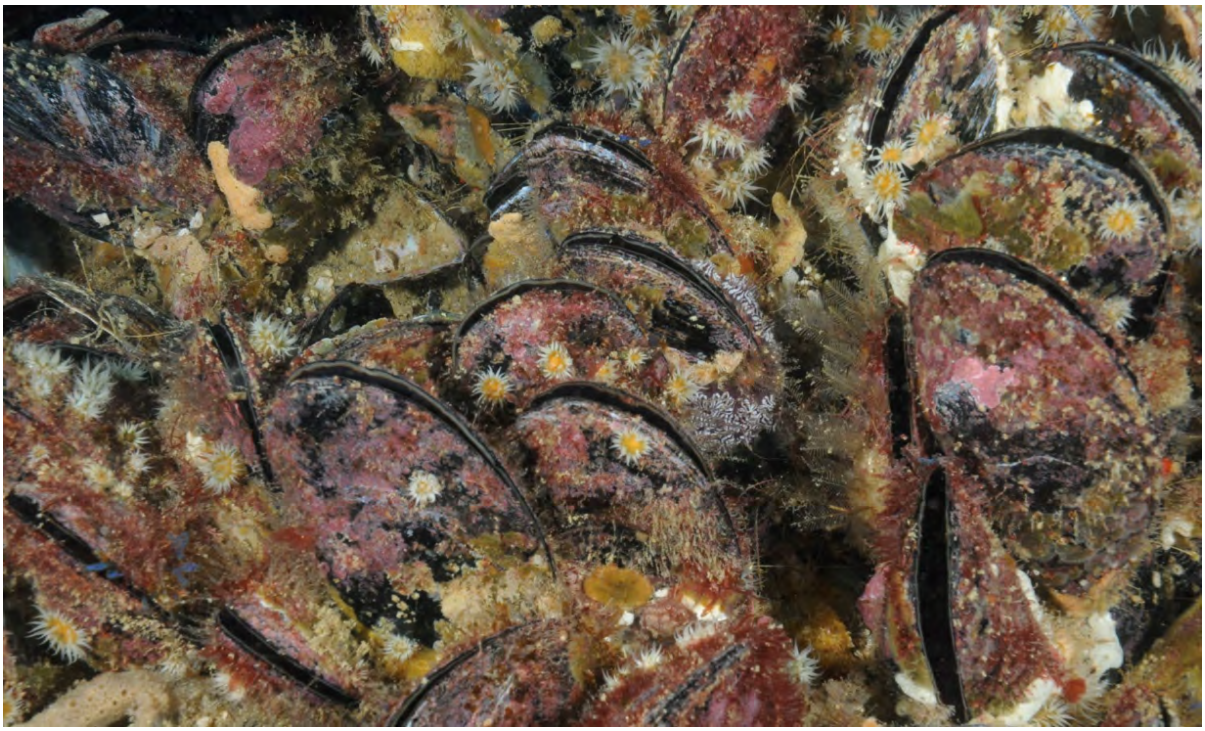


Figure 22. Blue mussels *Mytilus edulis* on subtidal reef in Point Hicks Marine National Park. Photo by Mark Norman Museum of Victoria.

Intertidal

Soft sediment

The intertidal soft sediment is in the north-west of Point Hicks MNP as sand beach fronting an extensive dune system (Ball and Blake 2007). As noted by Plummer *et al.* (2003) no specific data on the biota on sandy beaches are available in the MNP or nearby. Intertidal soft sediment flora is restricted to macroalgae drift and macroalgal epiphytes. Beach-washed materials in sandy beach habitats are a significant source of food for many shore birds, and contribute to the detrital cycle that nourishes many of the invertebrates, such as bivalves, living in the sand (Parks Victoria 2006c).

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 are 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 the food itself (Underwood and Chapman 2004).

The composition of invertebrate assemblages living on the intertidal reefs at Point Hicks are more similar to those found at Mallacoota, Merimbula and Bermagui than to assemblages found further west along the Victorian coast (Hidas *et al.* 2007). East coast species contributing to these differences have lower densities at Point Hicks than in NSW (Hidas *et al.* 2010).

The MNP has a relatively narrow band rock platform around the base of Point Hicks itself (Ball and Blake 2007). The remote location of the MNP means that human threats to the intertidal reef such as biota collection and trampling is low, due to this there is has been no intertidal reef monitoring program in Point Hicks MNP. As noted by Plummer *et al.* (2003) no specific data on the biota on intertidal reefs are available in Point Hicks MNP or nearby.

Subtidal

Soft sediment

Between Whaleback Rock and the isolated reef directly off Point Hicks biogenic gravel, consisting of whole and broken shells often encrusted in pink algae, covers the ocean floor (Holmes *et al.* 2007a). Shell areas tend to have many small orange ball sponges *Tethya* in amongst the shells (Holmes *et al.* 2007a). Sometimes vertical sponges are also present, attached to larger shells (Holmes *et al.* 2007a). Areas with rippled sand also contains shells in the ripple troughs. These shells are usually covered in pink encrusting algae, possibly indicating the presence of rhodoliths in these areas (Holmes *et al.* 2007a). Sand areas tend to be bare, although if vegetation is present, it is usually clumps of *Caulerpa*. Some areas of sand are inhabited by sessile invertebrates; however, as the species of invertebrates observed must attach to a hard substrate, it is assumed that the sand forms a thin veneer over the reef (Holmes *et al.* 2007a).

Depth and sediment affect the distribution of benthic invertebrates along the Victorian coast. According to Coleman *et al.* (2007) and Heislers and Parry (2007) species richness was greater at 40 metres compared to 10 or 20 metres depth. Their coastal survey of benthic fauna included the benthos of Point Hicks MNP. One transect off Point Hicks was sampled with two 0.1 m^2 grab samples in 10, 20 and 40 m of water depth. The sediment ranged from fine sand to coarse sand with shells (Heislers and Parry 2007). The grab samples contained between 100 to 1130 individuals and 16 to 71 species (Heislers and Parry 2007). Crustaceans were the dominant taxa in each depth class, representing more than half of the most abundant families. The majority of these were amphipods and cumaceans, while isopods and ostracods were also common. Polychaetes represented the bulk of the remaining families while molluscs were poorly represented. Four families were common in all depth classes, including one amphipod family (Phoxocephalidae), and three polychaete families (Spionidae, Syllidae and Paraonidae). The invasive New Zealand screw shell, *Maoricolpus roseus*, was identified in very high densities at 40 m depth in the Pt Hicks MNP (Heislers and Parry 2007). Where this invasive species was most abundant, the diversity of infauna was reduced, suggesting that this exotic species poses a serious threat to the high diversity of infauna that is characteristic of much of Bass Strait (Heislers and Parry 2007).

Trawl surveys conducted off Point Hicks indicate that the dominant fish species on subtidal soft sediment are school whiting *Sillago flindersi*, sparsely spotted stingaree *Urolophus paucimaculatus*, piked dog shark *Squalus megalops*, jack mackerel *Trachurus declivis*, round snouted gurnard *Lepidotrigla mulhalli*, red rock cod *Scorpaena papillosus* and cocky gurnard *Lepidotrigla vanessa* (Plummer *et al.* 2003). Other important species include banded stingaree *Urolophus cruciatus* (Figure 23), short finned gurnard, scaber leatherjacket *Parika scaber* and gurnard perch *Neosebastes scorpaenoides* (Plummer *et al.* 2003).

Nearby inshore areas have been identified in recreational fishing guides as hosting gummy sharks *Mustelus antarcticus*, Australian salmon *Arripis trutta* and tailor *Pomatomus saltatrix* (Plummer *et al.* 2003). Newborn pups of gummy sharks inhabit shallow inshore areas and there is some evidence to suggest that the inshore sandy areas east of Wilsons Promontory, including Point Hicks MNP, may be important feeding areas for gummy shark pups (Plummer *et al.* 2003). The commercial catch data also indicates that the general area provides suitable habitat for gummy sharks, saw sharks and elephant sharks *Callorhinchus milii* (Plummer *et al.* 2003). These shark species are all demersal and so the subtidal soft sediment environment within and adjacent to Point Hicks MNP may provide an important feeding ground for these species (Plummer *et al.* 2003).

Figure 23. Banded stingaree *Urolophus cruciatus* in Point Hicks Marine National Park. Photo by Mark Norman 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 (<15 m) subtidal reefs are known for their high biological complexity, species diversity and productivity and in addition they have significant economic value through commercial and recreational fishing (outside of MPAs), diving and other tourism activities (Power and Boxshall 2007). Shallow subtidal reefs are often dominated by canopy forming algae. Deep reefs, where light penetration is limited, are often dominated by large sessile invertebrates such as massive sponges (Figure 21), whip corals, soft corals and colonial ascidians (Power and Boxshall 2007). Deep reef assemblages contain a unique combination of organisms and the biological and physical differences mean that deeper areas may also respond differently to threats.

Flora

In very shallow subtidal waters of Point Hicks MNP red algae and the bull kelp *Durvillaea potatorum* are the dominant algae (Ball and Blake 2007). Moving slightly deeper, crayweed *Phyllospora comosa* becomes the dominant biota type over the reef (Ball and Blake 2007; Williams *et al.* 2007). The *Phyllospora* community of the Point Hicks region is quite different to that of the Cape Howe and Beware Reef regions (Parks Victoria 2003; Edmunds *et al.* 2010b). The Point Hicks community has a relatively high abundance and diversity of small thallose red algae (as understorey and on open reef patches) (Parks Victoria 2003; Edmunds *et al.* 2010b). In comparison, the *Phyllospora* assemblages near Cape Howe are largely depauperate of any understorey algae, with the reef predominantly covered by either encrusting coralline algae or encrusting sponges (Parks Victoria 2003; Edmunds *et al.* 2010b). At Point Hicks MNP the understorey algal assemblage can vary quite a lot (Williams *et al.* 2007). At the SRMP sites Old Jetty Bay and Hicks Joggle, there are several species of small turfing brown algae, particularly associated with the low profile, sand affected reef patches. These species include *Halopteris* spp., *Cladostephus spongiosus*, *Dilophus marginatus*, *Dictyopteris acrostichoides* and *Zonaria turneriana*. A few red algal species, such as *Acrotylus australis* and *Rhodymenia linearis* also occur. At Hicks Southwest and Hicks Lighthouse, the understorey algae is dominated by red algal species, particularly *Rhodymenia linearis, Acrotylus australis* and *Sinkoraena tasmanica*.

The common kelp *Ecklonia radiata* is also a common canopy algae, increasing in dominance with depth to become the principal canopy component at 15 m depth (Parks Victoria 2003; Williams *et al.* 2007). On the deeper, *Ecklonia*-dominated reefs, the assemblages beneath the canopy vary substantially from reef to reef (Parks Victoria 2003). At Point Hicks itself, the reef beneath the *Ecklonia* canopy has a high cover of encrusting and erect sponges (Parks Victoria 2003). In contrast, the *Ecklonia* assemblage at Sensation Reef has a diverse and abundant understorey of small fleshy red algae, with many species found only in that area (Parks Victoria 2003). In some sites, like Old Jetty Bay the brown algae *Cystophora moniliformis*, *Sargassum verruculosum* and *Acrocarpia paniculata* as well as string kelp *Macrocystis pyrifera* has considerable cover (Williams *et al.* 2007).

In a survey by Kraft in 2001, some rarely encountered algae species have been found in the park outside their previously known range (Parks Victoria 2003). In this same survey, a specimen of a benthic alga *Porphyropsis minuta* was the first Victorian record other than Lawrence Rocks near Portland, and another recorded species of alga *Erythroneaema ceramoides* has not been recorded in Victoria since its original discovery at Port Phillip Heads in 1880 (Parks Victoria 2003). Another rare alga *Scageliopsis patens* was previously only known from Adelaide (Parks Victoria 2003).

Invertebrate fauna

Common invertebrate grazers found on Point Hick reefs include blacklip abalone *Haliotis rubra*, the eastern temperate gastropod *Astralium tentoriformis*, warrener *Turbo undulates* and sea urchin *Heliocidaris erythrogramma.* Predatory invertebrates include dogwhelks *Dicathais orbita*, eastern rock lobster *Jasus verreauxi*, octopus *Octopus moarum* and a wide variety of seastar species (Williams *et al.* 2007; Edmunds *et al.* 2010b). The cunjevoi *Pyura stolonifera* is an obvious invertebrate on the reef close to shore (Ball and Blake 2007). In general, Point Hicks shallow subtidal reefs are characterised by high abundances of the predatory gastropod *Cabestana spengleri*, the seastar *Patiriella calcar* and moderate abundances of blacklip abalone *Haliotis rubra* and the red bait crab *Plagusia chabrus* (Parks Victoria 2003; Edmunds *et al.* 2010b). Point Hicks MNP invertebrate assemblage is distinct from Cape Howe and Beware Reef regions (Edmunds *et al.* 2010b).

The long-spined black sea urchin *Centrostephanus rodgersii* (Figure 24) does occur in Point Hicks MNP (Williams *et al.* 2007). *Centrostephanus* forms large grazing aggregations which denude the reef of erect algal species, forming 'sea urchin barrens' and these have been observed in the MNP (O'Hara 2000; Holmes *et al.* 2007a; Edmunds *et al.* 2010b). The occurrence of urchin barren habitat reflects the influence of species from the east coast of Australia on the MNP (Williams *et al.* 2007). Removal of large seaweeds by *Centrostephanus* causes substantial changes to subtidal reef community structure (Williams *et al.* 2007).

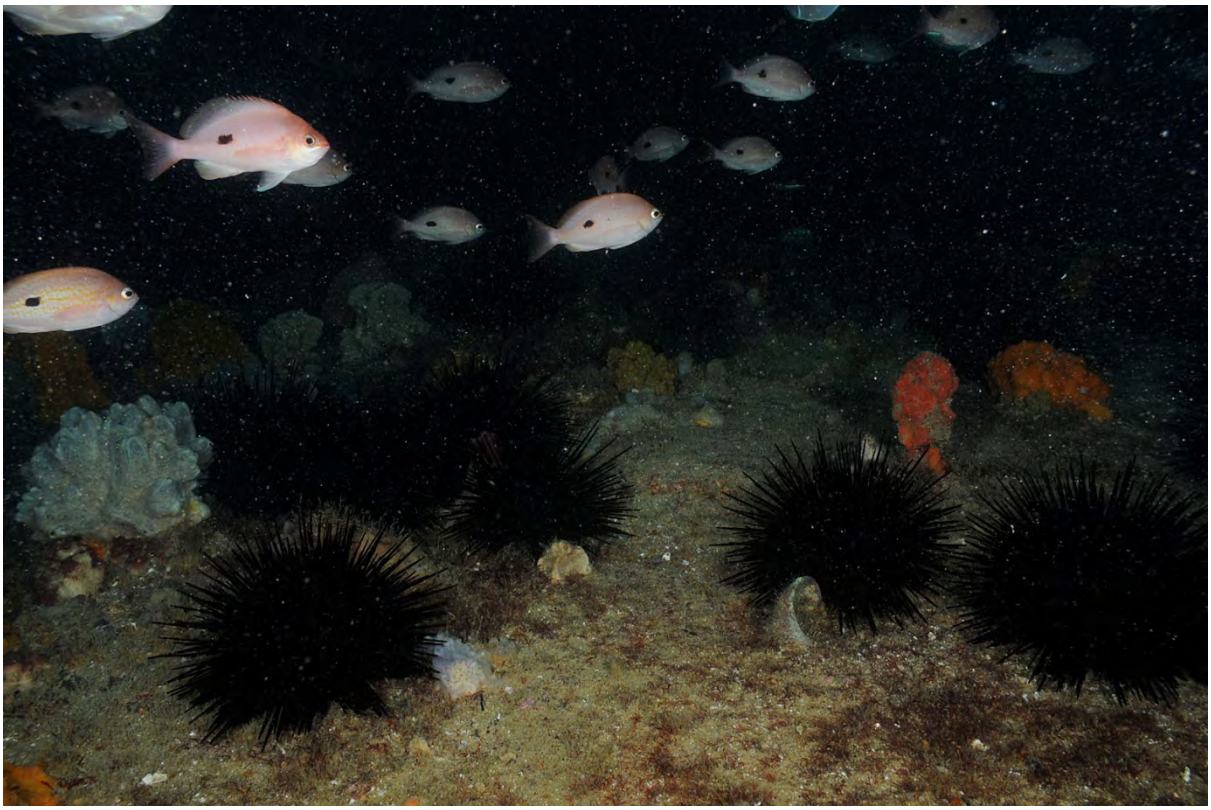


Figure 24. Black urchins *Centrostephanus rodgersii* and butterfly perch *Caesioperca lepidoptera* in Point Hicks Marine National Park. Photo by Mark Norman Museum of Victoria.

Deep subtidal reefs (> 20 m) are dominated by sessile invertebrates. From 15 – 20 m to approximately 40 m depth, the *Ecklonia* canopy thins out and is gradually replaced by a 'garden' of massive erect sponges, encrusting sponges, gorgonian coral *Mopsella zimmeri*, sea-whip coral *Primnoella australasiae*, and basket star *Conocladus australis* (Ball and Blake 2007).

Fish

The fish assemblages associated with the Twofold Shelf bioregion *Phyllospora* communities are quite different to *Phyllospora* communities elsewhere in Victoria (Parks Victoria 2003). These fish assemblages have characteristics typical of both eastern and southern temperate waters (Williams *et al.* 2007). There are high abundances of banded morwong*,* Maori wrasse *Ophthalmolepis lineolata*, one-spot puller *Chromis hypsilepis* and white-ear damselfish *Parma microlepis* (Williams *et al.* 2007; Edmunds *et al.* 2010b). Species such as the mado *Atypichthys strigatus*, rock cale *Crinodus lophodon,* purple wrasse *Notolabrus fucicola* and the blue morwong *Nemadactylus douglasii* are regularly observed (Ball and Blake 2007; Williams *et al.* 2007). The fish assemblages in Point Hicks MNP are distinct from Beware Reef and Cape Howe (Edmunds *et al.* 2010b). They are dominated by large numbers of blue-throated wrasse *Notolabrus tetricus* and particularly the purple wrasse (Edmunds *et al.* 2005; Williams *et al.* 2007; Edmunds *et al.* 2010b). The eastern blue grouper *Achoerodus viridis* is also a prominent species in the MNP, but present in low numbers (Parks Victoria 2003). The density of herring cale *Odax cyanomela*s can show large temporal variations and the densities of sea sweep *Scorpis aequipinnis* is generally low (Edmunds *et al.* 2010b). Zebra fish *Girella zebra* can occur in large numbers (Williams *et al.* 2007). The banded morwong is common over both shallow and deep reef (Ball and Blake 2007). Schools of butterfly perch *Caesioperca lepidoptera* (Figures 24 and 25) can be observed in deeper areas where sessile invertebrates start to dominate (Ball and Blake 2007).

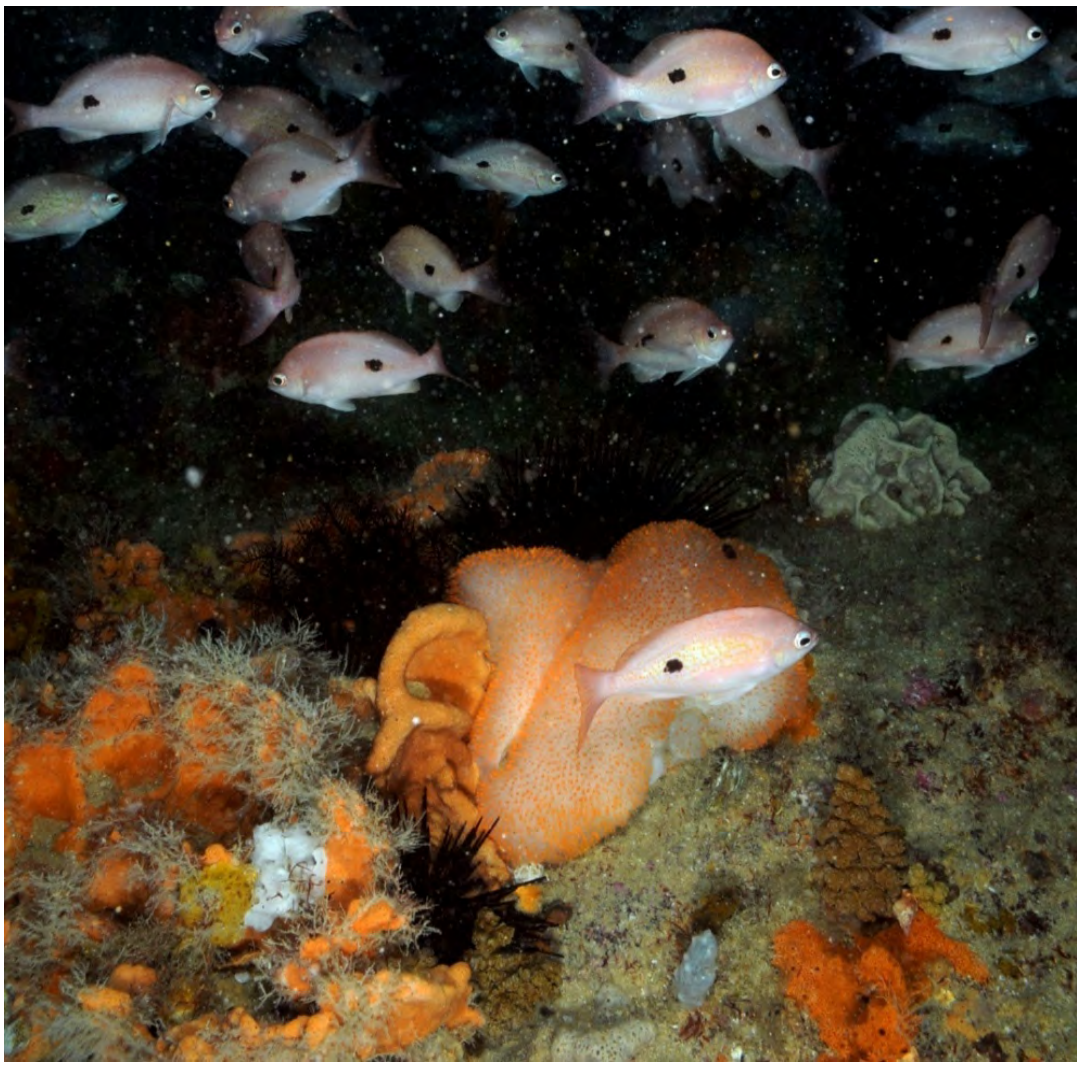


Figure 25. A school of butterfly perch *Caesioperca lepidoptera* over a subtidal reef sponge garden in Point Hicks Marine National Park. Photo by Mark Norman, Museum of Victoria.

Water column

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

2.3.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora

No threatened marine flora has been recorded in Point Hicks MNP (Parks Victoria 2006f).

Fish

Many fish found in streams and rivers nearby Point Hicks National Park, have marine larval stages that would pass through and probably feed in the MNP. This would include the state and nationally vulnerable Australian grayling (Table 16). The nationally threatened whale shark has been recorded in the waters of Point Hicks MNP. The eastern blue groper *Achoerodus viridis* is present in low numbers in Point Hicks MNP. It is threatened by over fishing and a temporary protection from all fishing in Victoria was introduced in April 2011.

Table 16. Conservation listed fish records from Point Hicks Marine National Park and surrounds.

		Victorian listing		National listing
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**
Australian grayling	*Prototroctes maraena*	L	VU	VU
whale shark	*Rhincodon typus*			VU

L = FFG listed, VU = vulnerable

Birds

Twenty-six conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Point Hicks MNP (Table 17). Twenty are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. Two, the little egret and fairy tern are regarded as endangered. Four birds are listed as vulnerable at both the state and national level, including the northern giant-petrel, fairy prion, shy and black-browed albatross. Twelve birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA). Hooded Plover nesting sites have been recorded along the coast to the east of the park and at the mouth of the Mueller and Thurra Rivers, and it is likely that they forage along the park's shore (Parks Victoria 2006f).

Table 17. Conservation listed shorebird and seabirds records from Point Hicks Marine National Park and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
bar-tailed godwit	*Limosa lapponica*				C	J
common greenshank	*Tringa nebularia*				C	J
whimbrel	*Numenius phaeopus*		VU		C	J
red-necked stint	*Calidris ruficollis*				C	J
sooty oystercatcher	*Haematopus fuliginosus*		NT			
little egret	*Egretta garzetta*	L	EN			
royal spoonbill	*Platalea regia*		VU			
common sandpiper	*Actitis hypoleucos*		VU		C	J
hooded plover	*Thinornis rubricollis*	L	VU			
grey plover	*Pluvialis squatarola*		NT		C	J
common tern	*Sterna hirundo*				C	J
fairy tern	*Sternula nereis*	L	EN			
little tern	*Sternula albifrons*	L	VU		C	J
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
white-fronted tern	*Sterna striata*		NT			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
Pacific gull	*Larus pacificus*		NT			
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
common diving-petrel	*Pelecanoides urinatrix*		NT			
fairy prion	*Pachyptila turtur*		VU	VU		
Wilson's storm-petrel	*Oceanites oceanicus*					J
short-tailed shearwater	*Ardenna tenuirostris*					J
northern giant-petrel	*Macronectes halli*	L	NT	VU		
shy albatross	*Thalassarche cauta*	L	VU	VU		
black-browed albatross	*Thalassarche melanophris*		VU	VU		

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

Marine mammals and reptiles

The southern right whale *Eubalaena australis* and humpback whale *Megaptera novaeangliae* have been recorded in or near the Point Hicks MNP (Table 18). The southern right whale *E. australis* is listed as critically endangered in Victorian waters and endangered nationally. The humpback whale *M. novaeangliae* is listed as vulnerable at the state and national level. The killer whale *Orcinus orca*, leopard seal *Hydrurga leptonyx* and Australian fur seal *Arctocephalus pusillus doriferus* have been observed in the waters in and around the park. Marine mammals such as dolphins, whales, Australian fur seal *A. pusillus doriferus* and threatened New Zealand fur seal *Arctophoca forsteri* are transient through the MNP (Parks Victoria 2006f). The yellow-bellied sea snake *Pelamis platurus* has been recorded in or near the MNP. Four other listed marine reptiles occur as vagrants along the eastern Victorian coast: loggerhead turtle *Caretta caretta*, green turtle *Chelonia mydas*, Pacific ridley *Lepidochelys olivacea* and leatherback turtle *Dermochelys coriacea* and probably transit through the MNP (Plummer *et al.* 2003). Many other animals probably use the MNP waters but its remoteness means there are few observations.

Table 18. Conservation listed marine mammal and reptile records from Point Hicks Marine National Park and surrounds.

		Victorian listing		National listing	International convention
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**Bonn**
southern right whale	*Eubalaena australis*	L	CR	EN	L
humpback whale	*Megaptera novaeangliae*	L	VU	VU	L
New Zealand fur seal	*Arctophoca forsteri*		VU	L	
Australian fur seal	*Arctocephalus pusillus doriferus*			L	
killer whale	*Orcinus orca*			L	L
Loggerhead turtle	*Caretta caretta*				L
Leatherback turtle	*Dermochelys coriacea*	L			

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

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that Point Hicks MNP had one mollusc the welk *Fax molleri* presumed to be endemic to the park (O'Hara and Barmby 2000; O'Hara and Poore 2000).

Fourteen biota (Table 19) have been recorded or presumed to be at their distributional limit in Point Hicks MNP (O'Hara and Barmby 2000; Plummer *et al.* 2003). Four red algae have been recorded as being at the easterly limit of their distribution in Point Hicks MNP. Eight biota have been recorded as being at their western limit of distribution in Point Hicks MNP, including five gastropods, one feather star, one sea urchin and the whale shark. One crab and one gastropod are presumed to be at their western limit of distribution (O'Hara and Barmby 2000; O'Hara and Poore 2000). The distributional limits of the biota listed in Table 19 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 19. Marine species at their distribution limits in Point Hicks Marine National Park (O'Hara 2002).

Order	Family	Species	Common name	Category
Gigartinales	Plocamiaceae	*Plocamium dilatatum*	red algae	RE
Erythropeltidales	Erythrotrichiaceae	*Porphyropsis minuta**	red algae	RE
Ceramiales	Ceramiaceae	*Scageliopsis patens**	red algae	RE
		*Erythroneaema ceramoides**	red algae	RE
Brachyura	Oziidae	*Ozius truncatus*	crab	PW
Gastropoda	Onchidiidae	*Onchidella australis*	marine snail	PW
Gastropoda	Cerithiidae	*Glyptozaria euglypta*	marine snail	RW
Gastropoda	Anabathridae	*Pisinna albizona*	marine snail	RW
Gastropoda	Anabathridae	*Pisinna laseroni*	marine snail	RW
Gastropoda	Turridae	*Vexitomina torquata*	marine snail	RW
Polyplacophora	Chitonidae	*Chiton (Rhyssoplax) jugosus*	chiton	RW
Crinoidea	Isocrinidae	*Metacrinus cyaneus*	feather star	RW
Echinoidea	Temnopleuridae	*Pseudechinus notius*	sea urchin	RW
Orectolobiformes	Rhincodontidae	*Rhincodon typus*	whale shark	RW

PE = presumed eastern limit, PW = presumed western limit, PN = presumed northern limit, RE = recorded eastern limit, RW = recorded western limit.
'* from Kraft, G.T. (2001) as reported by Plummer *et al.* (2003).

Figure 26. Featherduster worms *Sabellastarte australiensis* on subtidal reef in Point Hicks Marine National Park. Photo by Mark Norman, Museum of Victoria.

2.3.5 MAJOR THREATS

Threats to natural values in Point Hicks MNP were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 years, were considered and ranked to identify hazards. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Four hazards with the potential to be extreme in Point Hicks MNP were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the MNP is indicated in brackets:

1. Introduced species from commercial vessels (including secondary introductions) leading to changes in community structure (potentially all of MNP, benthic communities most at risk);
2. Poaching of abalone in commercial quantities leading to decreased abalone populations and consequent impacts on subtidal reef communities (subtidal reef);
3. Lack of ecological knowledge leading to inappropriate management and thus impacts on habitats and communities (potentially all of MNP); and
4. Introduced marine pests from recreational boats leading to impacts on relevant ecological communities (potentially all of MNP, benthic communities most at risk).

The introduction of marine pests threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). Two introduced species or marine pest has been recorded Point Hicks MNP, the screw shell *Maoricolpus roseus* (Holmes *et al.* 2007a) and the New Zealand sea star *Astrostole scabra* (Edmunds *et al.* 2010b). It is presumed that the introduced green meany or green shore crab *Carcinus maenas* occurs on the intertidal reefs of all the MPAs, except Ninety Mile Beach which has no intertidal reef. Other species of particular concern include the Northern Pacific seastar *Asterias amurensis*, European fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile (subsp fragile)* (Parks Victoria 2003).

The screw shell *Maoricolpus roseus* has been recorded within the Point Hicks MNP (Heislers and Parry 2007). This 5 cm long gastropod was introduced to Tasmania from New Zealand in the 1920s (Bax *et al.* 2003). It has now spread out to the 80 m depth contour off the eastern Victorian and New South Wales coasts (Patil *et al.* 2004). In New Zealand it is found from soft sediments to exposed habitats. This habitat flexibility means there is a higher potential for greater ecological and environmental impacts over larger areas than introduced species restricted to specific inshore environments (Patil *et al.* 2004). The dense beds of this invasive species change the benthic structure with unknown (and unexamined) effects on ecosystem services (Patil *et al.* 2004). It can cover soft sediments with its hard shell, and once dead, its shell provides abundant homes for a particular hermit crab that can use its heavy tapered shell, thus potentially shifting the pre-invasion food web (Bax *et al.* 2003). Dense beds of this burrowing filter feeder may have adverse impacts on native filter feeders, with native turritellids numbers declining with increasing *M. roseus* numbers (Patil *et al.* 2004). In Point Hicks MNP where this invasive species was most abundant, the diversity of infauna was reduced, suggesting that this exotic species poses a serious threat to the high diversity of infauna that is characteristic of much of Bass Strait (Heislers and Parry 2007).

Figure 27. Finger sponges and colonial sea squirt in Point Hicks Marine National Park. Photo by Mark Norman, Museum of Victoria.

A number of other introduced marine pests also have the potential to colonise the park, especially in the sheltered waters of Stable Bay and the western side of Point Hicks (Parks Victoria 2006f). The park is vulnerable to pest introductions from ballast water and biofouling because of shipping lanes (Parks Victoria 2006f). Recreational vessels and users are also potential vectors for exotic species and diseases (*e.g.* from contaminated diving equipment) (Parks Victoria 2006f). Impacts from introduced marine pests are as diverse as the species themselves and include altering natural nutrient cycles and outcompeting native species for food and or space. Introduced marine pests can have economic impacts (*e.g.* commercial fisheries) and social impacts (*e.g.* affect public health and safety) (Parks Victoria 2006f).

A virus affecting abalone called abalone viral ganglioneuritus has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area and has been confirmed from Discovery Bay MNP to near Cape Otway (DPI 2009). It is not in the Point Hicks MNP but its spread into the park could have serious long term ecological consequences for rocky reef communities (DPI 2009).

Climate change represents a serious threat to marine ecosystems (McLeod *et al.* 2009) but specific ecological consequences of accelerating climate change are not well understood in marine systems, particularly in temperate systems. Climate change is predicted to increase water temperature, alter chemical composition (salinity, acidity and carbonate saturation), change circulation and productivity, increase frequencies of extreme weather events and exposure to damaging ultraviolet light (UVB), and increase air temperature, cloud cover and sea levels (conservatively 80 cm by 2100; CSIRO-BoM 2007; Fine and Franklin 2007; VCC 2008; McLeod *et al.* 2009). A combined increase in cloud cover and sea level could result in decreased light availability potentially changing benthic flora. Increased storm surges and ocean current changes also have the potential to change the distribution of fauna and flora and could result in loss of habitats (CSIRO-BoM 2007). Intertidal communities will face

increased desiccation, storm wave exposure and habitat shift. Changes in the relationship between climate and annual life-history events may force major change in functional groups and consequent ecosystem function (Fine and Franklin 2007). Climate change is also anticipated to modify species recruitment and habitat connectivity, species interactions and disturbance regimes in the marine environment (CSIRO-BoM 2007; Fine and Franklin 2007). A number of species are at the eastern or northern limit of their distributional range at Point Hicks and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in Point Hicks MNP, has increased its range down the east coast of Australia to Tasmania and that increase is thought to be linked to climate change with the EAC extending further south (Banks *et al.* 2010).

Figure 28. Black urchins *Centrostephanus rodgersii* and yellow zoanthid corals in Point Hicks Marine National Park. Photo by Mark Norman, Museum of Victoria.

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

2.3.6 CURRENT RESEARCH AND MONITORING

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. The research relevant to Point Hicks 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 20 and Appendix 2).

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

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising the allocation of resources for defending Marine Protected Areas against invasive species.
Multiple Research Partners: Marine Monitoring and Marine Natural Values ***University of Melbourne:*** Mick Keough, Paul Carnell Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling data. ***Deakin University:*** Gerry Quinn, Jan Barton, Adam Pope 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
Community Based Monitoring Reef Life Survey - Subtidal Reefs

Point Hicks MNP does not have an ongoing intertidal reef monitoring program as it has limited intertidal reef area with relatively low human pressure. The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003) in and around the Point Hicks MNP began in 2001. Since that time four sites in the MNP and four reference sites outside of the MNP (Figure 17) have been surveyed over four census events (Edmunds *et al.* 2005; Williams *et al.* 2007; Edmunds *et al.* 2010b). The monitoring involves standardised

underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than ten metres (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water.

Keough and Carnell's (2009) preliminary analysis of the SRMP data from the first three census events up to 2006 was done at the bioregion level of Point Hicks MNP, Cape Howe MNP and Beware Reef MS. The analysis compared sites within MPAs to reference sites outside the MPAs. They found there was no significant difference in species richness and number of species between MPA and reference sites post-declaration for the Twofold Shelf bioregion. Limitations to this work include the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). All algae analysed had similar percentage cover between MPA and reference sites (Keough and Carnell 2009). The purple sea urchin *Heliocidaris erythrogramma* and dogwelk *Dicathais orbita* showed a greater abundance at reference sites compared to MPA sites (Keough and Carnell 2009). The triton *Cabestana spengleri*, red bait crab *Plagusia chabrus* and *H. erythrogramma* had significant differences in abundance between the various MPAs (Keough and Carnell 2009). The abundance of dominant fish species varied, but were generally similar between MPA and reference sites over time (Keough and Carnell 2009). Mado, purple wrasse and blue-throated wrasse were particularly variable but differences were not related to MPAs (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 MPA declaration, apart from recovery from fishing pressure, is to ensure the protection of the MNP area against future threats to biodiversity and natural processes.

A targeted analysis of monitoring data in relation to conservation outcomes for the park will be done by 2013. The subtidal reef monitoring program will continue to be implemented in Point Hicks MNP. The major directions for monitoring include implementing an expanded and improved monitoring program following a review of the major findings taking into account knowledge generated since park declaration and conservation outcomes developed for the MNPs (Keough *et al.* 2007; Power and Boxshall 2007; Keough and Carnell 2009)..

Statewide, the Museum of Victoria is collecting additional data on the marine natural values of Victoria's MPAs. They are gathering information about natural history through video and photos (Figures 26, 27, 28 and 29), 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's surveillance monitoring efforts to MPAs where there is greatest potential for successful management.

2.3.7 KNOWLEDGE GAPS

No new surveys exist for the ecological communities of sandy beaches, intertidal soft sediments or biota on intertidal reef of Point Hicks MNP. There is little new data on fish abundances, distributions or interactions except in shallow subtidal reef habitats. No information exists at present for water column assemblages. Major threats have been identified for Point Hicks MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.

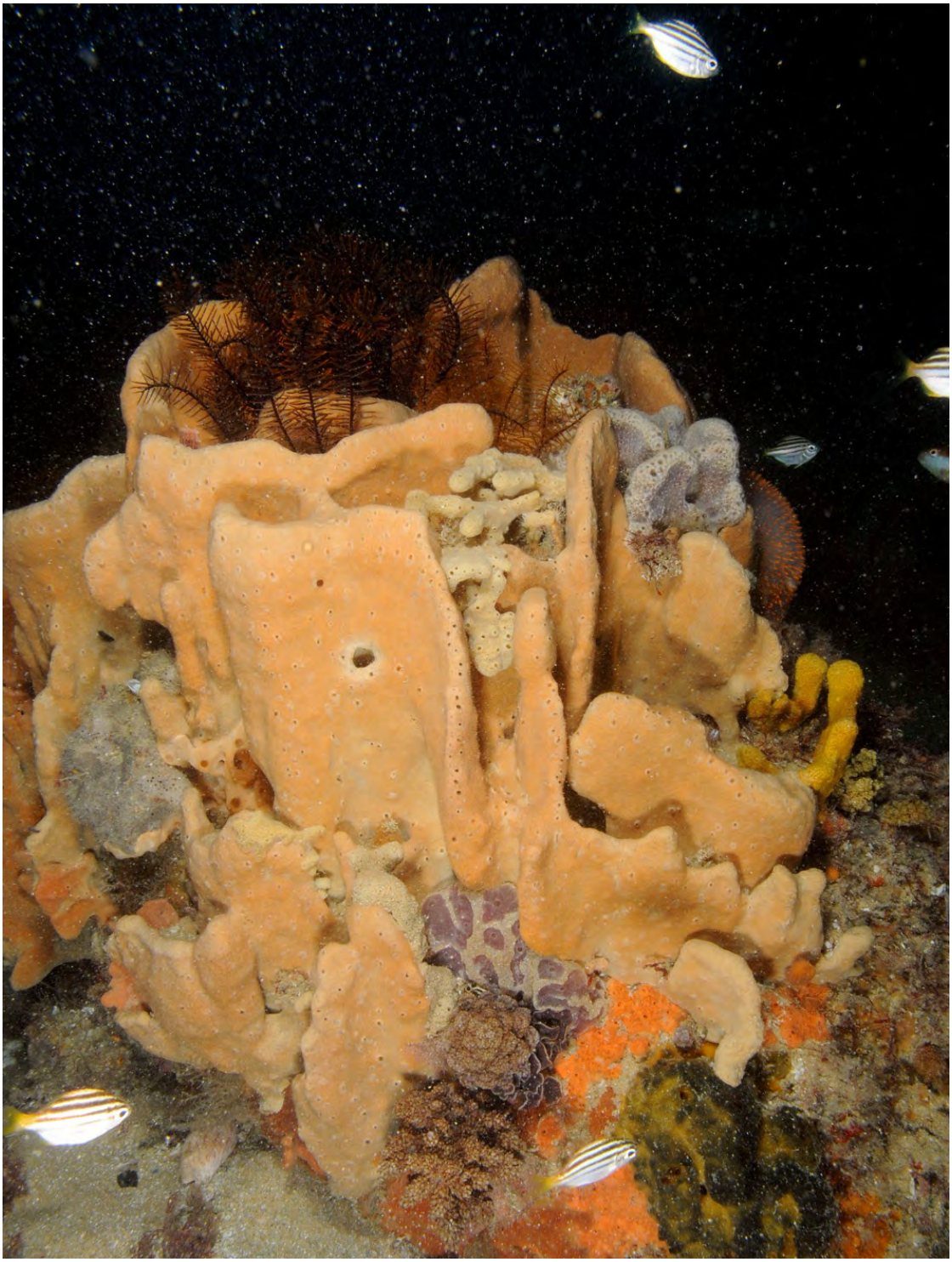


Figure 29. Castle sponge in Point Hicks Marine National Park. Photo by Mark Norman, Museum of Victoria.

2.4 Cape Howe MNP – Twofold Shelf Bioregion

Cape Howe is one of three Marine National Parks in the Twofold Shelf bioregion, which also contains one other MPA, Beware Reef Marine Sanctuary, and Gippsland Lakes and Cape Conran Coastal Parks (Figure 2). Cape Howe MNP is approximately 15 km east of Mallacoota. It extends offshore from high water mark to the seaward limit of Victoria's coastal waters. It borders 4.8 km of coastline from approximately 1 km east of Telegraph Point and Gabo Island to the New South Wales border, excluding a section of coast and sea around Iron Prince (Figure 30 and 31). It is Victoria's most easterly MNP abutting Cape Howe Wilderness Zone of Croajingolong National Park, one of only three wilderness zones on the Victorian coast (Parks Victoria 2006c).

Aboriginal tradition indicates that the park is part of the *Country* of the Bidwell people and that other Aboriginal people, including the Yuin Nation, also have an association with the coastal region of this area (Parks Victoria 2006c).

Important natural values of Cape Howe MNP are its diversity of habitats including long sandy beaches, intertidal reef along its eastern shore, shallow and deep subtidal reefs, extensive subtidal soft sediment, and expansive areas of deep open water (Parks Victoria 2006c). Its rocky reefs have a complex structure, including eroded low-profile sandstone reef and high-profile granite reef (Carey *et al.* 2007b). The shallow subtidal reef is dominated by a mixture of crayweed *Phyllospora comosa* and bull kelp *Durvillaea potatorum,* the reef further offshore tends to be dominated by *P. comosa* (Ball and Blake 2007; Edmunds *et al.* 2010b). On these reefs the herbivorous sea urchin *Centrostephanus rodgersii*, can remove all erect algae to create 'urchin barrens' (Williams *et al.* 2007). Common invertebrates include the blacklip abalone *Haliotis rubra*, the warrener *Turbo undulatus* and another turban shell *Astralium tentoriformis* (Williams *et al.* 2007; Edmunds *et al.* 2010b). Common fish are herring cale *Odax cyanomelas*, the leatherjacket *Meuschenia freycineti*, striped mado *Atypichthys strigatus,* banded morwong *Cheilodactylus spectabilis* and the damselfishes *Parma microlepis* and *Chromis hypsilepis* (Williams *et al.* 2007; Edmunds *et al.* 2010b). Its deep (30 to 50m) sandstone reefs are heavily covered with a diverse array of sponges, ascidians and gorgonians (Carey *et al.* 2007b; Holmes *et al.* 2007b).

The extensive area of subtidal soft sediments are mainly a fine and medium sand, with a low carbonate content, which becomes dominated by shells in depths >50 m (Holmes *et al.* 2007b). Extensive macroalgal beds occur on sediment and sediment covered reef 10 to 40 m depth with *Caulerpa* dominating in 30 to 40 m. Sponges dominate sediment at depths >40 m, with orange ball sponges *Tethy*a dominant in 40 to 60 m depth (Holmes *et al.* 2007b). Crustaceans such as amphipods, cumaceans, isopods and ostracods, and polychaetes are the dominant infauna in 10 to 20 m depth sediments (Heislers and Parry 2007). Common fish over sediment and sediment covered reef are yellow scad *Trachyurus novaezelandiae*, ocean leatherjacket *Nelusetta ayraudi*, whiting *Sillago,* grubfish *Parapercis* sp. eastern blue-spotted flathead *Platycephalus caeruleopunctatus*, velvet leatherjacket *Meuschenia scaber* and the butterfly perch *Caesioperca lepidoptera* (Moore *et al.* 2009). The draughtboard shark *Cephaloscyllium laticeps* is also common and can be found down to the deepest depths (105 m) of the MNP (Moore *et al.* 2009).

Cape Howe MNP has a high diversity of intertidal and shallow subtidal invertebrates (Edmunds *et al.* 2005; Carey *et al.* 2007b). Eastern temperate, southern cosmopolitan and temperate species co-occur as a result of the mixing of warm eastern and cool southern waters (Edmunds *et al.* 2005; Parks Victoria 2006c). Thirty-eight species of marine flora and fauna are believed to be at their eastern, western or northern distributional limits within the planning area (O'Hara and Poore 2000).

Cape Howe MNP is thought to be an important feeding area for several threatened bird species (Parks Victoria 2006c; Carey *et al.* 2007b). This includes the endangered Australasian bittern *Botaurus poiciloptilus,* critically endangered grey-tailed tattler *Heteroscelus brevipes*, and the endangered wandering albatross *Diomedea exulans.* All of which are listed under the *Flora and Fauna Guarantee* (FFG) *Act* (1998) with the wandering albatross also listed under the *Commonwealth Environment Protection and Biodiversity Conservation* (*EPBC*) *Act* (1999). The MNP protects feeding areas for bird species that are listed under the Japan–Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA). It is also an important foraging area for a significant breeding colony of little penguins *Eudyptula minor* from neighbouring Gabo Island (Plummer *et al.* 2003).

The conservation listed southern right *Eubalaena australis* and humpback whales *Megaptera novaeangliae,* and leatherback *Dermochelys coriacea*, green *Chelonia mydas* and hawksbill turtles *Eretmochelys imbricata* use the MNP waters (Parks Victoria 2006c). The southern right whale *E. australis* has been observed to calf in the park but is not known to feed there. The state vulnerable New Zealand fur seal *Arctophoca forsteri* has also been recorded breeding in the MNP. The killer whale *Orcinus orca,* minke whale *Balaenoptera acutorostrata* and Australian fur seal *Arctocephalus pusillus doriferus* have been observed in the waters in and around the park.

Serious threats to the Cape Howe MNP include limited ecological knowledge of important processes. Poaching of abalone, invasive marine pests from commercial and recreational boats; anchor damage; 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 Cape Howe MNP (Parks Victoria 2006c). Ongoing intertidal and subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Cape Howe MNP.

2.4.1 PHYSICAL PARAMETERS & PROCESSES

Cape Howe MNP is 4060 hectares in size which makes it the fourth largest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 21, Figure 30). Its shoreline geology consists of predominately large mobile dunes with sandy beaches, and boulder strewn outcrops of sandstone in the east (Bird 1993). Water depths reach 105 m (Holmes *et al.* 2007b). Greater than 85 % of the MNP is > 20 m depth. Prevailing winds and swells are generally from the south-west and north-east. The coastline is influenced by high-energy waves and swells. Weather originating from the south-west and east influences water activity and movement, as do twice-daily tides (Parks Victoria 2006c). The warm water East Australian Current is a major influence in the MNP (Parks Victoria 2006c). As the continental shelf is quite close to the far eastern Victorian shore, cold water upwellings are frequent and mix with the warmer waters, bringing increased nutrients and creating an ecosystem high in productivity (Parks Victoria 2006c; Edmunds *et al.* 2010a). A small intermittent estuary, the outflow from Lake Wau Wauka, runs directly into the park (Table 21). The catchment adjacent to the MNP is the remote and relatively undisturbed Cape Howe Wilderness Zone which is part of Croajingolong National Park.

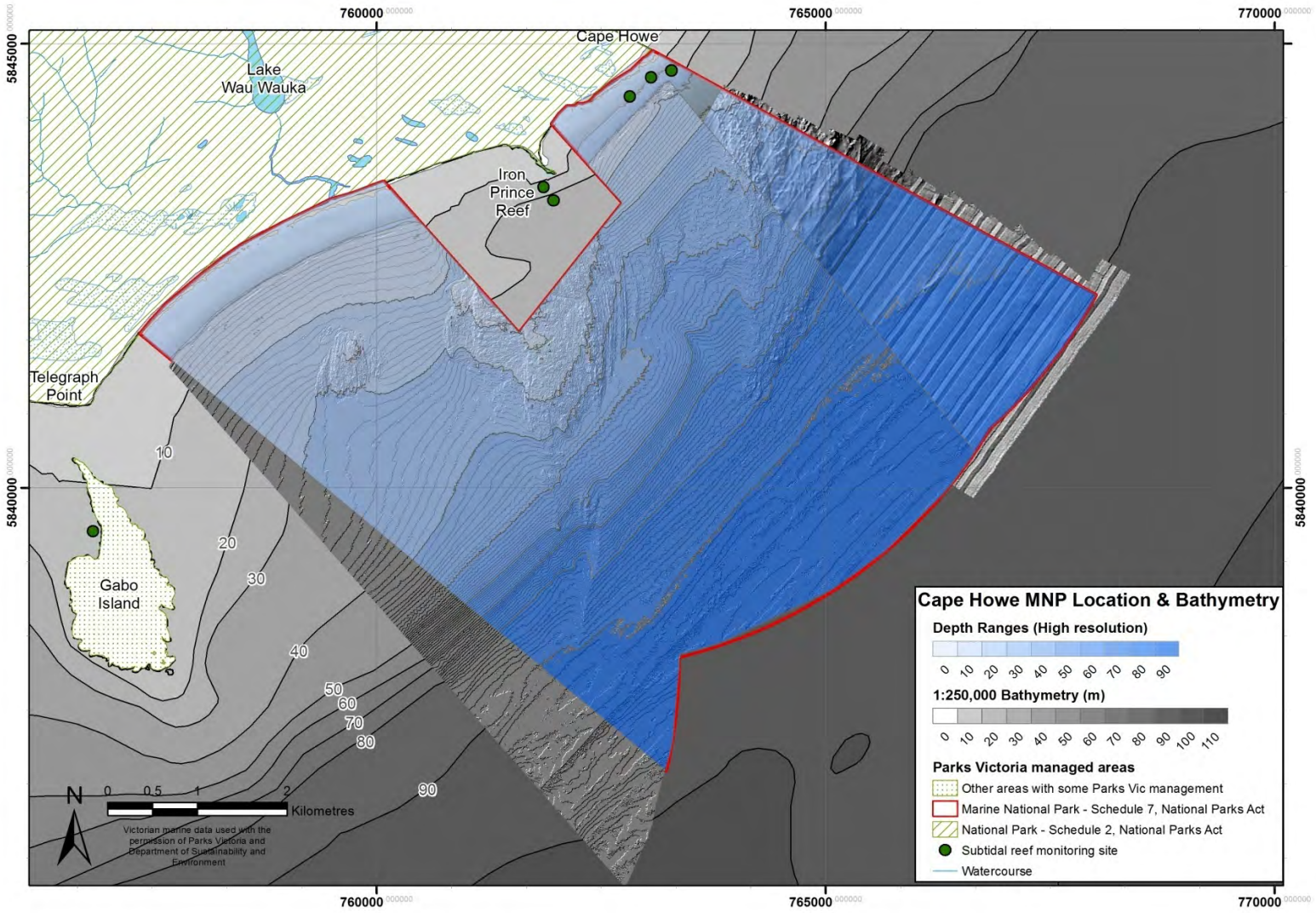


Figure 30. Location map of Cape Howe Marine National Park with high resolution bathymetry. Subtidal reef monitoring sites inside and outside the MNP are shown, there are no intertidal monitoring sites.

Figure 31. Aerial view of the coast of Cape Howe Marine National Park (QASCO 20/01/04). Photography ortho-rectified by PIRVic. Figure from Ball and Blake (2007).

Table 21. Physical attributes of the Cape Howe Marine National Park.

Park Name	**Cape Howe**
Conservation status	Marine National Park
Biophysical Region	Twofold Shelf
Size	4060 ha (ranked 4th of 24)
Length of coastline	~ 4.8 km
Shoreline geology	Sandstone & granite
Area with depth:	
<5 m	123 ha
5 - 10 m	72 ha
10-20 m	313 ha
20-30 m	432 ha
30-40 m	494 ha
40-50 m	365 ha
50-60 m	299 ha
60-70 m	244 ha
70-80 m	222 ha
80-90 m	695 ha
90-100 m	799 ha
Mean tidal variation - spring	0.9 m
Mean tidal variation - neap	0.6 m
Mean water temp - summer	19 ^{o}C
Mean water temp - winter	14 ^{o}C
Adjacent catchment	Cape Howe Wilderness Zone & Gabo Island Lighthouse Reserve
Discharges into MNP	Lake Wau Wauka & small intermittent creeks in to the MNP
Nearest major estuary (distance & direction)	Lake Wau Wauka occasionally discharges into MNP Mallacoota Inlet mouth is 14 km west Nadjee Lake is 4.3 km north

2.4.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to more effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. Aerial photography (Figure 31) and satellite imagery from 2004 was used to map the intertidal and shallow (< 10 m) subtidal habitats of Cape Howe MNP (Ball and Blake 2007). The subtidal area was ground truthed in 2007 with underwater video (Ball and Blake 2007). The intertidal area could not be ground truthed due to the inaccessibility of the shore (Ball and Blake 2007). In 2004/2005 the deep (> 10 m) subtidal substrate and biota of Cape Howe MNP was surveyed and mapped acoustically (Figure 32 and Figure 33) by Holmes *et al.* (2007b). Underwater video transects allowed the substrate and biota to be predictively modelled for the areas not surveyed.

The habitats present in Cape Howe MNP include intertidal soft sediment and some reef, extensive subtidal soft sediment and some subtidal reef, and open ocean (Figure 32 and Figure 33). Intertidally a band of rocky shore extends from the east side of Iron Prince to the NSW border, with the rest of the intertidal area being sand beach fronting an extensive dune system (Ball and Blake 2007). The majority of the shallow subtidal habitat is bare rippled sandy sediment. The shallow subtidal reef habitat is restricted to an area running parallel to the shore for a distance of approximately 700 m from the north-eastern MNP boundary extending down to depths of approximately 16 m (Ball and Blake 2007). The reef is primarily a mixture of high profile broken reef and more solid low profile reef. The inshore reef is generally broken and patchy (Ball and Blake 2007). The reef changes from low relief in the west to larger bombies, steep ledges and drop-offs in the east (Williams *et al.* 2007). This reef has been extensively described and sampled as part of the SRMP (Williams *et al.* 2007; Edmunds *et al.* 2010b).

Based on predictive modelling, deep (> 10 m) subtidal soft sediment covers 33 sq. km of the MNP, while deep subtidal reef was mapped over 8 sq. km and located mainly in the near-shore centre of the MNP offshore of Iron Prince (Holmes *et al.* 2007b). An equal amount of reef is covered with sediment. The sediment is primarily sand in water < 50 m deep, while mixed sand and shell fragments in deeper water (Holmes *et al.* 2007b). The reef generally is flat or with a gentle slope with some drop offs. The reef structure is a mixture of solid reef and boulders (Holmes *et al.* 2007b). Extensive macroalgae beds, predominately of *Caluerpa* occur in 30 to 40 m across the MNP (Holmes *et al.* 2007b).

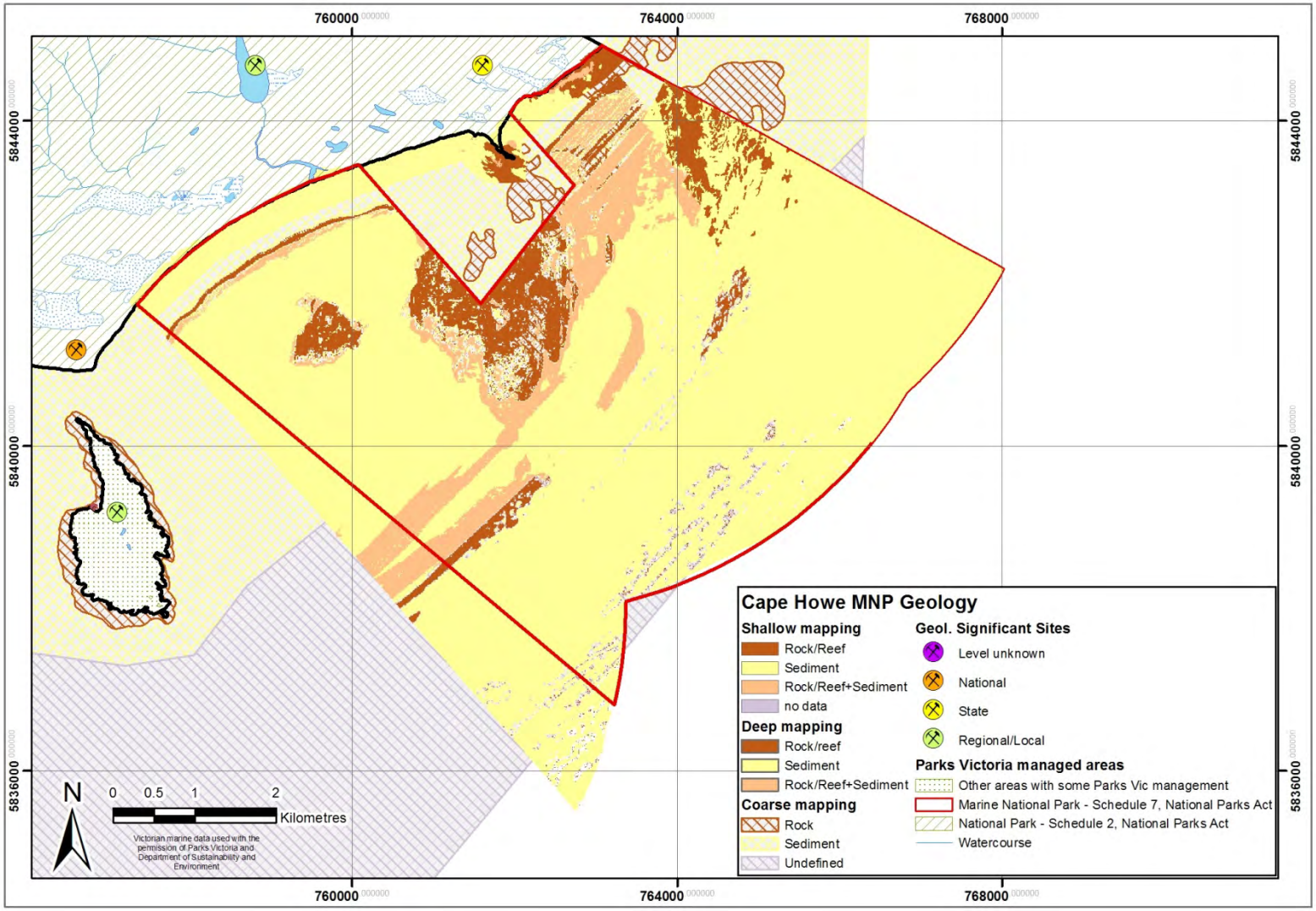


Figure 32. Substrate mapping of Cape Howe Marine National Park showing sites of geological significance.

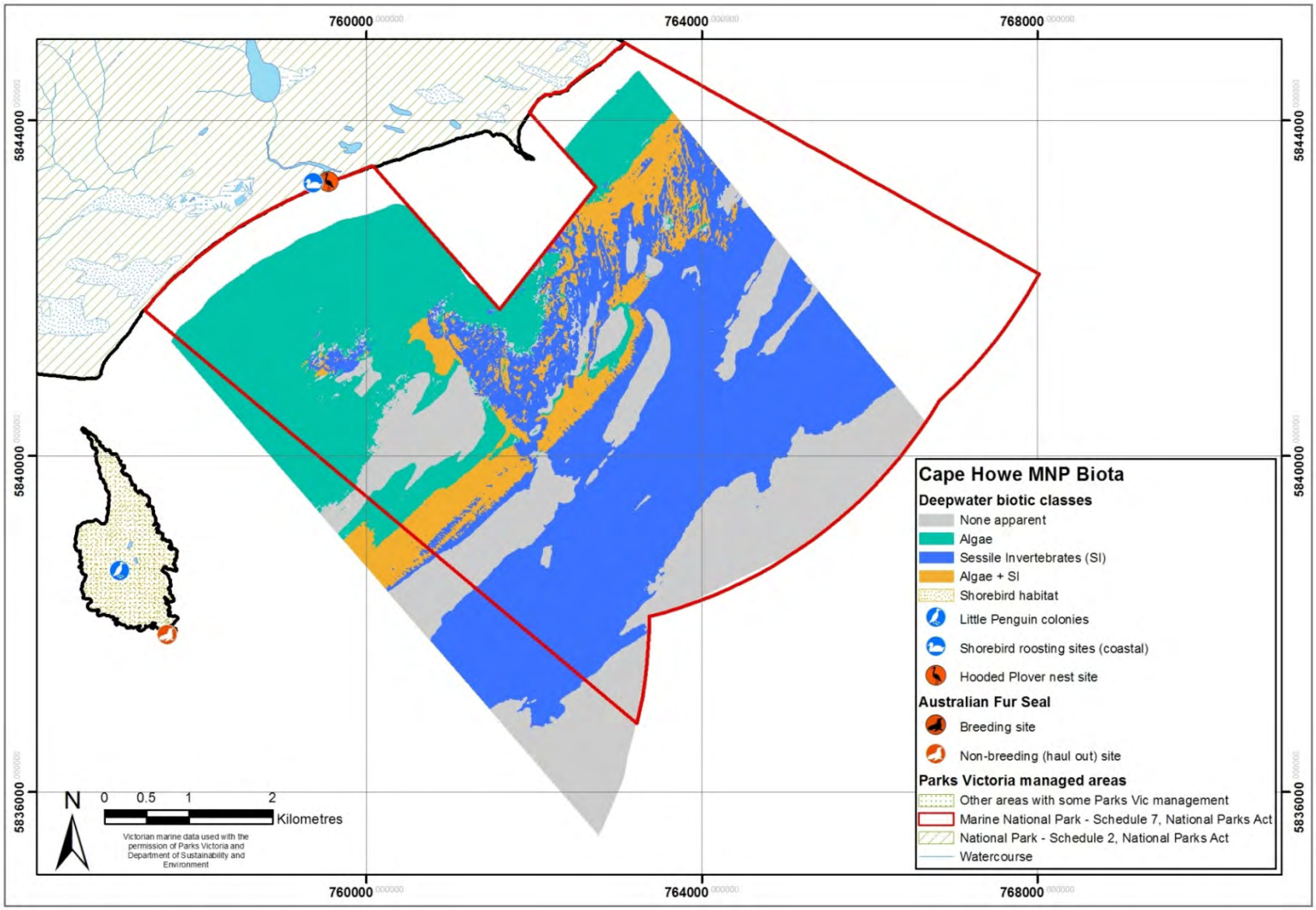


Figure 33. Biota mapping of Cape Howe Marine National Park showing sites of biological significance

2.4.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) there have been extensive monitoring and mapping surveys conducted in Cape Howe MNP. There has been extensive broadscale habitat mapping, with the intertidal areas mapped from aerial and satellite imagery (Ball and Blake 2007) and the deep subtidal areas mapped with hydroacoustic surveys (Holmes *et al.* 2007b). Both surveys were ground truthed with underwater video imagery. There have been four SRMP surveys of the shallow subtidal reef biota of Cape Howe which are summarised by Williams *et al.* (2007) and Edmunds *et al.* (2010b). In addition to the SRMP fish surveys, benthic deep water (> 10 m) fish have been surveyed with baited video in 2006 (Moore *et al.* 2008; Moore *et al.* 2009). A total of 74 species of fish belonging to 39 families were sampled over subtidal sediments and reef (Moore *et al.* 2008). Additional funding has allowed samples from deep subtidal soft sediment surveyed in the MNP in 1998 to be processed and identified (Heislers and Parry 2007). There have been no surveys of sandy beaches, intertidal reef or the pelagic habitats. Important locations for some birds and mammals are shown in Figure 33. Surveys in the MNP found that red algae dominate the diversity of macrophytes, gastropods, decapod crustaceans and echinoderms the invertebrates and fish and birds the vertebrates in Cape Howe MNP (Table 22, Appendix 1).

Figure 34. A canopy of the kelp *Ecklonia radiata* with an understorey of small algae on a reef in Cape Howe Marine National Park.

Table 22. Summary of the number of species in major biotic groups from surveys in Cape Howe Marine National Park.

Biotic group	Number of species
Macrophytes	**59**
Green algae	3
Brown algae	13
Red algae	39
Seagrasses	4
Invertebrates	**57**
Decapod crustaceans	14
Chitons	1
Gastropods	27
Sea slugs	3
Cephalopods	1
Echinoderms	11
Vertebrates	**124**
Fish	40
Birds	63
Reptiles	5
Mammals	6

Intertidal

Soft sediment

As noted by Plummer *et al.* (2003) no specific data on the biota on sandy beaches are available in the MNP or nearby. Intertidal soft sediment flora is restricted to macroalgae drift and macroalgal epiphytes. Beach-washed materials in sandy beach habitats are a significant source of food for many shore birds, and contribute to the detrital cycle that nourishes many of the invertebrates, such as bivalves, living in the sand (Parks Victoria 2006c).

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 are 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 the food itself (Underwood and Chapman 2004). The remote location of the MNP means that human threats to the intertidal reef such as biota collection and trampling is low, due to this there is has been no intertidal reef monitoring program in Cape Howe MNP.

Macroalgae and Aggregating Sessile Invertebrates

The dominant intertidal algae in Cape Howe MPA are sea lettuce *Ulva australis*, neptune's necklace *Hormosira banksii* and various coralline red algae (Plummer *et al.* 2003). The bull

kelp *Durvillaea potatorum* occurs on the intertidal fringe and most of the upper intertidal rocks are unvegetated (Plummer *et al.* 2003).

Mobile Invertebrates
The upper intertidal is dominated by barnacles *Tesseropora rosea*, *Chthamalus antennatus* and mussels *Xenostrobus pulex* with Sydney rock oyster *Saccostrea glomerata*, red bait crabs *Plagusia chabrus*, keyhole limpets Fissurellidae and Paguridae hermit crabs are also present in rock pools (Plummer *et al.* 2003). In deeper pools, the elephant snail *Scutus antipodes*, abalone *Haliotis rubra* and *Haliotis coccoradiata*, seastars *Patiriella* spp. and swift-footed crab *Leptograpsus variegatus* are common (Plummer *et al.* 2003).

Fish
Intertidal fish communities have not been surveyed at Cape Howe MNP. Little is known about intertidal fish, although sea mullet *Mugil cephalus* are sometimes caught in rockpools in Cape Howe MNP (Plummer *et al.* 2003).

Subtidal

Soft sediment

Extensive macroalgal beds occur on sediment and sediment covered reef 10 to 40 m deep in Cape Howe MNP (Holmes *et al.* 2007b). These beds differentiate into *Caulerpa* dominated beds in 30 to 40 m (Holmes *et al.* 2007b). Sponges dominate sediment deeper than 40 m. Orange ball sponges of the genus *Tethy*a dominate sediments in 40 to 60 m depth in the MNP (Holmes *et al.* 2007b).

Depth and sediment type affect the distribution of benthic invertebrates along the Victorian coast. A statewide coastal survey of benthic fauna by Coleman *et al.* (2007) and Heislers and Parry (2007) included the benthos of Cape Howe MNP. One transect off Cape Howe MNP sampled the soft sediment with two 0.1 m^2 grab samples in 10 and 20 m of water depth. The fine sand contained between 142 to 162 individuals from 16 to 26 families with 68 to 207 species (Heislers and Parry 2007). Representation of major taxa was relatively consistent between depths. Crustaceans were the dominant taxa including amphipods, cumaceans, isopods and ostracods (Heislers and Parry 2007). Polychaetes were also common while molluscs were poorly represented. Seven families were common in both depth classes, including four crustacean families, three amphipods (Phoxocephalidae, Urohaustoriidae and Ampeliscidae), one cumacean (Gynodiastylidae) and three polychaete families (Spionidae, Syllidae and Paraonidae).

In waters > 10 m the most common fish over sediments is yellow scad *Trachyurus novaezelandiae*, juveniles dominate the shallower sediments whereas schools of adults were found in the deeper sediments (Moore *et al.* 2008). The ocean leatherjacket *Nelusetta ayraudi* is common over the deeper sediments whilst schools of whiting *Sillago* species are commonly sighted over more shallow sediment (Moore *et al.* 2008). Grubfish *Parapercis* sp. and flathead *Platycephalus* like ocean leather jackets are associated with deep sediments. The eastern blue-spotted flathead *Platycephalus caeruleopunctatus* is found throughout the relatively shallower depths of the MNP (<68 m) (Moore *et al.* 2009). It lives on sandy, flat, sparsely vegetated or bare sediment and on sediment covered reef (Moore *et al.* 2009). The velvet leatherjacket *Meuschenia scaber* and the butterfly perch *Caesioperca lepidoptera* are common over both sediment and reef (Moore *et al.* 2008). The draughtboard shark *Cephaloscyllium laticeps* is also common across the MNP and predominately lives over both sediment and reef < 59 m (Moore *et al.* 2009). It can be found down to the deepest depths (105 m) of the MNP (Moore *et al.* 2009).

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). Shallow subtidal reefs are often dominated by canopy forming algae. Deep reefs, where light penetration is limited, are often dominated by large sessile invertebrates such as massive sponges (Figure 38), whip corals, soft corals and colonial ascidians. Biotic assemblages can form habitat and food sources for invertebrates and fish. The biota of the Cape Howe MNP comprises both southern and eastern Australian temperate species. Assemblages vary according to the location, depth and exposure (Williams *et al.* 2007).

Flora

The inshore reef is dominated by a mixture of crayweed *Phyllospora comosa* and bull kelp *Durvillaea potatorum,* the reef further offshore tends to be dominated by *P. comosa* (Ball and Blake 2007; Williams *et al.* 2007). The algal understorey (Figure 34) at Cape Howe is dominated by encrusting coralline algae, with only sparse cover of erect fleshy understorey species (Williams *et al.* 2007). The brown algae *Carpomitra costata*, *Zonaria turneriana* and *Halopteris* spp, red algae *Delisea pulchra*, *Phacelocarpus peperocarpus*, *Rhodymenia linearis, Galaxaura marginate* are the common fleshy understorey species (Williams *et al.* 2007). *Arthrocardia wardii* and *Haliptilon roseum* are the common erect coralline algae. The Phyllospora canopy is particularly dense in places, with little light at the reef surface which is covered by sponges rather than algae (Williams *et al.* 2007). Deeper waters have macroalgal beds on sand covered reef, including large beds of the green algae *Caulerpa* in the north-east of the MNP (Holmes *et al.* 2007b; Figure 36).

Invertebrate fauna

An important invertebrate of the Cape Howe MNP and the eastern Twofold Shelf bioregion is the long-spined black sea urchin *Centrostephanus rodgersii* (Williams *et al.* 2007; Edmunds *et al.* 2010b). *Centrostephanus* forms large grazing aggregations which denude the reef of erect algal species, forming 'urchin barrens'. Urchin barrens have been observed in Cape Howe MNP (Ball and Blake 2007; Holmes *et al.* 2007b; Williams *et al.* 2007; Edmunds *et al.* 2010b). The occurrence of urchin barren habitat at this location reflects the influence of species from the east coast of Australia on the Twofold Shelf bioregion. Removal of large seaweeds by *Centrostephanus* causes substantial changes to subtidal reef community structure on reefs in eastern temperate Australia (Williams *et al.* 2007; Edmunds *et al.* 2010b).

There are high abundances of large herbivorous invertebrates on shallow subtidal reefs in Cape Howe MNP including the sea urchin *Centrostephanus rodgersii*, blacklip abalone *Haliotis rubra*, the warrener *Turbo undulatus* and another turban shell *Astralium tentoriformis* (Williams *et al.* 2007). Other common invertebrate grazers are the eastern temperate gastropod *Astralium tentoriformis*, and purple sea urchin *Heliocidaris erythrogramma.* Predatory invertebrates include dogwhelks *Dicathais orbita*, eastern rock lobster *Jasus verreauxi*, octopus *Octopus moarum* and a wide variety of seastar species (Williams *et al.* 2007). Other large reef invertebrates include mobile filter feeding animals such as feather stars *Cenolia trichoptera* and sessile (attached) species such as sponges, corals, bryozoans, hydroids and ascidians (Williams *et al.* 2007). Sessile invertebrates such as sponges, asicidians, seawhips and gorgonian corals dominate the reef in 30 to 40 m (Holmes *et al.* 2007b).

Fish

Common subtidal reef fish at Cape Howe MNP are herring cale *Odax cyanomelas*, leatherjacket *Meuschenia freycineti*, striped mado *Atypichthys strigatus,* banded morwong *Cheilodactylus spectabilis* and the damselfishes *Parma microlepis* and *Chromis hypsilepis* (Williams *et al.* 2007). Herring cale is an abundant large species of fish. It feeds on kelp and can be an important structuring agent of algal communities when present in high numbers during breeding aggregations. The other kelp feeding species, rock cale *Crinodus lophodon*

is not so abundant (Williams *et al.* 2007). Blue throat wrasse *Notolabrus tetricus* and purple wrasse *Notolabrus fucicola* are generally not very abundant at the MNP, more common is the Maori wrasse *Opthalmolepis lineolate* (Williams *et al.* 2007). The striped mado, damselfish species, eastern hulafish *Trachinops taeniatus* or yellow tail mackerel *Trachurus novaezelandiae* can be numerically dominate at individual sites (Williams *et al.* 2007). The damsel fishes, white ear *Parma microlepis* and the one-spot puller *Chromis hypsilepis* occur together predominantly in 'urchin barrens' (Williams *et al.* 2007). The plankton feeding striped mado is typically highly abundant on reefs in eastern Australia. Large long-finned pike *Dinolestes lewini* occurs widely on the shallow subtidal reefs of Cape Howe MNP (Williams *et al.* 2007).

In waters > 10 m the velvet leatherjacket *Meuschenia scaber* and butterfly perch *Caesioperca lepidoptera* are common over both reef and sediment covered reef (Moore *et al.* 2008). Also associated with these habitats are white ear, Maori wrasse, six-spined leatherjacket *Meuschenia freycineti* and the blue morwong *Nemadactylus douglasii* (Moore *et al.* 2009). The eastern blue grouper *Achoerodus viridis* is strongly associated with solid reef and boulders (Moore *et al.* 2009). The green moray *Gymnothorax prasinus* is found only in reef with high topographic complexity as it needs the crevices and holes as refuges during the day (Moore *et al.* 2009).

Water column

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

Figure 35. Shell fragment dominated soft sediment and an erect sponge providing habitat for many invertebrates and fish in 105 m depth in Cape Howe Marine National Park, one of the deepest known parts of Victorian coastal waters.

Figure 36. A bed of the green algae *Caulerpa* with encrusted shells on sandy sediments in Cape Howe Marine National Park.

2.4.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora

No conservation listed marine flora has been recorded in Cape Howe MNP (Parks Victoria 2006c).

Fish

The eastern blue groper *Achoerodus viridis* is present in low numbers in Cape Howe MNP. It is threatened by over fishing and a temporary protection from all fishing in Victoria was introduced in April 2011.

Birds

Thirty-eight conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Cape Howe MNP (Table 23). Twenty-six are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. The Australasian bittern and wandering albatross are regarded as endangered and grey-tailed tattler as critically endangered at the state level. Six birds are listed at both the state and national level, vulnerable nationally under the *EPBC Act 1999*. Twenty-four birds are recognized internationally under the Australia Migratory Bird Agreement with either

China (CAMBA) or Japan (JAMBA). Four conservation listed birds, the sooty oystercatcher *Haematopus fuliginosus*, little tern *Sternula albifrons*, short-tailed shearwater *Ardenna tenuirostris* and white-faced storm-petrel *Pelagodroma marina* have been recorded as breeding in or in the immediate surrounds of the MNP. In addition the masked lapwing *Vanellus miles* and little penguin *Eudyptula minor* have also been recorded breeding in the MNP. The Eastern reef egret *Egretta sacra* has been recorded from the MNP but is no longer present.

Table 23. Conservation listed shorebird and seabird records from Cape Howe Marine National Park and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
common sandpiper	*Actitis hypoleucos*		VU		C	J
red knot	*Calidris canutus*		NT		C	J
curlew sandpiper	*Calidris ferruginea*				C	J
red-necked stint	*Calidris ruficollis*				C	J
Latham's snipe	*Gallinago hardwickii*		NT		C	J
grey-tailed tattler	*Heteroscelus brevipes*	L	CR		C	J
Eastern curlew	*Numenius madagascariensis*		NT		C	J
whimbrel	*Numenius phaeopus*		VU		C	J
bar-tailed godwit	*Limosa lapponica*				C	J
ruddy turnstone	*Arenaria interpres*				C	J
Australasian bittern	*Botaurus poiciloptilus*	L	EN			
lesser sand plover	*Charadrius mongolus*		VU		C	J
Pacific golden plover	*Pluvialis fulva*		NT		C	J
hooded plover	*Thinornis rubricollis*	L	VU			
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
common tern	*Sterna hirundo*				C	J
white-fronted tern	*Sterna striata*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
Eastern reef egret	*Egretta sacra*				C	
Pacific gull	*Larus pacificus*		NT			
black-faced cormorant	*Phalacrocorax fuscescens*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
little tern	*Sternula albifrons*	L	VU		C	J
fairy prion	*Pachyptila turtur*		VU	VU		
Wilson's storm-petrel	*Oceanites oceanicus*					J
white-faced storm-petrel	*Pelagodroma marina*		VU			
common diving-petrel	*Pelecanoides urinatrix*		NT			
sooty shearwater	*Ardenna grisea*				C	J
wedge-tailed shearwater	*Ardenna pacifica*					J

Common name	Scientific name	Victorian listing FFG	Victorian listing VROTS	National listing EPBC	International treaty CAMBA	International treaty JAMBA
short-tailed shearwater	*Ardenna tenuirostris*					J
Arctic jaeger	*Stercorarius parasiticus*					J
pomarine jaeger	*Stercorarius pomarinus*				C	J
Buller's albatross	*Diomedea bulleri*	L		VU		
wandering albatross	*Diomedea exulans*	L	EN	VU		J
shy albatross	*Thalassarche cauta*	L	VU	VU		
yellow-nosed albatross	*Thalassarche chlororhynchos*	L	VU	VU		
black-browed albatross	*Thalassarche melanophris*		VU	VU		

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

Marine mammals and reptiles

The southern right whale *Eubalaena australis* and humpback whale *Megaptera novaeangliae* have been recorded in or near the Cape Howe MNP (Table 24). The southern right whale *E. australis* is listed as critically endangered in Victorian waters and endangered nationally. The humpback whale *M. novaeangliae* is listed as vulnerable at the state and national level. The southern right whale *E. australis* has been observed to calf in the MNP. The state vulnerable New Zealand fur seal *Arctophoca forsteri* has also been recorded breeding in the MNP. The state and nationally listed leatherback turtle *Dermochelys coriacea* and the nationally vulnerable green *Chelonia mydas* and hawksbill *Eretmochelys imbricata* turtles have been recorded from the park. Three other listed marine reptiles occur as warm water transients along the eastern Victorian coast: loggerhead turtle *Caretta caretta*, Pacific ridley *Lepidochelys olivacea* and yellow-bellied sea snake *Pelamis platurus* and probably use the waters of the MNP (Plummer *et al.* 2003). The yellow-bellied sea snake has been recorded washed up dead on the beach in the MNP a number of times. The killer whale *Orcinus orca,* minke whale *Balaenoptera sp.,* both migratory species and Australian fur seal *Arctocephalus pusillus doriferus* have been observed in the waters in and around the park.

Table 24. Conservation listed marine mammal and reptile records from Cape Howe Marine National Park and surrounds.

Common name	Scientific name	Victorian listing FFG	Victorian listing VROTS	National listing EPBC	International convention Bonn
southern right whale	*Eubalaena australis*	L	CR	EN	**L**
humpback whale	*Megaptera novaeangliae*	L	VU	VU	L
New Zealand fur seal	*Arctophoca forsteri*		VU		
Australian fur seal	*Arctocephalus pusillus doriferus*			L	
killer whale	*Orcinus orca*			L	L
minke whale	*Balaenoptera sp.*			L	L
leatherback turtle	*Dermochelys coriacea*	L	CR	VU	L
green turtle	*Chelonia mydas*			VU	L
hawksbill turtle	*Eretmochelys imbricata*			VU	L

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

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that Cape Howe MNP did not have any molluscs, echinoderms or decapod crustaceans endemic to the park (O'Hara and Barmby 2000; O'Hara and Poore 2000).

Table 25. Marine species at their distribution limits in Cape Howe Marine National Park (O'Hara and Barmby 2000; O'Hara and Poore 2000).

Order	Family	Species	Common name	Category
Bonnemaisoniales	Bonnemaisoniaceae	*Leptophyllis conferta*	red algae	PE
Ceramiales	Ceramiaceae	*Antithamnion biarmatum*	red algae	PE
Ceramiales	Ceramiaceae	*Callithamnion obstipum*	red algae	PE
Ceramiales	Ceramiaceae	*Ceramium pusillum*	red algae	PE
Ceramiales	Ceramiaceae	*Griffithsia elegans*	red algae	PE
Ceramiales	Ceramiaceae	*Involucrana crassa*	red algae	PE
Ceramiales	Ceramiaceae	*Ochmapexus minimus*	red algae	PE
Ceramiales	Dasyaceae	*Dasya comata*	red algae	PE
Corallinales	Corallinaceae	*Jania puchella*	red algae	PE
Corallinales	Corallinaceae	*Melobesia membranacea*	red algae	PE
Gelidiales	Gelidiaceae	*Gelidium australe*	red algae	PE
Gigartinales	Cystocloniaceae	*Rhodophyllis multipartita*	red algae	PE
Gigartinales	Mychodeaceae	*Mychodea marginifera*	red algae	PE
Gigartinales	Plocamiaceae	*Plocamium mertensii*	red algae	PE
Rhodymeniales	Rhodymeniaceae	*Rhodymenia prolificans*	red algae	PE
Rhodymeniales	Rhodymeniaceae	*Rhodymenia verrucosa*	red algae	PE
Hydrocharitales	Hydrocharitaceae	*Halophila decipiens*	seagrass	PW
Hydrocharitales	Hydrocharitaceae	*Halophila ovalis*	seagrass	PW
Polyplacophora	Acanthochitonidae	*Acanthochitona retrojectus*	chiton	PE
Gastropoda	Fissurellidae	*Emarginula gabensis*	marine snail	PE
Gastropoda	Triphoridae	*Aclophoropsis festiva*	marine snail	PE
Gastropoda	Triphoridae	*Eutriphora tricolor*	marine snail	PE
Gastropoda	Turridae	*Splendrilla subviridus*	marine snail	PN
Gastropoda	Anabathridae	*Pisinna frauenfeldi*	marine snail	PW
Gastropoda	Anabathridae	*Pisinna vincula*	marine snail	PW
Gastropoda	Conidae	*Conus papilliferus*	marine snail	PW
Gastropoda	Haliotidae	*Haliotis coccoradiata*	marine snail	PW
Gastropoda	Triphoridae	*Aclophoropsis maculosa*	marine snail	PW
Gastropoda	Trochidae	*Clanculus floridus*	marine snail	PW
Gastropoda	Turridae	*Austroturris steira*	marine snail	PW
Thalassinidea	Upogebiidae	*Upogebia australiensis*	ghost shrimp	PW
Caridea	Alpheidae	*Alpheus socialis*	shrimp	PW
Caridea	Palaemonidae	*Palaemon debilis*	shrimp	PW
Dendrobranchiata	Penaeidae	*Parapenaeus australiensis*	prawn	PW
Brachyura	Portunidae	*Scylla serrata*	crab	PW
Asteroidea	Goniasteridae	*Tosia magnifica*	seastar	PW
Echinoidea	Echinothuriidae	*Araeosoma thetidis*	sea urchin	PW

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

Thirty-eight biota have been recorded or presumed to be at their distributional limit in Cape Howe MNP (O'Hara and Barmby 2000; O'Hara and Poore 2000; Table 25). Twenty biota are presumed to be at the easterly limit of their distribution in Cape Howe MNP, including 16 red algae, one chiton, and three marine snails. Seventeen biota are presumed to be at their western limit of distribution, including three seagrass, eight marine snails, four shrimps, one crab, one seastar and one sea urchin. One marine snail is presumed to be at its northern limit of distribution (O'Hara and Barmby 2000; O'Hara and Poore 2000). The distributional limits of the biota listed in Table 25 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.

In a study assessing the conservation of shallow subtidal reef fishes in Victoria Colton and Swearer (2009; 2010) observed 71 species of fish at Cape Howe and Gabo Island. They regard seven (Table 26), as species of concern as they are numerically and spatially rare at the state level. Four of these species are fished but low numbers in shallow subtidal reef may be partly because this is not their primary habitat.

Table 26. Fish species of conservation concern because of their limited statewide distribution and abundance recorded at Cape Howe and Gabo Island (Colton and Swearer 2009). Species in bold are targeted for fishing.

Family	Species	Common name	Reason
Carangidae	*Seriola lalandi*	yellowtail kingfish	Unknown, fishery, tends to be pelagic
Cheilodactylidae	*Nemadactylus macropterus*	jackass morwong	Usually deeper, fished
Moridae	*Lotella rhacina*	rock cod	Unknown
Orectolobidae	*Orectolobus sp. (O. maculatus, or O. halei)*	spotted or banded wobbegong	Unknown
Pentacerotidae	*Pentaceropsis recurvirostris*		Unknown
Sphyraenidae	*Sphyraena novaehollandiae*	barracuda	Fishery; prefers different habitat to that sampled
Triakidae	*Mustelus antarcticus*	gummy shark	Fished

2.4.5 MAJOR THREATS

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 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). Five hazards with the potential to be extreme were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Poaching of abalone in commercial quantities leading to decreased abalone populations and consequent impacts on subtidal reef communities (subtidal reef);
2. Lack of ecological knowledge leading to inappropriate management and thus impacts on habitats and communities (all of MNP);
3. Introduced marine pests from recreational boats leading to impacts on relevant ecological communities (potentially all of MNP);
4. Introduced species from commercial vessels (including secondary introductions) leading to changes in community structure (potentially all of MNP); and
5. Anchoring of recreational boats causing physical damage to subtidal reef habitats and communities (subtidal reef).

Figure 37. The introduced screw shell *Maoricolpus roseus* in high densities on deep soft sediments in Cape Howe Marine National Park.

The introduction of marine pests threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). Two introduced species or marine pest has been recorded Point Hicks MNP, the screw shell *Maoricolpus roseus* (Holmes *et al.* 2007a; Figure 37) and the New Zealand sea star *Astrostole scabra* (Edmunds *et al.* 2010b). It is presumed that the introduced green meany or green shore crab *Carcinus maenas* occurs on the intertidal reefs of all the MPAs, except Ninety Mile Beach which has no intertidal reef. Other species of particular concern include the Northern Pacific seastar *Asterias amurensis*, European fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile (subsp fragile)* (Parks Victoria 2003).

The screw shell *Maoricolpus roseus* is a 5 cm long gastropod that was introduced to Tasmania from New Zealand in the 1920s (Bax *et al.* 2003). It has now spread out to the 80 m depth contour off the eastern Victorian and New South Wales coast (Patil *et al.* 2004). In New Zealand it is found from soft sediments to exposed habitats. This habitat flexibility means there is a higher potential for greater ecological and environmental impacts over larger areas than introduced species restricted to specific inshore environments (Patil *et al.* 2004). The dense beds of this invasive species change the benthic structure with unknown (and unexamined) effects on ecosystem services (Patil *et al.* 2004). It can cover soft sediments with its hard shell, and once dead, its shell provides abundant homes for a particular hermit crab that can use its heavy tapered shell, thus potentially shifting the pre-invasion food web (Bax *et al.* 2003). Dense beds of this burrowing filter feeder may have adverse impacts on native filter feeders, with native turritellids numbers declining with increasing *M. roseus* numbers (Patil *et al.* 2004).

A virus affecting abalone called abalone viral ganglioneuritus has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area

and has been confirmed from Discovery Bay MNP to near Cape Otway (DPI 2009). It is not in the Cape Howe MNP but its spread into the park could have serious long term ecological consequences for rocky reef communities (DPI 2009).

Climate change represents a serious threat to marine ecosystems (McLeod *et al.* 2009) but specific ecological consequences of accelerating climate change are not well understood in marine systems, particularly in temperate systems. Climate change is predicted to increase water temperature, alter chemical composition (salinity, acidity and carbonate saturation), change circulation and productivity), increase frequencies of extreme weather events and exposure to damaging ultraviolet light (UVB), and increase air temperature, cloud cover and sea levels (conservatively 80 cm by 2100; CSIRO-BoM 2007; Fine and Franklin 2007; VCC 2008; McLeod *et al.* 2009). A combined increase in cloud cover and sea level could result in decreased light availability potentially changing benthic flora. Increased storm surges and ocean current changes also have the potential to change the distribution of fauna and flora and could result in loss of habitats (CSIRO-BoM 2007). Intertidal communities will face increased desiccation, storm wave exposure and habitat shift. Changes in the relationship between climate and annual life-history events may force major change in functional groups and consequent ecosystem function (Fine and Franklin 2007). Climate change is also anticipated to modify species recruitment and habitat connectivity, species interactions and disturbance regimes in the marine environment (CSIRO-BoM 2007; Fine and Franklin 2007). A large number of species are at the eastern or northern limit of their distributional range at Cape Howe and such species would be particularly vulnerable to climate change. In contrast, the urchin *Centrostephanus rodgersii*, which is found in Cape Howe MNP, has increased its range down the east coast of Australia to Tasmania and that increase is thought to be linked to climate change with the EAC extending further south (Banks *et al.* 2010).

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

2.4.6 CURRENT RESEARCH AND MONITORING

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007-2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007-2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. The research relevant to Cape Howe 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 27 and Appendix 2).

Table 27. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Cape Howe Marine National Park.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising the allocation of resources for defending Marine Protected Areas against invasive species.
Multiple Research Partners: Marine Monitoring and Marine Natural Values ***University of Melbourne:*** Mick Keough, Paul Carnell Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling data. ***Deakin University:*** Gerry Quinn, Jan Barton, Adam Pope 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.
University of Melbourne: Egemen Tanin, Les Kitchen, Lars Kulik Developing options for improving management of illegal activities in Marine National Parks and Sanctuaries.
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.
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
Community Based Monitoring Reef Life Survey - Subtidal Reefs

Cape Howe MNP does not have an ongoing intertidal reef monitoring program as it has limited intertidal reef area with relatively low human pressure. The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003) in and around the Cape Howe MNP began in 2001. Since that time four sites in the MNP and four reference sites outside of the MNP (Figure 30) have been surveyed over four census events (Edmunds *et al.* 2005; Williams *et al.* 2007; Edmunds *et al.* 2010b). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than ten metres (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water.

Keough and Carnell's (2009) preliminary analysis of the SRMP data from the first three census events up to 2006 was done at the bioregion level of Cape Howe MNP, Point Hicks MNP and Beware Reef MS. The analysis compared sites within MPAs to reference sites

outside the MPAs. They found there was no significant difference in species richness and number of species between MPA and reference sites post-declaration for the Twofold Shelf bioregion. Limitations to this work include the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). All algae analysed had similar percentage cover between MPA and reference sites (Keough and Carnell 2009). The purple sea urchin *Heliocidaris erythrogramma* and dogwelk *Dicathais orbita* showed a greater abundance at reference sites compared to MPA sites (Keough and Carnell 2009). The triton *Cabestana spengleri*, red bait crab *Plagusia chabrus* and *H. erythrogramma* had significant differences in abundance between the various MPAs (Keough and Carnell 2009). The abundance of dominant fish species varied, but were generally similar between MPA and reference sites over time (Keough and Carnell 2009). Mado, purple wrasse and blue-throated wrasse were particularly variable but differences were not related to MPAs (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 MPA declaration, apart from recovery from fishing pressure, is to ensure the protection of the MNP area against future threats to biodiversity and natural processes.

A targeted analysis of monitoring data in relation to conservation outcomes for the park will be done by 2013. The subtidal reef monitoring program will continue to be implemented in Cape Howe MNP. The major directions for monitoring include implementing an expanded and improved monitoring program following a review of the major findings taking into account knowledge generated since park declaration and conservation outcomes developed for the MNPs (Keough *et al.* 2007; Power and Boxshall 2007; Keough and Carnell 2009)

Other ongoing research in Cape Howe MNP includes research being conducted by the University of Melbourne trialling options for improving management of illegal activities in the MNP.

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

2.4.7 KNOWLEDGE GAPS

No new surveys exist for the ecological communities of sandy beaches, intertidal soft sediments. No information exists at present for water column assemblages. Major threats have been identified for Cape Howe MNP but we have limited knowledge of the effect on the natural values, particularly ecological communities.

Figure 38. An adult cat shark in sponges, sea whips and algae in the Cape Howe Marine National Park at about 30 m depth

3 Marine Sanctuaries

3.1 Beware Reef Marine Sanctuary – Twofold Shelf Bioregion

Beware Reef MS is the only Marine Sanctuary in the Twofold Shelf Bioregion, which also contains Ninety Mile Beach, Point Hicks and Cape Howe Marine National Parks. Beware Reef MS is approximately 400 km east of Melbourne, and 5 km south east of Cape Conran and 2.6 km offshore from the Cape Conran Coastal Park. The MS covers 220 hectares and comprises a 1.5 km square around the isolated Beware Reef (Figure 40 & Figure 41) Beware Reef MS is accessible by boat from the West Cape ramp on Cape Conran (Parks Victoria 2006a). The high diversity of marine flora and fauna make Beware Reef MS a highly regarded scuba diving area (ECC 2000). Three steamship wrecks, the *Auckland*, *Ridge Park* and *Albert San* also are important recreational diving venues in the MS (Parks Victoria 2006a).

Aboriginal tradition indicates that the Beware Reef MS is part of the *Country* of the Bidwell people and Gunai/Kurnai people and that other Aboriginal people including the Monero-Ngarigo people and Moogji Aboriginal Council people also have an association with the coastal region of this area (Parks Victoria 2006a).

Important natural values of Beware Reef MS are its isolated intertidal and subtidal granite reef, extensive subtidal soft sediment, and open ocean that provide habitat for a diversity of marine flora and fauna species, including sessile invertebrates, algae, fish and transient whales (ECC 2000; Carey *et al.* 2007b). The intertidal reef provides a haul-out area for Australian *Arctocephalus pusillus doriferus* and New Zealand *Arctophoca forsteri* fur seals (Parks Victoria 2006a; Carey *et al.* 2007b). Stands of bull kelp *Durvillaea potatorum* grow on the reef (Carey *et al.* 2007b; Edmunds *et al.* 2010b). Sponge 'gardens' of soft corals, sponges, sea anemones, ascidians and zooanthids dominate the reef in deep waters. The MS has extensive deep subtidal sandy sediment surrounding the reef (Carey *et al.* 2007b).

In the shallow subtidal (< 10m) the stands of canopy forming algae at Beware Reef MS are generally bull kelp *Durvillaea potatorum* and crayweed *Phyllospora comosa*, with a lesser contribution by the common kelp *Ecklonia radiata* (Edmunds *et al.* 2010b). Red algae dominates the understorey and includes *Rhodymenia wilsonii, Plocamium dilatatum* and *R. linearis* (Edmunds *et al.* 2010b). Beware Reef MS invertebrate assemblages have large numbers of the feather star *Cenolia trichoptera* and high densities of the black sea urchin *Centrostephanus rodgersii* and blacklip abalone *Haliotis rubra* (Edmunds *et al.* 2010b; Figure 47). The herbivorous sea urchin *Centrostephanus rodgersii* can remove all erect algae to create 'urchin barrens' on the reefs in the MNP (Edmunds *et al.* 2010b).

Common fish at Beware Reef MS are blue throated wrasse *Notolabrus tetricus* and purple wrasse *N. fucicola* (Edmunds *et al.* 2010b). Other fish species include the Maori wrasse *Ophthalmolepis lineolata*, one-spot puller *Chromis hypsilepis,* white-ear damselfish *Parma microlepis* and toothbrush leather jacket *Acanthaluteres vittiger* (Williams *et al.* 2007; Edmunds *et al.* 2010b). Large aggregations of butterfly perch *Caesioperca lepidoptera* are also a feature of the reef (Edmunds *et al.* 2010b).

Beware Reef MS provides important feeding habitat for several threatened bird species such as the shy albatross *Thalassarche cauta* and wandering albatross *Diomedea exulans*, which are listed under both the *Flora and Fauna Guarantee* (*FFG*) Act (1998) and *Commonwealth Environment Protection and Biodiversity Conservation* (*EPBC*) *Act* (1999). Both are listed as vulnerable nationally with the wandering albatross listed as endangered in Victoria. The MS protects feeding areas under the *EPBC Act* (1999) and species that are listed under the Japan–Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird

Agreement (CAMBA, Parks Victoria 2006a). The threatened southern right whale *Eubalaena australis*, humpback whale *Megaptera novaeangliae*, southern elephant seal *Mirounga leonina* and New Zealand fur seal *Arctophoca forsteri* use the MS waters. New Zealand fur seals and Australian fur seals *Arctocephalus pusillus doriferus* use the intertidal reef as a haul-out site for most of the year (Parks Victoria 2006a). The killer whale *Orcinus orca*, bottlenose dolphin *Tursiops truncatus* and common dolphin *Delphinus delphis* have been observed in the waters in and around the park (Parks Victoria 2006a). Seventeen species of marine flora and fauna are believed to be at their eastern or western distributional limits within the MSP.

Serious threats to the Beware Reef MNP include limited ecological knowledge of important processes. Invasive marine pests from commercial and recreational boats; anchor damage; poaching of abalone; increased sediments from catchment runoff; 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 Beware Reef MNP (Parks Victoria 2006a). Ongoing intertidal and subtidal reef monitoring, and specific research aims to increase ecological knowledge about the natural values of, and threats to Beware Reef MNP.

Figure 39. Finger sponge, feather stars, zooanthids and butteryfly perch *Caesioperca lepidotera* on subtidal reef on Beware Reef Marine Sanctuary. Photo by Mark Norman Museum of Victoria.

3.1.1 PHYSICAL PARAMETERS & PROCESSES

Beware Reef MS is 220 hectares in size which makes it the 15th largest of the 24 Marine National Parks or Sanctuaries in Victoria (Table 28, Figure 40). The reef is granite rising from a sandy sea floor (Ball and Blake 2007; Edmunds *et al.* 2010b). The seafloor of the park drops away to 33.5 metres in depth (Figure 41) and the MS is predominately > 20 metres deep (Ball and Blake 2007). Prevailing winds and swells are generally from the south-west and south-east (Parks Victoria 2006a). The MS is influenced by high-energy waves and currents (Parks Victoria 2006a). Tidal variation is 0.9 metres for spring tides and 0.6 metres for neap tides (Plummer *et al.* 2003). Surface water temperatures average 18.5

°C in the summer and 13.5 °C in the winter. The MS is influenced by the warm East Australian Current waters and the cooler Bass Strait waters. The continental slope is close and cold-water upwellings are frequent (ECC 2000). These upwellings provide nutrients to the inshore ecosystems, contributing to high productivity (ECC 2000). No estuaries or intermittent creeks run directly into the park as it is an isolated reef offshore from the coast (Table 28).There are no declared sites of geological or geomorphological or biotic significance in the MS (Figure 42).

Table 28. Physical attributes of the Beware Reef Marine Sanctuary.

Park Name	Beware Reef
Conservation status	Marine Sanctuary
Biophysical Region	Twofold Shelf
Size	220 ha (ranked 15th of 24)
Length of adjacent coastline	0 km
Shoreline geology	Granite
Area with depth:	
<5 m	1 ha
5- 10 m	3 ha
10-20 m	14 ha
20-30 m	116 ha
30-40 m	86 ha
Mean tidal variation - spring	0.9 m
Mean tidal variation - neap	0.6 m
Mean water temp - summer	18.5
Mean water temp - winter	13.5
Adjacent catchment	offshore of Cape Conran Coastal Park
Discharges into MS	none
Nearest major estuary (distance & direction)	Yeerung River 3 km north east

3.1.2 MARINE HABITAT DISTRIBUTION

Mapping of habitats is important for understanding and communicating the distribution of natural values within Marine National Parks and Sanctuaries, particularly as the marine environment is not as easily visualised as the terrestrial environment (Parks Victoria 2003). For management purposes, knowledge of the distribution and extent of habitats is required to target management activities, including emergency response, monitoring and research effectively. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities.. The main habitats present in Beware Reef MS include some intertidal reef, extensive subtidal soft sediment, subtidal reef, and the water column (Parks Victoria 2006a). The subtidal habitat of the Beware Reef MS has been mapped by a detailed bathymetric survey in 2005 (Ball and Blake 2007) followed by LiDAR bathymetric surveys in 2009 (Figure 41). A narrow ridge of reef extends to the south east from the small intertidal reef in the north-west sector of the MS (Figure 41). The exposed intertidal reef is a gently rounded 0.3 hectare granite platform, which is wave-swept in high seas (Parks Victoria 2006a). The subtidal reef profile in the shallower water consists of small gullies, slopes and flats down to ten metres (Edmunds *et al.* 2010b). Below this the high profile reef generally drops off steeply into deeper water and consists of walls, broken reef, gutters and outcrops (Plummer *et al.* 2003; Edmunds *et al.* 2010b). The reef has steep drop-offs on the northern side, with urchin-modified habitat and sessile invertebrate wall fauna below the kelp zone (Edmunds *et al.* 2005). Immediately surrounding the reef ridge the seabed is relatively flat soft sediment and approximately 20 to 30 metres deep (Ball and Blake 2007).

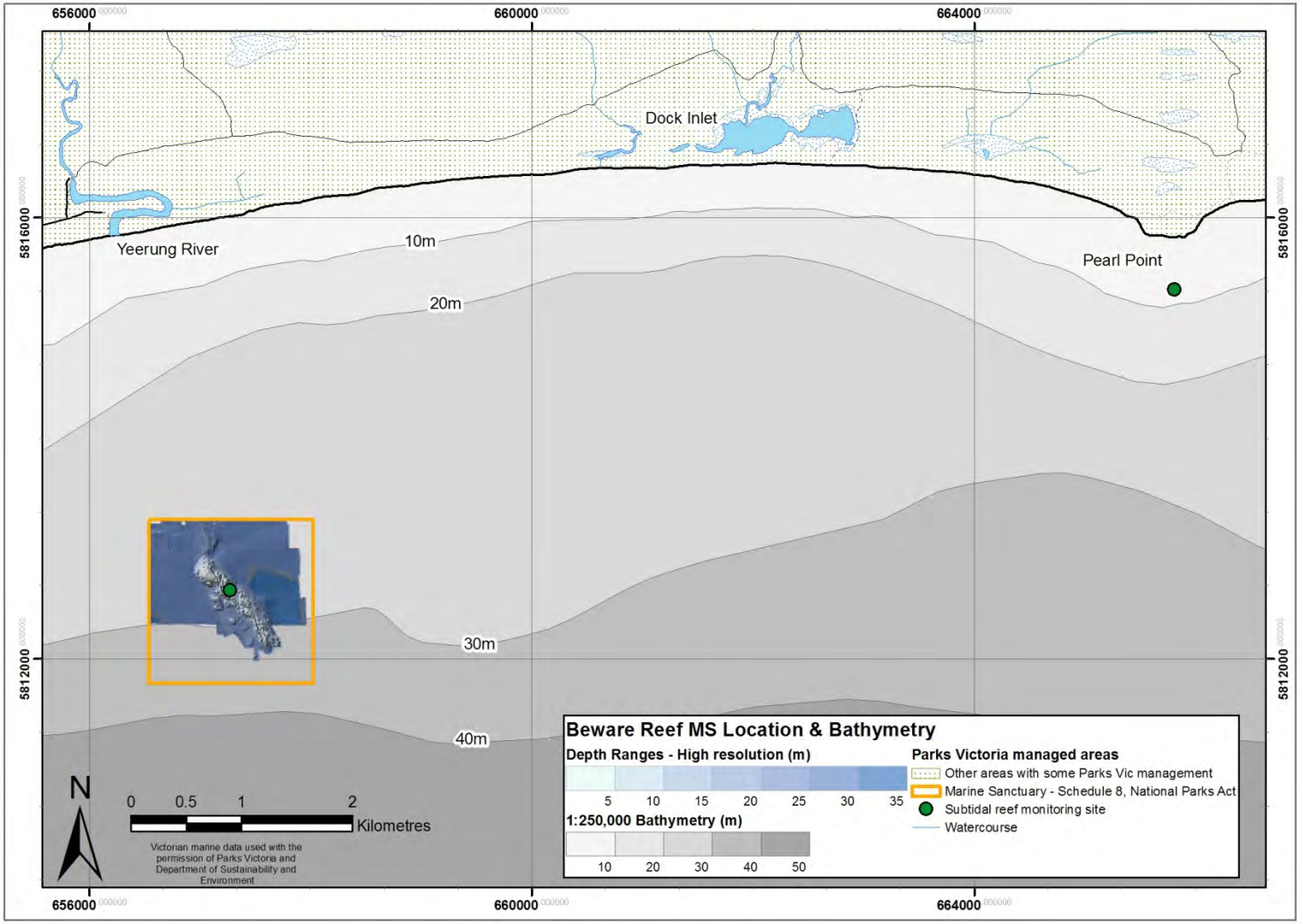


Figure 40. Location map of Beware Reef Marine Sanctuary with bathymetry. Subtidal reef monitoring sites inside and outside the MS are shown, there are no intertidal monitoring sites.

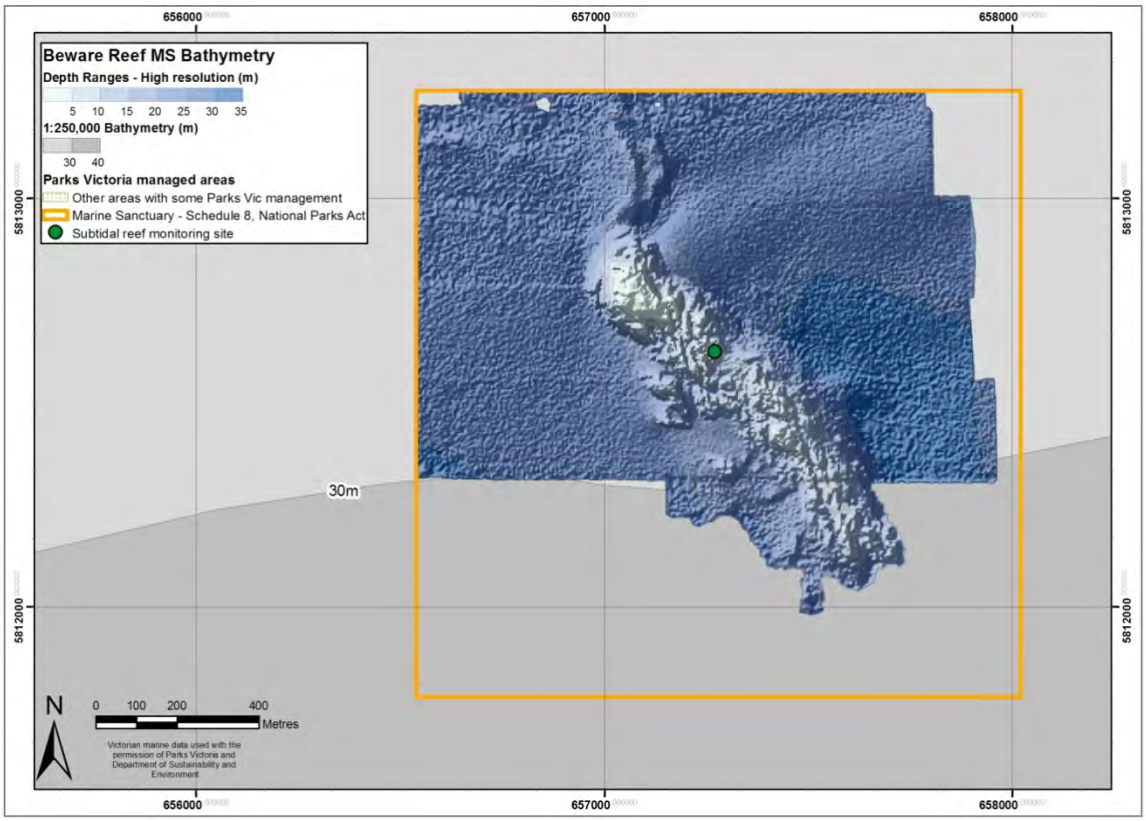


Figure 41. Bathymetry of Beware Reef Marine Sanctuary

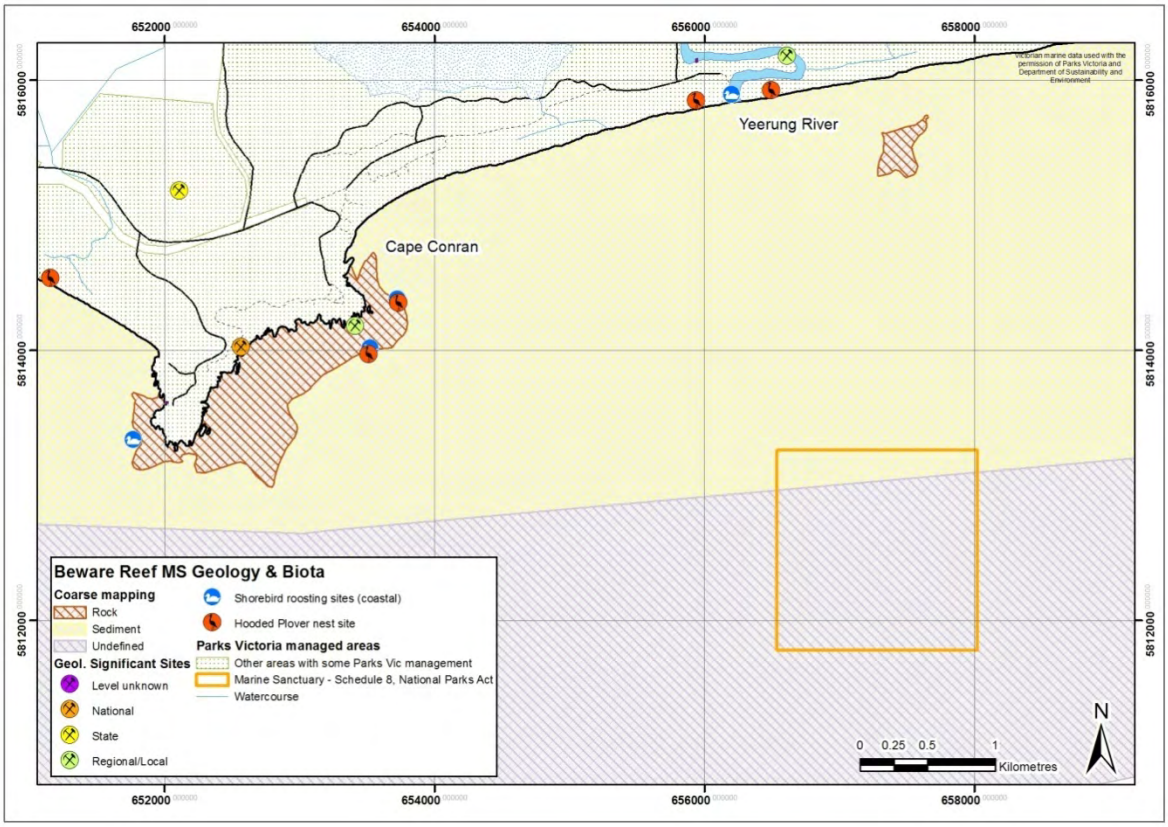


Figure 42. Geological and biotic significant sites near Beware Reef Marine Sanctuary.

3.1.3 MARINE ECOLOGICAL COMMUNITIES

General

Since the first natural values report by Plummer *et al.* (2003) Parks Victoria has invested in monitoring and mapping surveys in Beware Reef MS. This includes detailed bathymetric mapping (Figure 41) of the MS (Ball and Blake 2007). There have been four SRMP surveys of the shallow subtidal reef biota of Beware Reef MS (Edmunds *et al.* 2005; Williams *et al.* 2007; Edmunds *et al.* 2010b). There have been no surveys of the biota of intertidal reef or the pelagic habitats. From surveys so far (Table 29), red algae dominate the diversity of macrophytes, fish and birds the vertebrates, however many more species of biota have been identified and photographed by Friends of Beware Reef. Nearby important locations for some birds is shown in Figure 42 but there are no recognised significant biota sites in the MS.

Table 29. Summary of the number of species in major biotic groups found in Beware Reef Marine Sanctuary.

Biotic group	Number of species
Macrophytes	**19**
Brown algae	7
Red algae	12
Invertebrates	**9**
Decapod	3
Chitons	3
Echinoderms	3
Vertebrates	**53**
Fish	17
Birds	29
Reptiles	1
Mammals	7

Figure 43. Superb feather hydroid *Gymnangium superbum* in Beware Reef Marine Sanctuary. Photo taken by Friends of Beware Reef Marine Sanctuary.

Intertidal

Soft sediment

There is no intertidal soft sediment habitat in Beware Reef MS.

Reef

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

The exposed intertidal reef is a 0.3 hectare gently rounded offshore granite platform, which is wave-swept in high seas (Parks Victoria 2006a). Thick stands of bull kelp *Durvillaea potatorum* dominate the lower intertidal reef, with coralline algae and fleshy green and brown algae occurring elsewhere (Parks Victoria 2006a). *Durvillaea* is more abundant along the exposed southern side of the island (Edmunds *et al.* 2005).The cunjevoi *Pyura stolonifera* is the dominant invertebrate on the intertidal reef (Parks Victoria 2006a). Large barnacles and mussels cover much of the rock, while other areas are bare (Parks Victoria 2006a).

As noted by Plummer *et al.* (2003) no specific data on the biota of intertidal reefs are available for Beware Reef MS.

Subtidal

Soft sediment

Deep subtidal soft sandy sediment is widespread within the MS. No biological surveys have been undertaken of this community within the sanctuary to date, but it probably supports numerous polychaetes, isopods, gastropods, euphausiids, ophiuroids, bivalves, amphipods, cumaceans and cephalopods (Plummer *et al.* 2003). A trawl survey conducted 10 km west of the sanctuary indicates that the presence of some species of fish is seasonal. Common species found included: sparsely spotted stingaree *Urolophus paucimaculatus*, gurnard *Lepidotrigla spp.*, flathead *Platycephalus spp.*, common gurnard perch *Neosebastes scorpaenoides*, banded stingaree *Urolophus cruciatus* and school whiting *Sillago bassiensis* (Bird & Watson 1993 as reported in Plummer *et al.* 2003). Numerous shark species were also found in the survey: swell *Cephaloscyllium laticeps*, angel *Squatina australis*, spotted cat *Asymbolus analis*, southern saw *Pristiophorus nudipinnis*, elephant *Callorhynchus milii*, gummy *Mustelus antarcticus* and Port Jackson *Heterodontus portusjacksoni* sharks. Newborn pups of gummy sharks inhabit shallow inshore areas and there is some evidence to suggest that the inshore sandy areas east of Wilsons Promontory, including Beware Reef MS, may be important feeding areas for gummy shark pups (Plummer *et al.* 2003).

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 (< 15 m) subtidal reefs are known for their high biological complexity, species diversity and productivity and in addition they have significant economic value through commercial and recreational fishing (outside of MPAs), diving and other tourism activities (Power and Boxshall 2007). Shallow subtidal reefs are often dominated by canopy forming algae. Deep reefs, where light penetration is limited, are often dominated by large sessile invertebrates such as massive sponges, whip corals, soft corals and colonial

ascidians (Power and Boxshall 2007). Deep reef assemblages contain a unique combination of organisms and the biological and physical differences mean that deeper areas may also respond differently to threats.

Flora

Seaweeds provide important habitat structure for other organisms on the reef. This habitat structure varies considerably, depending on the type of seaweed species present (Williams *et al.* 2007). The major canopy species of the shallow reef at Beware Reef MS are bull kelp *Durvillaea potatorum* and crayweed *Phyllospora comosa*, with a lesser contribution by the common kelp *Ecklonia radiata* (Edmunds *et al.* 2010b). These species have large, stalk-like stipes and form a canopy 0.5 - 2 m above the rocky substratum (Williams *et al.* 2007). Lower layers of structure are formed by red algae typically 10 - 30 cm high and includes *Rhodymenia wilsonii, Plocamium dilatatum* and *R. linearis* (Edmunds *et al.* 2010b). There is a general absence of green algal and filamentous brown and red turf species (Edmunds *et al.* 2010b). Beware Reef has a similar shallow reef flora to the monitored sites at Point Hicks, including a similar mixed algal canopy and a higher cover of fucalean species, such as *Cystophora* spp. and *Sargassum* spp., and fleshy thallose red algae (Edmunds *et al.* 2010b). The cover of crustose coralline algae at Beware Reef MS varies a lot between monitoring times, but is characterised by a lower cover of encrusting coralline algae than Cape Howe (Edmunds *et al.* 2010b).

Bull kelp *D. potatorum* has not been observed at the other MPA or reference monitoring sites in the bioregion. It is a large robust species adapted to living in highly exposed conditions. Its abundance has been observed to increase with decreasing abundance of *E. radiata* (Edmunds *et al.* 2010b). There have been limited studies on seaweeds in the Twofold Shelf bioregion, but a considerable number of rare and new species have been documented (Edmunds *et al.* 2010b).

Figure 44. Banjo ray *Trygonorrhina fasciata* on subtidal reef in Beware Reef Marine Sanctuary. Photo taken by Friends of Beware Reef Marine Sanctuary.

Figure 45. Female herring cale *Odax cyanomelas* in Beware Reef Marine Sanctuary. Photo taken by Friends of Beware Reef Marine Sanctuary.

Figure 46. Rosy weedfish *Heteroclinus roseus* in the understory of bull kelp *Ecklonia radiata* canopy. Photo taken by Friends of Beware Reef Marine Sanctuary.

Invertebrate fauna

An abundant and diverse range of invertebrates is present on the subtidal reef (Plummer *et al.* 2003; Figures 47 and 48). The invertebrate fauna of the Twofold Shelf bioregion comprises both southern and eastern Australian temperate species. Common invertebrate grazers found at Beware Reef MS include the tent shell *Astralium tentoriformis* and elephant snail *Scutus antipodes* (Williams *et al.* 2007). Predatory invertebrates include the triton *Cabestana spengleri*, octopus *Octopus moarum* and a wide variety of seastar species (Williams *et al.* 2007). Other large reef invertebrates include mobile filter feeding animals such as feather stars *Cenolia trichoptera* and sessile (attached) species such as sponges, corals, bryozoans, hydroids (see Figure 48) and ascidians (Williams *et al.* 2007). The holdfasts of *E. radiata* are encrusted with sponges, worms and the brittle stars *Ophiothrix spongicola* and *O. caespitose* (Plummer *et al.* 2003).

Beware Reef invertebrate fauna is similar to both the Point Hicks and Cape Howe monitored sites. It has large numbers of the mobile filter feeding feather star *Cenolia trichoptera* like Point Hicks and high densities of the black sea urchin *Centrostephanus rodgersii* and blacklip abalone *Haliotis rubra* like Cape Howe (Edmunds *et al.* 2010b). The purple urchin

Heliocidaris erythrogramma is also abundant at the MS (Williams *et al.* 2007). The abundance of legal sized abalone appears to have increased in the MPAs of Twofold Shelf bioregion since declaration (Edmunds *et al.* 2010b). The black sea urchin *C. rodgersii* can form large grazing aggregations which denude the reef of erect algal species, forming 'sea urchin barrens' and these have been observed in the MS (Edmunds *et al.* 2010b). The occurrence of urchin barren habitat reflects the influence of species from the east coast of Australia on the MS (Williams *et al.* 2007). Removal of large seaweeds by *Centrostephanus* causes substantial changes to subtidal reef community structure (Williams *et al.* 2007).

Deep on the subtidal reefs (> 20 m) sessile invertebrates dominate with 'gardens' of massive erect sponges, encrusting sponges, gorgonian coral, sea-whip coral, zooanthids and basket stars (ECC 2000; Edmunds *et al.* 2005). The northern side of the reef has steep drop-offs, with urchin-modified habitat and sessile invertebrate wall fauna below the kelp zone (Edmunds *et al.* 2005). The sea urchins *C. rodgersii* and *H. erythrogramma*, and the feather star *C. trichoptera* were particularly prominent on the northern side (Edmunds *et al.* 2005). Anemones *Anthothoe albocincta* and *Balanophyllia bairdiana*, encrusting sponges and large finger sponges, colonial *Botrylloides* sp. and stalked ascidians are abundant on deeper vertical faces and in shaded gutters on the reef where limited light penetration reduces algae cover (Plummer *et al.* 2003). Crinoids *Cenolia trichoptera* and *C. tasmaniae* of green, orange and white colour morphs are common in cracks (Plummer *et al.* 2003). Hydroids, gorgonians *Mopsella* sp. and *Capnella* sp. and sea whips *Primnoella australasiae* are common towards the base of the reef (Plummer *et al.* 2003). The jewel anemone *Corynactis australis* and the nudibranch *Hypselodoris bennetti* are also found on the reef (Plummer *et al.* 2003).

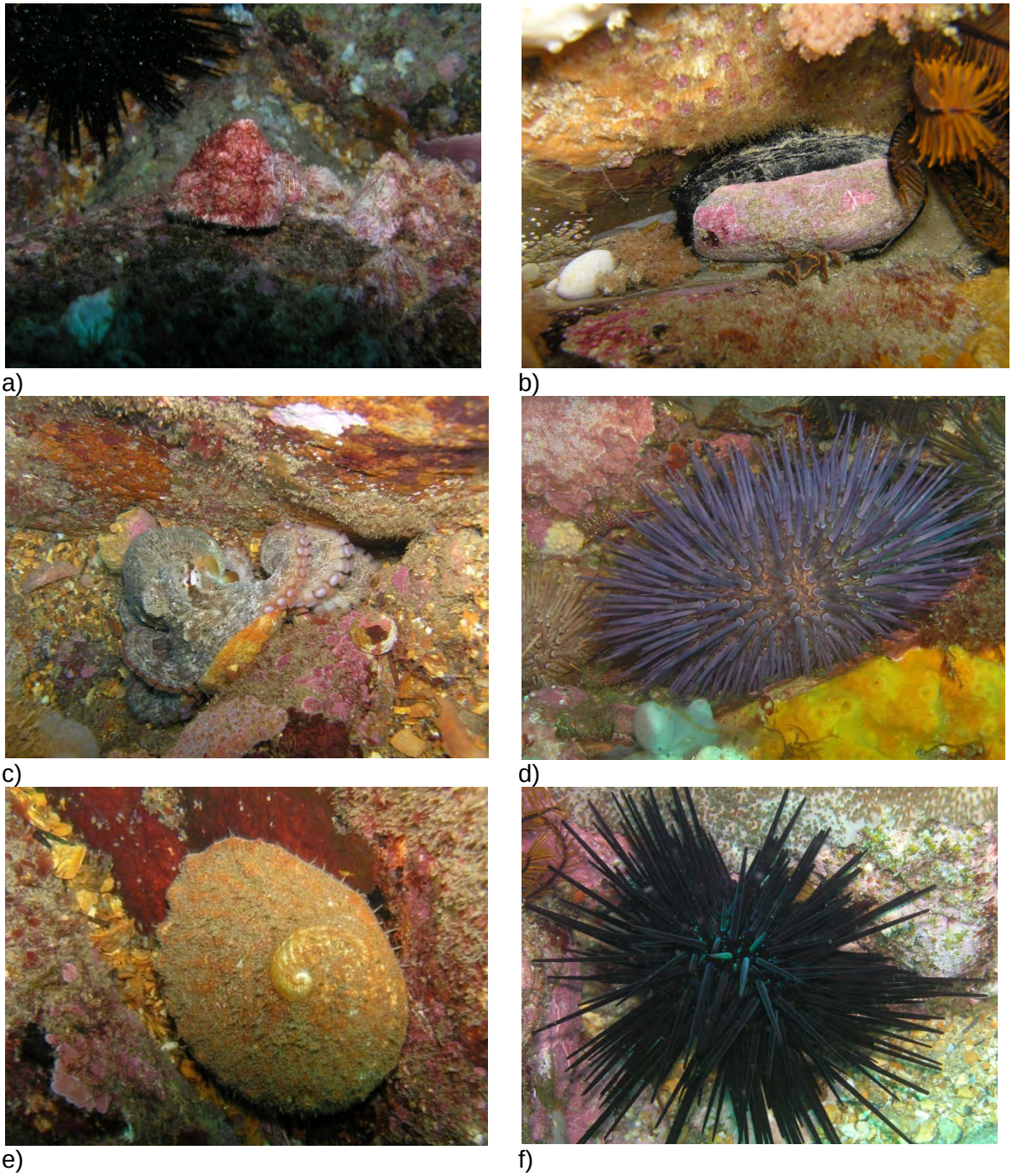
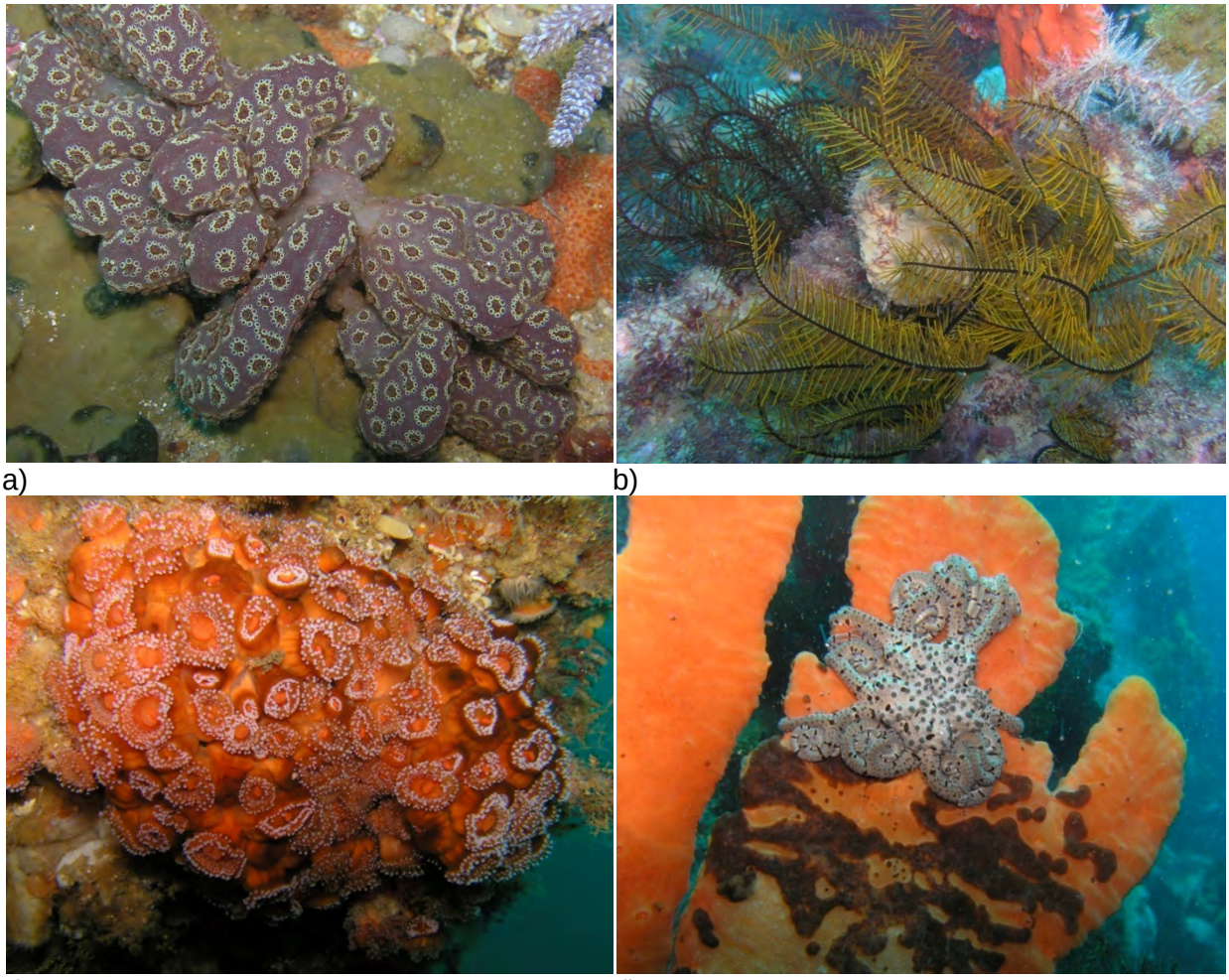


Figure 47. Invertebrate fauna of the subtidal reef in Beware Reef Marine Sanctuary: a) tent shell *Astralium tentoriformis*, b) elephant snail *Scutus antipodes*, c) gloomy octopus *Octopus tetricus*, d) purple urchin *Heliocidaris erythrogramma*, e) blacklip abalone *Haliotis rubra* and f) black sea urchin *Centrostephanus rodgersii*. Photos taken by Friends of Beware Reef Marine Sanctuary.



a) b)

c) d)

Figure 48. Deep subtidal reef invertebrates in Beware Reef Marine Sanctuary: a) ascidian *Botrylloides perspicuus*, b) feather star *Cenolia trichoptera*, c) southern jewel anemone *Corynactis australis* and d) basket star *Conocladius australis* on a sponge. Photos taken by Friends of Beware Reef Marine Sanctuary.

Fish

The fish assemblages associated with *Phyllospora* communities of the Twofold Shelf Bioregion have characteristics typical of both eastern and southern temperate waters, and are therefore quite different to elsewhere in Victoria (Edmunds *et al.* 2010b; Williams *et al.* 2007; Figures 44, 45, 46 and 53).

Wrasse and damselfish were the more abundant species at Beware Reef. Four species of wrasse, the blue throat wrasse *Notolabrus tetricus,* purple wrasse *N. fucicola*, Maori wrasse *Opthalmolepis lineolata* and rosy wrasse *Pseudolabrus psittaculus* are common (Williams *et al.* 2007; Edmunds *et al.* 2010b), although their abundance is variable between surveys (Edmunds *et al.* 2010b). The damsel fish, the one-spot puller *Chromis hypsilepis* and white-ear damselfish *Parma microlepis* are eastern warmer water species that occur in the MS (Edmunds *et al.* 2005; Williams *et al.* 2007; Edmunds *et al.* 2010b; Figure 49). Banded morwong *Cheilodactylus spectabilis* is also common at Beware Reef MS (Williams *et al.* 2007).

Beware Reef MS has very high densities of the plankton feeding butterfly perch *Caesioperca Lepidoptera*, with schools of over 1000 being observed (Figure 50). High densities of butterfly perch are generally associated with reefs of high relief with extension into deep water, such as at Beware Reef (Edmunds *et al.* 2010b). The abundance of this species

makes the MS distinct from other MPAs in the bioregion (Edmunds *et al.* 2005; Edmunds *et al.* 2010b).The rosy wrasse *Pseudolabrus rubicundus*, is also typical of higher relief reefs. Other fish observed in the MS are bullseye *Pempheris sp.,* long-snouted boarfish *Pentaceropsis recurvirostris,* draughtboard shark *Cephaloscyllium laticeps,* sea sweep *Scorpis aequipinnis*, Port Jackson shark *Heterodontus portusjacksoni*, wobbegong Shark *Orectolobus sp.* and weedy sea dragon *Phyllopteryx taeniolatus* (Plummer *et al.* 2003). Fish diversity has been observed to be higher on the northern side of the reef compared to the more exposed southern side (Williams *et al.* 2007).

a) b)

Figure 49. Eastern temperate fish species on Beware Reef Marine Sanctuary: a) juvenile white-ear damsel fish *Parma microlepis*, and b) one-spot puller *Chromis hypsilepis.* Photos taken by Friends of Beware Reef Marine Sanctuary.

Figure 50. School of butterfly perch *Caesioperca lepidoptera* in Beware Reef Marine Sanctuary. Photo by Mark Norman, Museum of Victoria

Water column

The water column as a whole is the largest habitat in the MS and is important in different ways for many organisms including for transit or as a permanent home for particular stages of their life cycle. Organisms that use the water column environment can be broadly grouped into two categories based on mode of movement: either pelagic (actively swimming; Figure 51) or planktonic (drifting with the current). Larger species are often planktonic during early life stages before becoming pelagic as they grow. Smaller species tend to be planktonic but can influence their movement to some extent by controlling their height in the water column. Organisms that make their permanent home in the water column include sea jellies, salps, many fish, and both phytoplankton and zooplankton. Planktonic organisms play an important role in nutrient cycling, dispersal of species and providing food for larger animals, both within the MNP and more broadly in the marine environment. The water column is also used by fish, invertebrates and algae for transport and food (and other resources like oxygen). Parks Victoria does not currently monitor the water column as a habitat (Power and Boxshall 2007). As described in the following section a wide variety of seabirds, mammals and reptiles of conservation significance are found in the waters of Beware Reef MS.

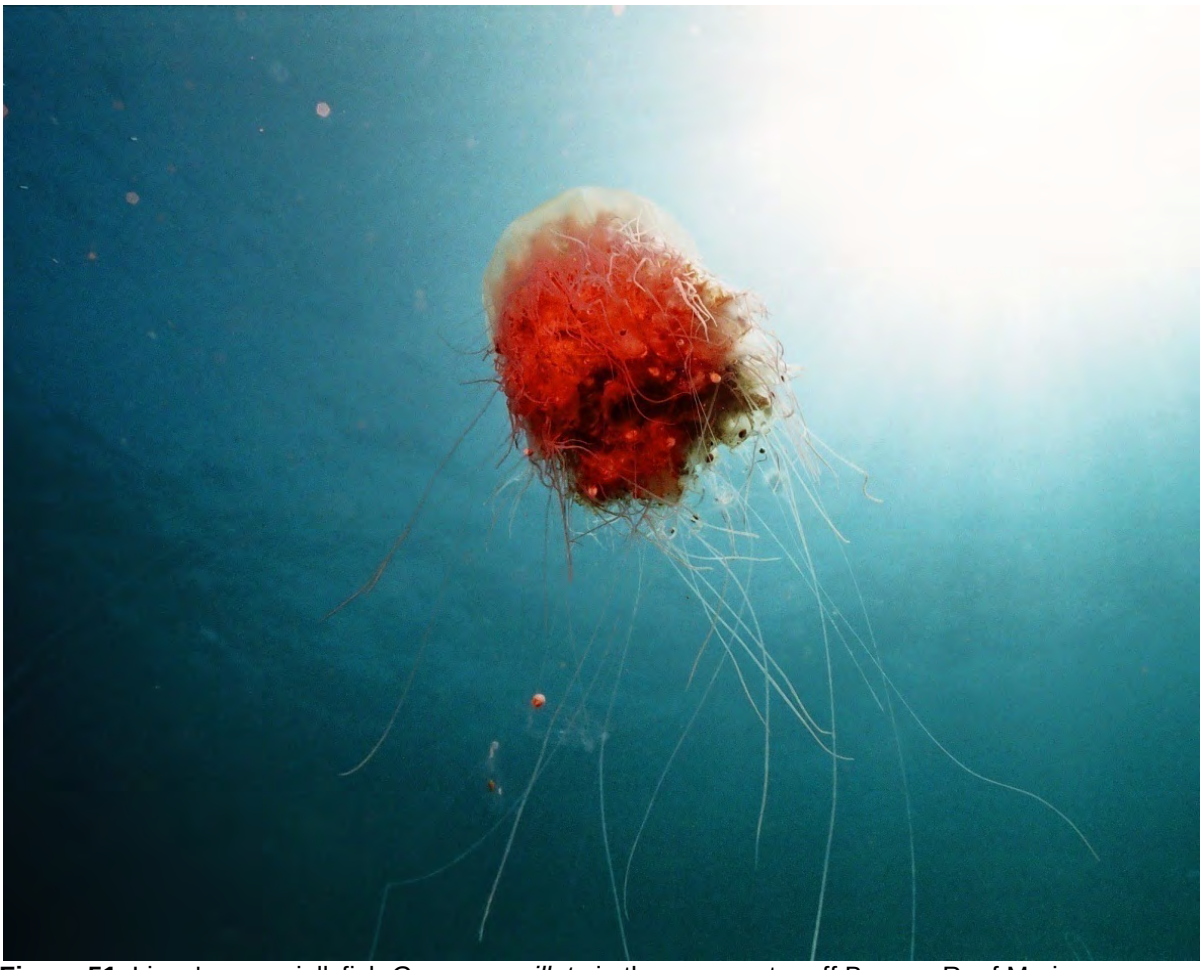


Figure 51. Lions's mane jellyfish *Cyanea capillata* in the open water off Beware Reef Marine Sanctuary. Photo by Friends of Beware Reef Marine Sanctuary.

3.1.4 SPECIES OF CONSERVATION SIGNIFICANCE

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

Flora
No conservation listed marine flora has been recorded in Beware Reef MS (Parks Victoria 2006a).

Fish
No conservation listed fish have been recorded at Beware Reef MS or its immediate surrounds.

Birds
Very few seabird sightings have been recorded for the sanctuary. Seventeen conservation listed shore or sea birds have been sighted in or in the immediate surrounds of Beware Reef MS (Table 30). Twelve are recognized as threatened in Victoria, listed under the *FFG Act 1988* or the Victorian Rare or Threatened Species (VROTS) list. One, the wandering albatross *Diomedea exulans* is regarded as endangered at the state level and vulnerable nationally. Three birds are listed as vulnerable at both the state and national level, including the fairy prion *Pachyptila turtur*, shy *Thalassarche cauta* and yellow-nosed *T. chlororhynchos* albatross. Eleven birds are recognized internationally under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA).

Little Penguins *Eudyptula minor* rest on the exposed reef platform throughout the year, and it is a common roosting and feeding area for other seabirds, particularly pied cormorants *Phalacrocorax varius* and Australian gannets *Morus serrator* (Parks Victoria 2006a).

Table 30. Conservation listed shorebird and seabirds records from Beware Reef Marine Sanctuary and surrounds.

		Victorian listing		National listing	International treaty	
Common name	**Scientific name**	**FFFG**	**VROTS**	**EPBC**	**CAMBA**	**JAMBA**
wandering albatross	*Diomedea exulans*	L	EN	VU		J
shy albatross	*Thalassarche cauta*	L	VU	VU		J
yellow-nosed albatross	*Thalassarche chlororhynchos*	L	VU	VU		J
fairy prion	*Pachyptila turtur*		VU	VU		J
Caspian tern	*Hydroprogne caspia*	L	NT		C	J
white-bellied sea-eagle	*Haliaeetus leucogaster*	L	VU		C	
hooded plover	*Thinornis rubricollis*	L	VU			
ruddy turnstone	*Arenaria interpres*				C	J
common tern	*Sterna hirundo*				C	J
eastern reef egret	*Egretta sacra*				C	
arctic jaeger	*Stercorarius parasiticus*					J
short-tailed shearwater	*Ardenna tenuirostris*					J
royal spoonbill	*Platalea regia*		VU			
Pacific gull	*Larus pacificus*		NT			
pied cormorant	*Phalacrocorax varius*		NT			
sooty oystercatcher	*Haematopus fuliginosus*		NT			
white-fronted tern	*Sterna striata*		NT			

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

Marine mammals and reptiles
Southern right whales *Eubalaena australis*, humpback whales *Megaptera novaeangliae*, southern elephant seals *Mirounga leonina* and New Zealand fur seals *Arctophoca forsteri*

have been recorded in or near the Beware Reef MS (Table 31). The southern right whale *E. australis* is listed as critically endangered in Victorian waters and endangered nationally. The humpback whale *M. novaeangliae* is listed as vulnerable at the state and national level. The southern elephant seal *M. leonina* is listed as vulnerable at the national level and the New Zealand fur seals *A. forsteri* at the state level (Table 31). New Zealand fur seals *A. forsteri* and Australian fur seals *Arctocephalus pusillus doriferus* (Figure 52) use the intertidal reef as a haul-out site for most of the year (Parks Victoria 2006a). The killer whale *Orcinus orca*, bottlenose dolphin *Tursiops truncatus* and common dolphin *Delphinus delphis* have been observed in the waters in and around the park (Parks Victoria 2006a). Fiver other listed marine reptiles occur as warm water vagrants along the eastern Victorian coast: leatherback turtle *Dermochelys coriacea,* loggerhead turtle *Caretta caretta*, green turtle *Chelonia mydas*, Pacific ridley *Lepidochelys olivacea*, and yellow-bellied sea snake *Pelamis platurus* and probably occur in the MNP (Plummer *et al.* 2003). Many other animals, probably use the MS waters but its remoteness means there are few observations.

Table 31. Threatened marine mammal and reptile records from Beware Reef Marine Sanctuary and surrounds.

		Victorian listing		National listing	International convention
Common name	**Scientific name**	**FFG**	**VROTS**	**EPBC**	**Bonn**
southern right whale	*Eubalaena australis*	L	CE	EN	L
humpback whale	*Megaptera novaeangliae*	L	VU	VU	L
southern elephant seal	*Mirounga leonina*			VU	
New Zealand fur seal	*Arctophoca forsteri*		VU	L	
Australian fur seal	*Arctocephalus pusillus doriferus*			L	
Killer Whale	*Orcinus orca*			L	L

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

Figure 52. An Australian fur seal *Arctocephalus pusillus doriferus* in Beware Reef Marine Sanctuary. Photo by Friends of Beware Reef Marine Sanctuary.

Species distribution information

An assessment of distribution, endemism and rarity of biota across the state found that Beware Reef MS had no known endemic or rare biota (O'Hara and Barmby 2000; O'Hara and Poore 2000).

Fifteen biota have been recorded or presumed to be at their distributional limit in Beware Reef MS (Table 32, O'Hara and Barmby 2000; O'Hara and Poore 2000; Plummer *et al.* 2003). One red algae has been recorded as being at the easterly limit of its distribution at Beware Reef MS (Table 32). Five algae and six invertebrates are presumed to be at their eastern limit of their distribution in the Beware Reef MS. Two chitons and one sea urchin are presumed to be at their western limit of distribution. The distributional limits of the biota listed in Table 32 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 32. Marine species at their distribution limits in Beware Reef MS (O'Hara 2002).

Order	Family	Species	Common name	Category
Laminariales	Lessoniaceae	*Macrocystis pyrifera*	brown algae	PE
Sphacelariales	Stypocaulaceae	*Phoiocaulon foecundum*	brown algae	PE
Sporochnales	Sporochnaceae	*Austroneraia australis*	brown algae	PE
Gigartinales	Areschougiaceae	*Rhabdonia coccinea*	red algae	PE
	Cystocloniaceae	*Craspedocarpus ramentaceus*	red algae	PE
	Cystocloniaceae	*Craspedocarpus venosus*	red algae	RE
Brachyura	Leucosiidae	*Phlyixia intermedia*	crab	PE
	Pilumnidae	*Pilumnus fissifrons*	crab	PE
Polyplacophora	Acanthochitonidae	*Acanthochitona kimberi*	chiton	PW
	Chitonidae	*Chiton (Rhyssoplax) bednalli*	chiton	PE
	Chitonidae	*Chiton pelliserpentis*	chiton	PW
Echinoidea	Fibulariidae	*Fibularia (Fibularia) nutriens*	sea urchin	PW
	Temnopleuridae	*Amblypneustes ovum*	sea urchin	PE
Ophiuroidea	Ophiactidae	*Ophiactis tricolor*	brittle star	PE
Perciformes	Clinidae	*Heteroclinus perspicillatus*	spotshoulder weedfish	PE

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

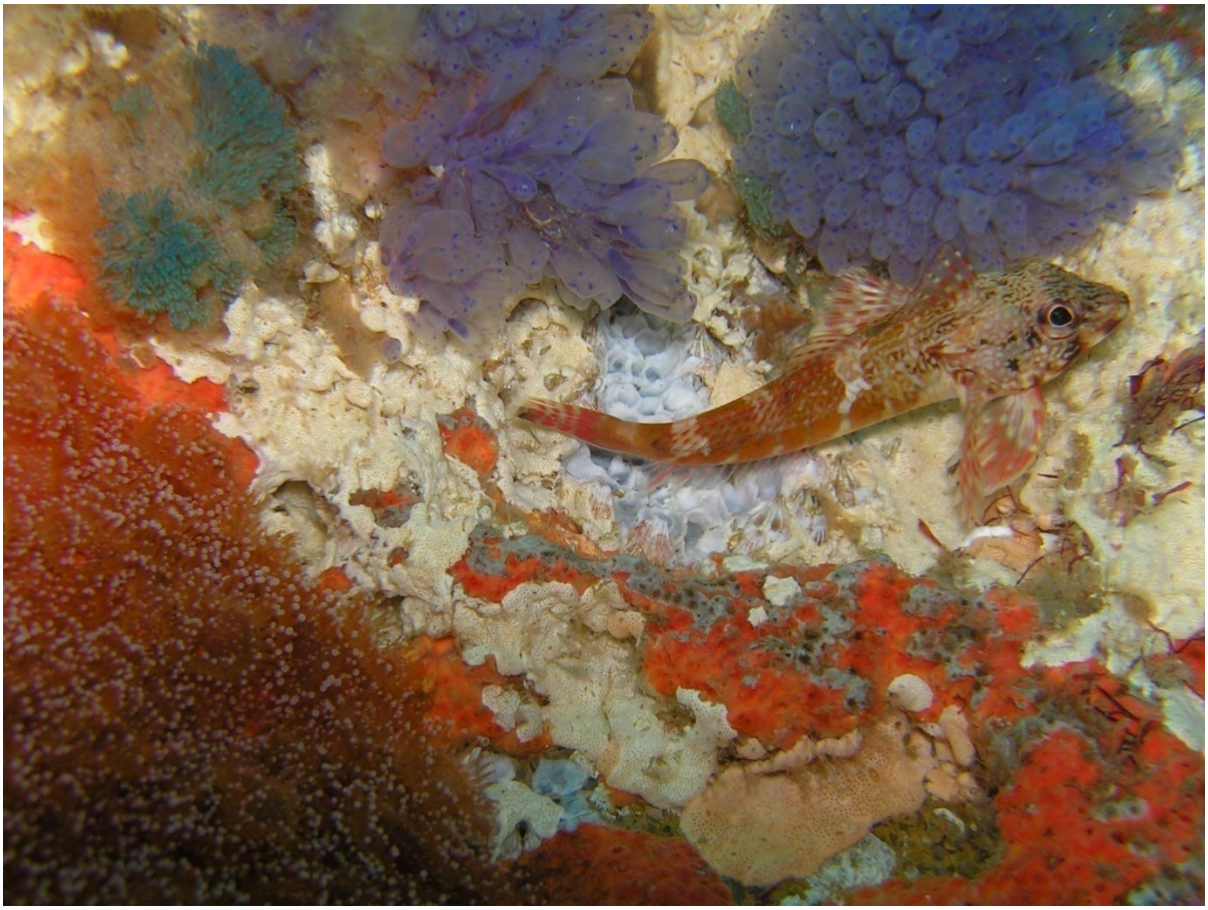


Figure 53. Thornfish *Bovichtus angustifrons* in Beware Reef Marine Sanctuary

3.1.5 MAJOR THREATS

Threats to natural values were derived from lists of hazards and associated risks in Carey *et al.* (2007b). These were the result of a statewide consultative process to identify threats to MPAs. Through public and agency workshops, the natural values in individual MPAs and the threats that could affect them over the next 10 years, were considered and ranked to identify hazards. This list of hazards was then ranked (low, medium, high and extreme) by the risk posed by each hazard (Carey *et al.* 2007b). Seven hazards with the potential to be extreme were identified by Carey *et al.* (2007b). They are listed in rank order and the habitat or area at risk within the park is indicated in brackets:

1. Introduced marine pests from recreational boats leading to impacts on relevant ecological communities (subtidal reef and soft sediments);
2. Introduced species from commercial vessels (including secondary introductions) leading to changes in community structure (subtidal reef and soft sediments);
3. Anchoring of recreational boats causing physical damage to subtidal reef habitats and communities (subtidal reef);
4. Poaching of abalone in commercial quantities leading to decreased abalone populations and consequent impacts on subtidal reef communities (subtidal reef);
5. Lack of ecological knowledge leading to inappropriate management and thus impacts on habitats and communities (all of MS);
6. Increased sediment loads from catchment runoff from park/forest roads leading to decreased water quality (all of MS); and
7. Increased sediment loads from catchment runoff associated with timber harvesting leading to decreased water quality (all of MS).

The introduction of marine pests threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment (Parks Victoria 2003). Most marine pests known from Victorian waters are limited to Port Phillip Bay (Parks Victoria 2003). No marine pests have been recorded in Beware Reef MS, however one the New Zealand screw shell *Maoricolpus roseus* (Holmes *et al.* 2007a) and New Zealand sea star *Astrostole scabra* have been recorded in Point Hicks and Cape Howe MNPs. It is presumed that the introduced green meanie or green shore crab *Carcinus maenas* occurs on the intertidal reefs of all the MPAs, except Ninety Mile Beach which has no intertidal reef. Other species of particular concern include the Northern Pacific seastar *Asterias amurensis*, European fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile (subsp fragile)* (Parks Victoria 2003).

The screw shell *Maoricolpus roseus* has been recorded within the Point Hicks MNP (Heislers and Parry 2007; Holmes *et al.* 2007a). This five cm long gastropod was introduced to Tasmania from New Zealand in the 1920s (Bax *et al.* 2003). It has now spread out to the 80 m depth contour off the eastern Victorian and New South Wales coasts (Patil *et al.* 2004). In New Zealand it is found from soft sediments to exposed habitats. This habitat flexibility means there is a higher potential for greater ecological and environmental impacts over larger areas than introduced species restricted to specific inshore environments (Patil *et al.* 2004). The dense beds of this invasive species change the benthic structure with unknown (and unexamined) effects on ecosystem services (Patil *et al.* 2004). It can cover soft sediments with its hard shell, and once dead, its shell provides abundant homes for a particular hermit crab that can use its heavy tapered shell, thus potentially shifting the pre-invasion food web (Bax *et al.* 2003). Dense beds of this burrowing filter feeder may have adverse impacts on native filter feeders, with native turritellids numbers declining with increasing *M. roseus* numbers (Patil *et al.* 2004). In Point Hicks MNP where this invasive species was most abundant, the diversity of infauna was reduced, suggesting that this exotic species poses a serious threat to the high diversity of infauna that is characteristic of much of Bass Strait (Heislers and Parry 2007).

A virus affecting abalone called abalone viral ganglioneuritus has been slowly spreading east along Victoria's west coast. This virus can kill a large percentage of abalone in an area and has been confirmed from Discovery Bay MNP to Cape Otway (DPI 2009). It is not in the Beware Reef MS but its spread into the park could have serious long term ecological consequences for rocky reef communities (DPI 2009).

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

Centrostephanus rodgersii, which is found in Beware Reef MS, 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 Beware Reef MSP (Parks Victoria 2006a). For example research is being conducted into marine pest species which may impact on park values. Parks Victoria has also undertaken a strategic climate change risk assessment to identify the risks and stressors to natural values in the MPAs through assessment at the habitat level for parks in each marine bioregion. Parks Victoria will use an adaptive management approach to develop responses and actions that focus on priority climate change issues such as extreme weather events and existing risks that will likely be exacerbated by climate change.

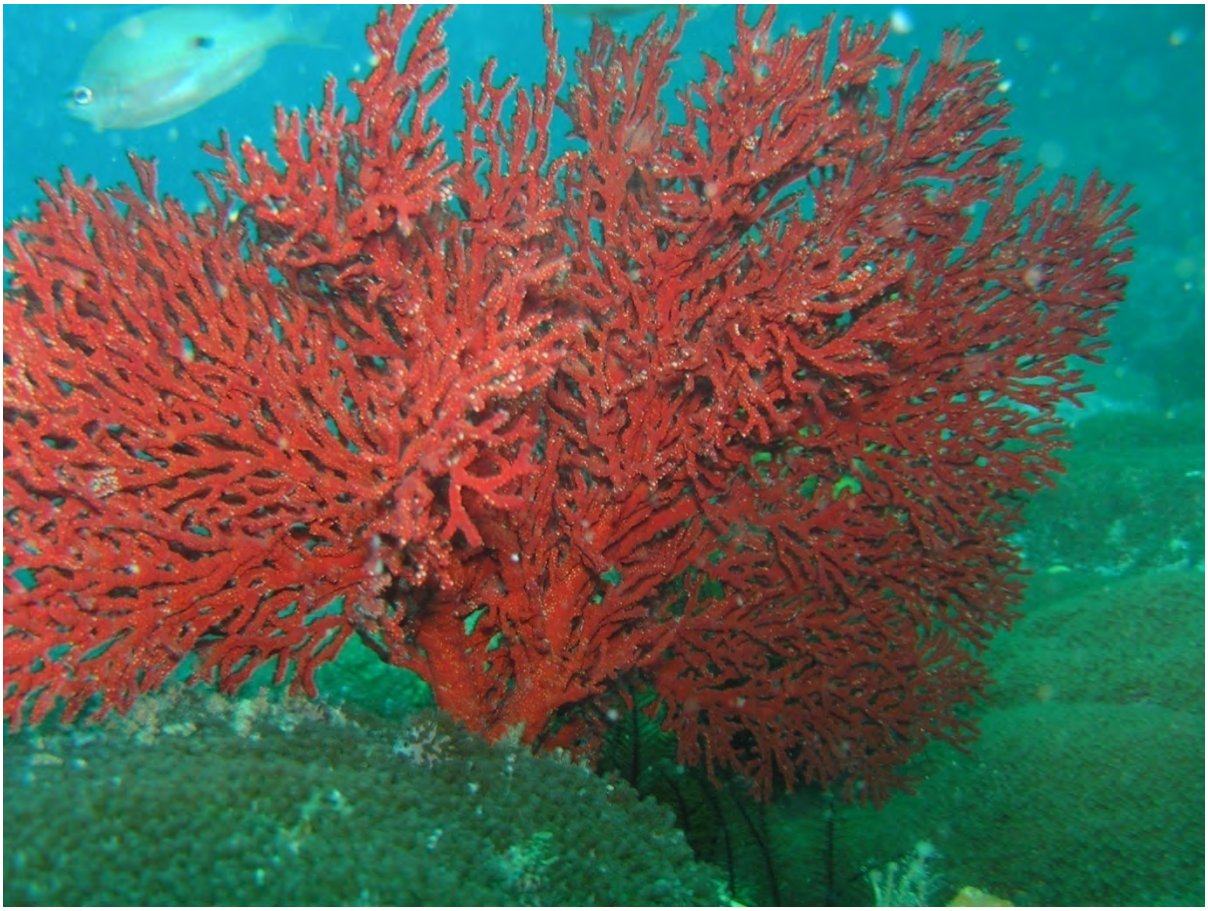


Figure 54. Eastern red sea fan *Mopsella sp.* in Beware Reef Marine Sanctuary. Photo taken by Friends of Beware Reef Marine Sanctuary.

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 Beware Reef 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 MNS has been carried out under permits issued by DSE, the permit database was also used to identify relevant projects for this report (see Table 33 and Appendix 2).

Table 33. Ongoing Research Partner Panel (and RPP-like) research projects and monitoring programs implemented in partnership with, or commissioned by, Parks Victoria relevant to Beware Reef Marine Sanctuary.

Ongoing RPP (and RPP-like) Projects
University of Melbourne: Kim Millers, Jan Carey, Mick McCarthy Optimising the allocation of resources for defending Marine Protected Areas against invasive species.
Multiple Research Partners: Marine Monitoring and Marine Natural Values ***University of Melbourne:*** Mick Keough, Paul Carnell Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling data. ***Deakin University:*** Gerry Quinn, Jan Barton, Adam Pope 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
Community Based Monitoring Reef Life Survey - Subtidal Reefs

Beware Reef MS does not have an ongoing intertidal reef monitoring program as it has limited intertidal reef area with relatively low human pressure. The shallow subtidal reef monitoring program (SRMP, Edmunds and Hart 2003) in and around the Beware Reef MS began in 2004. Since that time one site in the MS and one reference site at Pearl Point outside of the MS (Figure 40) have been surveyed over four census events (Edmunds *et al.* 2005; Williams *et al.* 2007; Edmunds *et al.* 2010b). The monitoring involves standardised underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally in a depth less than ten metres (Edmunds and Hart 2003). The SRMP monitors a specific suite of fish associated with reefs in shallow waters and is not designed to assess non-reef associated shallow water fish nor is it designed to assess the suite of species found in deeper water.

Keough and Carnell's (2009) preliminary analysis of the SRMP data from the first three census events up to 2006 was conducted at the bioregion level of Point Hicks and Cape Howe MNP, and Beware Reef MS. The analysis compared sites within MPAs to reference sites outside the MPAs. They found there was no significant difference in species richness and number of species between MPA and reference sites post-declaration for the Twofold

Shelf bioregion. Limitations to this work include the relatively short time since declaration and the corresponding small data set (Keough and Carnell 2009). All algae analysed had similar percentage cover between MPA and reference sites (Keough and Carnell 2009). The purple sea urchin *Heliocidaris erythrogramma* and dogwelk *Dicathais orbita* showed a greater abundance at reference sites compared to MPA sites (Keough and Carnell 2009). The triton *Cabestana spengleri*, red bait crab *Plagusia chabrus* and *H. erythrogramma* had significant differences in abundance between the various MPAs (Keough and Carnell 2009). The abundance of dominant fish species varied, but were generally similar between MPA and reference sites over time (Keough and Carnell 2009). Mado, purple wrasse and blue-throated wrasse were particularly variable but differences were not related to MPAs (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 MPA declaration, apart from recovery from fishing pressure, is to ensure the protection of the MPA area against future threats to biodiversity and natural processes.

A targeted analysis of monitoring data in relation to conservation outcomes for the park will be done by 2013. The subtidal reef monitoring program will continue to be implemented every two years in Beware Reef MS. The major directions for monitoring include implementing an expanded and improved monitoring program following a review of the major findings taking into account knowledge generated since park declaration and conservation outcomes developed for the MNPs (Keough *et al.* 2007; Power and Boxshall 2007; Keough and Carnell 2009).

Figure 55. Southern peacock weed *Distromium flabellatum* in Beware Reef Marine Sanctuary. Photo taken by Friends of Beware Reef Marine Sanctuary.

The Friends of Beware Reef Marine Sanctuary is an active diving community group that has mapped the shipwrecks in the MS (Parks Victoria 2006a). It is also collating and photographing the flora and fauna of the MS (Figures 55 and 56). Over three hundred types of biota have been photographed. The group is also monitoring the flora and fauna through the subtidal Reef Life Survey monitoring program.

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

3.1.7 KNOWLEDGE GAPS

No new surveys exist for the ecological communities of the intertidal reef or deep subtidal reef. There is little new data on fish abundances, distributions or interactions except in shallow subtidal reef habitats. No information exists at present for water column assemblages. Major threats have been identified for Beware Reef MS but we have limited knowledge of the effect on the natural values, particularly ecological communities. Limited information is available on the presence of species of conservation significance in the MS other than birds.

Figure 56. Crowned nudibranch *Polycera capensis* in Beware Reef Marine Sanctuary. Photo taken by Friends of Beware Reef Marine Sanctuary.

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 Flinders and Twofold Shelf bioregions on the east coast of Victoria and is one of a series of five reports covering Victoria's Marine National Park System. It uses the numerous monitoring and research programs that have increased our knowledge since declaration and aims to give a comprehensive overview of the important natural values of each MNP and MS.

The Flinders and Twofold Shelf bioregions encompass the east coast of Victoria from Wilsons Promontory and extend into Tasmania and New South Wales respectively. Wilsons Promontory MNP is in the Flinders bioregion, and Ninety Mile Beach, Point Hicks and Cape Howe MNPs and Beware Reef MS are in the Twofold Shelf bioregion. Both bioregions have cool temperate biota but with some warm-temperate species commonly found in NSW due to the influence of the East Australian Current (EAC). The continental shelf narrows towards the east of Twofold Shelf bioregion, where nutrient rich, cold water upwellings occur. Long sandy beaches with granite headlands and promontories are typical of the coast in the bioregions. Shores in Flinders plunge steeply onto a deep sandy sea floor. In Twofold Shelf the sandy low carbonate soft sediments slope off more gently to deep waters.

The MPAs are spread along the eastern Victorian coast to the NSW border and all are remote from large population centres. Wilsons Promontory adjoins other marine protected areas, and all MNPs, except Ninety Mile Beach MNP, adjoin terrestrial national parks. Wilsons Promontory MNP, at 15,530 hectares, is the largest MPA in Victoria. Ninety Mile Beach, Point Hicks and Cape Howe are 2650, 3805 and 4054 respectively. This makes them the ninth, fifth and fourth largest MNPs. Beware Reef, at 220 hectares, is the second largest MS. The four MNPs extend from high water mark on the coast to the limit of state waters 3 nautical miles offshore, except Wilsons Promontory which has a slightly more complicated offshore boundary. Beware Reef MS does not adjoin the coast and is a 1.5 km square around an isolated granite reef.

Mapping of marine 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 effectively target management activities, including emergency response, monitoring and research. Mapping of marine habitats provides a baseline inventory, allows the identification of suitable monitoring sites and possible tracking of environmental change, as well as identifying areas vulnerable to particular threats or suitable for recreational activities. High resolution habitat and bathymetry mapping has increased our understanding of habitats in the shallow waters of all the MPAs, and extends to the whole MPA for Point Hicks and Cape Howe MNPs. All

the MPAs, except Ninety Mile Beach MNP, have both shallow and deep subtidal reef. All, except for Beware Reef, have extensive intertidal soft sediment habitat or beaches. Flora in this habitat is restricted to macroalgae drift which, with other wrack material, contributes to the detrital cycle and is a significant source of food for many shore birds and invertebrates. All MPAs have subtidal soft sediment habitat, which can have very high numbers of invertebrate species living on and in it. Subtidal soft sediment and open water are the dominant habitat types in the MPAs.

In Wilsons Promontory MNP intertidal rocky reef is limited to a narrow band as the shores are very steep. Intertidal rocky reef is a relatively narrow band rock platform around the base of Point Hicks and only along the far eastern shore of Cape Howe MNP. The Beware Reef MS intertidal reef platform provides a haul-out area for Australian *Arctocephalus pusillus doriferus* and New Zealand *Arctophoca forsteri* fur seals. The intertidal reef invertebrate assemblages in Twofold Shelf are more similar to southern NSW reef than those to the west along the Victorian coast. There is no intertidal reef monitoring program in either bioregion, because of limited intertidal reef and low threat from harvesting or trampling.

Ongoing monitoring and focused research projects have described the flora and fauna of the subtidal reefs in all the MPAs except Ninety Mile Beach MNP. The shallow subtidal reefs in the MPAs differ in the composition of canopy forming macroalgae species, understorey and the associated invertebrate and fish assemblages. Common to all MPAs is the blacklip abalone *Haliotis rubra* and wrasse spp. The herbivorous, warm water sea urchin *Centrostephanus rodgersii* occurs on the reefs in both bioregions and can remove all erect algae to create 'urchin barrens'. Warm water fish species such as the damsel fish, including the one-spot puller *Chromis hypsilepis* and white-ear damselfish *Parma microlepis,* are a feature of Twofold Shelf shallow subtidal reefs.

Wilsons Promontory MNP has a wide range of subtidal habitat types, from low to high wave exposure creating distinct east west biogeographic patterns. On high exposure reef, common in the west and south of the MNP, crayweed *Phyllospora comosa* dominates the canopy, the seastars *Patiriella brevispina* and *P. vernicina* are typical and herring cale *Odax cyanomelax* is abundant. On moderate to low exposure reef in the east *Ecklonia-Seirococcus* assemblage dominates the canopy, the seastar *Nectria macrobranchia* is typical and herring cale *O. cyanomelax* abundance is low. Urchins *Heliocidaris erythrogramma*, blacklip abalone *H. rubra* and feather stars *Cenolia trichoptera* are abundant on shallow subtidal reefs throughout the MNP. Fish species number and abundance is high compared to shallow subtidal reefs west of Wilsons Promontory MNP. Four species of fish dominate, the barber perch *Casioperca rasor*, blue-throated wrasse *Notolabrus tetricus*, purple wrasse *N. fucicola*, long-finned pike *Dinolestes lewini* and herring cale *O. cyanomelax*. The eastern blue grouper *Achoerodus viridis* is present in low numbers in Wilsons Promontory MNP.

Subtidal low calcarenite rocky reefs dominated by sessile invertebrates and sparse red algae occur along Ninety Mile Beach. Preliminary mapping has not located the reefs within the Ninety Mile Beach MNP, they may have been covered by sand at the time of mapping. Shallow subtidal rocky reefs in Point Hicks MNP are highly exposed and have varied forms, from simple to complex providing a wide range of habitats. The canopy is a mixture of *P. comosa* and common kelp *Ecklonia radiata*, with the proportions of these two species varying according to the habitat, depth and location. The reef beneath the canopy varies from encrusting and erect sponges to small fleshy red algae. Invertebrate assemblages include relatively high abundances of the predatory whelk *Cabestana spengleri* and the seastar *Patiriella calcar,* and moderate abundances of blacklip abalone *H. rubra* and the red bait crab *Plagusia chabrus*. Fish assemblages are dominated by large numbers of blue throat wrasse *Notolabrus tetricus* and purple wrasse *N. fucicola*. Other fish species include the banded morwong *Cheilodactylus spectabilis,* sea sweep *Scorpis aequipinnis,* and Maori

wrasse *Ophthalmolepis lineolata*. The eastern blue grouper *Achoerodus viridis* is present in low numbers in Point Hicks MNP.

In Cape Howe MNP shallow subtidal rocky reefs have a complex structure, including eroded low-profile sandstone reef and high-profile granite reef. The canopy is dominated by crayweed *P. comosa*, with some bull kelp *Durvillaea potatorum* in shallower waters. Invertebrate diversity is high and common invertebrates include the warrener *Turbo undulatus* and turban shell *Astralium tentoriformis*. Its fish assemblage is distinct in the bioregion. Common fish are herring cale *O. cyanomelas*, the six-spined leatherjacket *Meuschenia freycineti*, striped mado *Atypichthys strigatus,* and banded morwong *C. spectabilis*. The eastern blue grouper *Achoerodus viridis* is present in low numbers in Cape Howe MNP.

The shallow subtidal reef in the Beware Reef has seaweed, invertebrate and fish communities that are distinctly different to the other reefs in Twofold Shelf MPAs. The canopy is dominated by bull kelp *D. potatorum* and crayweed *P. comosa*, with a lesser contribution by the common kelp *E. radiata*. Invertebrate assemblages have large numbers of the feather star *Cenolia trichoptera* and high densities of the black sea urchin *Centrostephanus rodgersii* and blacklip abalone *H. rubra*. Common fish at Beware Reef MS are blue throated wrasse *N. tetricus* and purple wrasse *N. fucicola*. Other fish species include the Maori wrasse *O. lineolata*, and toothbrush leather jacket *Acanthaluteres vittiger*. Large aggregations of butterfly perch *Caesioperca lepidoptera* are also a feature of the reef.

Subtidal soft sediment is a dominant habitat in all of the five MPAs in the Flinders and Twofold Shelf bioregions but detailed knowledge of its flora and fauna is restricted to shallow waters. Point Hicks and Cape Howe are the exception where the entire MPAs have been mapped and substrate and biota modelled. Sediments are predominantly inhabited by infauna (small crustaceans and worms that burrow into the sand) and bottom-dwelling skates and rays. The fish fauna of subtidal soft sediment at Wilsons Promontory MNP are typical of much of the shallower parts of Bass Strait. Common benthic fish are the sparsely spotted stingaree *Urolophus paucimaculatus*, Tasmanian numbfish *Narcine tasmaniensis*, banded stingaree *U. cruciatus*, angel shark *Squatina australis* and shortnose sawshark *Pristiophorus nudipinnis*. Boney fishes include sand flathead *Platycephalus bassensis*, silver trevally *Pseudocaranx dentex*, prickly toadfish *Contusus brevicaudus* and several species of leatherjackets.

The majority of Ninety Mile Beach MNP is < 20 m deep, with extensive intertidal and subtidal quartzose sand. Specific information on distribution and diversity of biota in the MNP is scarce. A large endemic southern Australian seastar *Coscinasterias muricata* is abundant along this coast, as well as an unusual soft coral *Pseudogorgia godeffroyi*. Aggregations of juvenile white shark *Carcharodon carcharias*, snapper *Pagrus auratus*, Australian salmon *Arripis* sp. and long-finned pike *D. lewini* and short-finned pike *Sphyraena novaehollandiae* occur in Ninety Mile Beach MNP.

The dominant subtidal sediment in Point Hicks MNP and Cape Howe is sand, or in deeper waters (> 50 m) coarse gravel made up of shells or shell fragments. Orange ball sponges *Tethy*a are common amongst the shell dominated substrate. Nearly half of the mapped sediment in Point Hicks had no identifiable biota living on it. The rest has sessile invertebrates predominately sponges in depths > 30 m. Sparse green algae *Caulerpa* is found amongst the invertebrates in 50 to 70 m. In Cape Howe MNP *Caulerpa* occurs in shallower depths (30 to 40 m). Inshore of the *Caulerpa* in Cape Hower are sparse macroalgal beds on sediment and sediment covered reef, while in deeper waters there are sessile invertebrates, predominately sponges. Common fish over sediment and sediment covered reef in the MNP are yellow scad *Trachyurus novaezelandiae*, ocean leatherjacket *Nelusetta ayraudi*, whiting *Sillago,* grubfish *Parapercis* sp., eastern blue-spotted flathead

Platycephalus caeruleopunctatus, velvet leatherjacket *Meuschenia scaber* and the butterfly perch *Caesioperca lepidoptera.* The draughtboard shark *Cephaloscyllium laticeps* is also common and can be found down to the deepest depths (105 m) of Cape Howe MNP.

Seagrass beds are found in sheltered bays, *Heterozostera* in Oberon Bay and *Amphibolis* and *Halophila* in Waterloo Bay in Wilsons Promontory MNP. A variety of fish have been recorded on seagrass and associated sand substrate in the MNP including the southern goatfish *Upeneichthys vlamingii*, silverbelly *Parequula melbournensis*, wide-bodied pipefish *Stigmatopora nigra*, spotted pipefish *S. argus*, slender weed whiting *Siphonognathus attenuatus*, blue throated wrasse *N. tetricus*, gobies *Nesogobius* spp., weedfish *Heteroclinus* spp. and *Cristiceps* spp. and toothbrush leatherjackets *Acanthaluteres vittiger*. Seagrass beds are not a feature of the Twofold Shelf bioregion. The deep reefs in both the bioregions have a dense and often spectacular cover of epifauna, especially sponges, stalked ascidians, soft corals, sea anemones, zooanthids gorgonians and sea whips, and abundant fish life (e.g. Figure 57).

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 17 species in Beware Reef MS and up to 38 in Cape Howe MNP. They are also important for many migratory birds, from 7 species in Wilsons Promontory MNP to 24 in Cape Howe MNP. Numerous species are found at the limit of their distribution range within individual MPAs. In Wilsons Promontory MNP over 126 species, including algae, invertebrates and fish, are believed to be at the edge of their distributional range, whilst none are known from Ninety Mile Beach MNP. Fourteen are believed to be at the edge of their range in Point Hicks MNP, 17 in Beware Reef MS and 38 in Cape Howe MNP.

The humpback whale *Megaptera novaeangliae,* threatened southern right whale *Eubalaena australis* and vulnerable New Zealand fur seal *Arctophoca forsteri* are found in the waters of both bioregions. Five marine warm water reptiles: loggerhead turtle *Caretta caretta*, green turtle *Chelonia mydas*, Pacific ridley *Lepidochelys olivacea*, leatherback turtle *Dermochelys coriacea*, and yellow-bellied sea snake *Pelamis platurus* occur as warm water vagrants in the bioregions. The islands surrounded by Wilsons Promontory MNP, particularly Kanowna in the Anser Group, are breeding colonies of little penguins *Eudyptula minor*, Australian fur seals *A. pusillus doriferus*, and a small colony of threatened New Zealand fur seals *A. forsteri*. The MNP is also a nationally significant area for recovery of great white shark *Carcharodon carcharias* populations. In Ninety Mile Beach MNP one species of crab, *Halicarcinus* sp *MoV746* is presumed endemic to the MNP. In Point Hicks MNP whale shark *Rhincodon typus* uses the MNP waters. One mollusc the welk *Fax molleri is* presumed to be endemic to the park. Cape Howe MNP is an important foraging area for a significant breeding colony of little penguins *E. minor* from neighbouring Gabo Island. The threatened southern right whale *E. australis* has been observed to calve in the park. The state vulnerable New Zealand fur seal *A. forsteri* has also been recorded breeding in the MNP. The southern elephant seal *Mirounga leonina* has been recorded in Beware Reef MS.

The introduction of foreign species or marine pests, by recreational or commercial vessels, threatens the integrity of marine biodiversity and may reduce the social and economic benefits derived from the marine environment. The introduced screw shell *Maoricolpus roseus* has been recorded in high densities on the subtidal sediment in Point Hicks MNP. It is presumed that the introduced green meany or green shore crab *Carcinus maenas* occurs on the intertidal reefs of all the MPAs, except Ninety Mile Beach MNP which has no intertidal reef. Other species of particular concern include the Northern Pacific seastar *Asterias amurensis* (recently found in the Wilsons Promontory National Park), European fanworm *Sabella spallanzanii*, Japanese kelp *Undaria pinnatifida* and broccoli weed *Codium fragile (subsp fragile)*.

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

Specific threats to individual MPAs have been identified. Generally recreational boating, as well as being a vector for introduced species and diseases, has been identified as posing a threat to seagrass beds, soft sediments and shallow subtidal reefs through propeller scour or anchors. Disturbance of wildlife are also a threat, *e.g.* shore birds by vehicles, people or dogs; or breeding colonies of seals by boats in Wilsons Promontory MNP. Poaching of abalone or fish is a threat within the MPAs. Commercial vessels that pass near or through the waters of the MPAs also pose a threat due to the risk of oil spills. Increased nutrients and sediments through land use or waste discharge pose a threat to water quality in the MPAs.

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 both bioregions and such species would be particularly vulnerable to climate change. In contrast, the increased range of the urchin *Centrostephanus rodgersii*, is thought to be linked to climate change with the EAC extending further south.

Parks Victoria has established extensive marine monitoring and research programs for the MPAs that address important management challenges, focussing both on improving baseline knowledge of the MPAs as well as applied management questions not being addressed by others. This knowledge will continue to enhance Parks Victoria's capacity to implement evidence-based management through addressing critical knowledge gaps. The research and monitoring programs have been guided by the research themes outlined as part of Parks Victoria's Research Partners Panel (RPP) program, a Marine Research and Monitoring Strategy 2007 - 2012 and Marine National Park and Marine Sanctuary Monitoring Plan 2007 - 2012 (Power and Boxshall 2007). Much of the research has been undertaken as part of the RPP program involving collaboration with various research institutions. Subtidal reef monitoring occurs in all MPAs in the bioregions except Ninety Mile Beach MNP. No intertidal monitoring is conducted in the bioregions due to limited or no intertidal reef and low human pressure. Other statewide projects are currently underway to photograph and document their marine natural values, and also to determine which MPAs are most at risk from introduced species and to detect poaching.

Detailed bathymetry mapping has been done for shallow waters in all MPAs, and for all of Point Hicks and Cape Howe MNPs. In Point Hicks and Cape Howe mapping has been done that allows predictive modelling of the distribution and extent of habitats for the entire MPA. For the remaining three MPAs our knowledge of their basic habitats, their distribution and extent, is generally limited, although Friends of Beware Reef have significantly added to our understanding of knowledge of habitats for the MS. Most of our knowledge about the flora and fauna of the MPAs is from the shallow subtidal reef marine monitoring program. There have been limted surveys of the intertidal reefs, which are a relatively small habitat in the MPAs. Technological improvements have increased our ability to explore and describe deep habitats, as has been done for reefs in Wilsons Promontory and soft sediments and reefs in Point Hicks and Cape Howe. There are significant knowledge gaps with regard to our understanding of the natural values associated with intertidal and subtidal soft sediments,

and open waters, for these MPAs. Whilst threats to the MPAs have been identified we have limited knowledge of the effect of those threats on the natural values.

Figure 57. Green moray eel *Gymnothorax prasinus* in Beware Reef Marine Sanctuary. Photo taken by Friends of Beware Reef Marine Sanctuary.

References

Ball, D. and Blake, S. (2007). *Shallow habitat mapping in Victorian Marine National Parks and Sanctuaries, Volume 2: Eastern Victoria*. Parks Victoria Technical Series No. 37. Parks Victoria, Melbourne.

Banks, S. C., Ling, S. D., Johnson, C. R., Piggott, M. P., Williamson, J. E. and Beheregaray, L. B. (2010). Genetic structure of a recent climate change-driven range extension. *Molecular Ecology* **19**: 2011–2024.

Bax, N., Williamson, A., Aguero, M., Gonzalez, E. and Geeves, W. (2003). Marine invasive alien species: a threat to global biodiversity. *Marine Policy* **27**: 313-323.

Bird, E. C. F. (1993). *The coast of Victoria: The shaping of scenery*. Melbourne University Press, Melbourne.

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

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

Coleman, M. A., Gason, A. S. H. and Poore, G. C. B. (1997). High species richness in the shallow marine waters of south-eastern Australia. *Marine Ecological Progress Series* **154**: 17-26.

Coleman, N., Cuff, W., Moverley, J., Gason, A. S. H. and Heislers, S. (2007). Depth, sediment type, biogeography and high species richness in shallow-water benthos. *Marine and Freshwater Research* **58**: 293-305.

Colton, M. A. and Swearer, S. E. (2009). *The conservation status of reef fish communities in Victorian waters: Final project report, Regional Catchment Investment Plan*. University of Melbourne report to the Port Phillip and Western Port Catchment Management Authority, Melbourne.

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

Connell, S. D. (2007). Subtidal temperate rocky habitats: Habitat heterogeneity at local to continental scales. In S. D. Connell and B. M. Gillanders (eds.) *Marine Ecology*. Oxford University Press; Sydney.

CSIRO-BoM (2007). *Climate Change in Australia - Technical Report 2007*. CSIRO Publishing, Canberra.

DPI (2009). *Abalone Viral Gangioneuritus Information Sheet April 2009.* Department of Primary Industry, Melbourne.

ECC (2000). *Marine, coastal and estuarine investigation*. Environment Conservation Council, East Melbourne.

Edgar, G. J., Barrett, N. S. and Stuart-Smith, R. D. (2009). Exploited reefs protected from fishing transform over decades into conservation features otherwise absent from seascapes. *Ecological Applications* **19**: 1967-1974.

Edgar, G. J. and Stuart-Smith, R. D. (2009). Ecological effects of marine protected areas on rocky reef communities - a continental-scale analysis. *Marine Ecological Progress Series* **388**: 51-62.

Edmunds, M. (2003). Review of marine natural values study. Parks Victoria. Melbourne.

Edmunds, M., Chidgey, S. S. and Willcox, S. T. (2000). Association between biological communities and physical variables on Victorian rock reefs. In L. W. Ferns and D. Hough (eds.) *Environmental inventory of Victoria's marine ecosystems Stage 3 (2nd edition) - Understanding biodiversity representativeness of Victoria's rocky reefs*. Parks, Flora and Fauna Division, Department of Natural Resources and Environment, East Melbourne.

Edmunds, M., Crozier, J., Judd, A. and Gilmour, P. (2007). *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Wilsons Promontory Marine National Park*. Volume 3. Parks Victoria Technical Series No. 50. Parks Victoria, Melbourne.

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

Edmunds, M., Hart, S. and Ingwersen, C. (2005). *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Marine Protected Areas in the Twofold Shelf Region*. Parks Victoria Technical Series No. 23. Parks Victoria, Melbourne.

Edmunds, M., Hart, S., Jenkins, S. and Elias, J. (2003). *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Wilsons Promontory Marine National Park*. Parks Victoria Technical Series No. 6. Parks Victoria, Melbourne.

Edmunds, M., Mustoe, S., Stewart, K., Sheedy, E. and Ong, J. (2010a). *VNPA Nature Conservation Review: Marine Conservation Priorities and Issues in Victoria*. Australian Marine Ecology Report 405 report to Victorian National Parks Association, Melbourne.

Edmunds, M., Stewart, K., Pritchard, K., Cutajar, J., Zavalas, R., Sheedy, B., Ong, J., Kerrigan, J. and Lewis, Z. (2009). *Port Phillip Bay channel deepening project. Deep reef impact and recovery assessment.* Australian Marine Ecology report to Port of Melbourne Corporation, Melbourne.

Edmunds, M., Stewart, K., Pritchard, K. and Zavalas, R. (2010b). *Victorian subtidal reef monitoring program: The reef biota at marine protected areas within the Twofold Shelf.* Volume 3. Parks Victoria Technical Series No. 62. Parks Victoria, Melbourne. 169.

Ferns, L. W. and Hough, D. (2000). *Environmental inventory of Victoria's marine ecosystems Stage 3 (2nd edition) - Understanding biodiversity representativeness of Victoria's rocky reefs.* Parks, Flora and Fauna Division, Department of Natural Resources and Environment, East Melbourne.

Fine, M. and Franklin, L. A. (2007). Climate change in marine ecosystems. In S. D. Connell and B. M. Gillanders (eds.) *Marine Ecology*. Oxford University Press, Sydney.

Harris, G., Nilsson, C., Clementson, L. and Thomas, D. (1987). The water masses of the east coast of Tasmania: Seasonal and interannual variability and the influence on phytoplankton biomass and productivity *Marine & Freshwater Research* **38**: 569-590.

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

Hidas, E. Z., Ayre, D. J. and Minchinton, T. E. (2010). Patterns of demography for rocky-shore, intertidal invertebrates approaching their geographical range limits: tests of the abundant-centre hypothesis in south-eastern Australia. *Marine & Freshwater Research* **61**: 1243-1251.

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

Holmes, K. W., Radford, B., Van Niel, K. P., Kendrick, G. A. and Grove, S. L. (2007a). *Mapping the Benthos in Victoria's Marine National Parks, Volume 2: Point Hicks*. Parks Victoria Technical Series No. 41. Parks Victoria, Melbourne.

Holmes, K. W., Radford, B., Van Niel, K. P., Kendrick, G. A., Grove, S. L. and Chatfield, B. (2007b). *Mapping the Benthos in Victoria's Marine National Parks, Volume 1: Cape Howe*. Parks Victoria Technical Series No. 40. Parks Victoria, Melbourne.

IMCRA (2006). *Integrated Marine and Coastal Regionalisation of Australia: an ecosystem-based classification for marine and coastal environments. Version 4*. Environment Australia, Commonwealth Department of the Environment, Canberra.

Keough, M. J. and Carnell, P. E. (2009). *Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling data* Department of Zoology, University of Melbourne for Parks Victoria, Melbourne.

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.

Kirkwood, R., Boren, L., Shaughnessy, P., Szteren, D., Mawson, P., Hückstädt, L., Hofmeyr, G., Oosthuizen, H., Schiavini, A., Campagna, C. and Berris, M. (2003). Pinniped-focused tourism in the Southern Hemisphere: A review of the industry. In N. J. Gales, M. A. Hindell and R. Kirkwood (eds.) *Marine mammals: fisheries, tourism, and management issues*., CSIRO Publishing, Melbourne.

LCC (1993). *Marine and Coastal Special Investigation Descriptive Report*. Land Conservation Council, Melbourne.

Lindsay, M. and Edmunds, M. (2006). *The reef biota at Wilsons Promontory Marine National Park*. Parks Victoria Technical Paper Series No. 27. Parks Victoria, Melbourne.

McLeod, E., Salm, R., Green, A. and Almany, J. (2009). Designing marine protected area networks to address the impacts of climate change. *Frontiers in Ecology and the Environment* **7**: 362-370.

Moore, C. H., Harvey, E. S. and van Niel, K. P. (2008). Establishing baseline data on demersal fish diversity and spatial distribution at Cape Howe Marine National Park. *draft*:

Moore, C. H., Harvey, E. S. and Van Niel, K. P. (2009). Spatial prediction of demersal fish distributions: enhancing our understanding of species-environment relationships. *ICES Journal of Marine Science* **66**: 2068-2075.

O'Hara, T. (2000). Habitats as surrogates for faunal and floral assemblages associated with rocky reefs along the Victorian coast. In L. W. Ferns and D. Hough (eds.) *Environmental inventory of Victoria's marine ecosystems Stage 3 (2nd edition) - Understanding biodiversity representativeness of Victoria's rocky reefs.* Parks, Flora and Fauna Division, Department of Natural Resources and Environment, East Melbourne.

O'Hara, T. (2002). Endemism, rarity and vulnerability of marine species along a temperate coastline. *Invertebrate Systematics* **16**: 671-684.

O'Hara, T. and Barmby, V. (2000). *Victorian Marine Species of Conservation Concern: Molluscs, Echinoderms and Decapod Crustaceans*. Parks, Flora and Fauna Division, Department of Natural Resources and Environment, East Melbourne..

O'Hara, T. and Poore, G. (2000). Patterns of distribution for southern Australian marine echinoderms and decapods. *Journal of Biogeography* **27**: 1321-1335.

Parks Victoria (2003). *Victoria's System of Marine National Parks and Marine Sanctuaries. Management Strategy 2003 - 2010*. Parks Victoria and the Department of Sustainability and Environment, Melbourne.

Parks Victoria (2006a). *Beware Reef Marine Sanctuary Management Plan*. Parks Victoria, Melbourne. 59.

Parks Victoria (2006b). *Bunurong Marine National Park, Bunurong Marine Park, Bunurong Coastal Reserve and Kilcunda-Harmers, Haven Coastal Reserve management plan*. Parks Victoria, Melbourne.

Parks Victoria (2006c). *Cape Howe Marine National Park Management Plan*. Parks Victoria, Melbourne.

Parks Victoria (2006d). *Ninety Mile Beach Marine National Park*. Parks Victoria, Melbourne.

Parks Victoria (2006e). *Ninety Mile Beach Marine National Park Management Plan*. Parks Victoria, Melbourne.

Parks Victoria (2006f). *Point Hicks Marine National Park Management Plan*. Parks Victoria Melbourne.

Parks Victoria (2006g). *Wilsons Promontory Marine National Park and Wilsons Promontory Marine Park Management Plan*. Parks Victoria, Melbourne.

Patil, J., Gunaserkera, R., McEnnulty, F. and Bax, N. (2004). *Development of genetic probes for rapid assessment of the impacts of marine invasive species on native biodiversity - Maoricolpus roseus*. CSIRO Marine Research, Hobart.

Patkin, K. (2005). The sustainability of interactions between pinniped and marine users: A case study of Kanowna Island, Wilsons Promontory Marine National Park. Honours thesis. School of Geography and Environmental Science, Monash University, Burwood.

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.

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

Underwood, A. J. and Chapman, G. A. (2004). Intertidal temperate rocky shores. In S. D. Connell and B. M. Gillanders (eds.) *Marine Ecology*. Sydney, Oxford University Press**.**

VCC (2008). *Victorian Coastal Strategy 2008*. Victorian Coastal Council, Melbourne.

Weston, M. A. (2003). *Managing the Hooded Plover in Victoria: a review of existing information*. Parks Victoria Technical Series No.4. Parks Victoria, Melbourne.

Williams, J., Gilmour, P. and Edmunds, M. (2007). *Victorian Subtidal Reef Monitoring: The Reef Biota Within the Twofold Bioregion*. Volume 2. Parks Victoria Technical Series No. 45. Parks Victoria, Melbourne.

4 Appendix 1

Compilation of species from databases from:

- the first Marine Natural Values reports; (MAFRI MNV v1, all MPAs except 90 Mile Beach MNP);
- and PV subtidal reef monitoring program (SRMP_All, all MPAs except 90 Mile Beach MNP);
- PV intertidal reef monitoring program (IRMP 02-04, Cape Howe MNP only);
- MAVRIC (Monitoring and Assessment of Victoria's Rocky Intertidal Coast – Wilsons Promontory MNP only); and
- Atlas of Victorian Wildlife (Fauna 100, records within 5km of all MPAs, excluding terrestrial areas)..

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. WP – Wilsons Promontory MNP; NMB – Ninety Mile Beach MNP; BR – Beware Reef MS; PH – Point Hicks MNP; CH – Cape Howe MNP.

Source	Habitat(s)	Wilsons Promontory MNP	Ninety Mile Beach MNP	Beware Reef MS	Point Hicks MNP	Cape Howe MNP
Fauna100_5kmSea	All	56	50	37	43	62
MAFRI distribution MNV v1	All	126		15	11	38
MAFRI endemic MNV v1	All	4		1	1	
MAVRIC	Rocky Intertidal	37				
IRMP 02-04	Rocky Intertidal					
SRMP_All	Rocky Subtidal	198		29	89	80

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
Green algae	Bryopsidaceae	*Bryopsis gemellipara*	Green alga	1				
	Caulerpaceae	*Caulerpa annulata*	Green alga	1				
		Caulerpa brownii	Green alga	1				
		Caulerpa cactoides	Green alga	1				
		Caulerpa flexilis	Green alga	1				
		Caulerpa flexilis var. *muelleri*	Green alga	1				
		Caulerpa longifolia	Green alga	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Caulerpa obscura	Green alga	1				
		Caulerpa scalpelliformis	Green alga	1			1	
		Caulerpa simpliciuscula	Green alga	1				
		Caulerpa trifaria	Green alga	1				
		Caulerpa vesiculifera	Green alga	1				
	Cladophoraceae	*Chaetomorpha coliformis*	Green alga				1	
		Chaetomorpha sp.	Green alga	1				
		Cladophora sp.	Green alga	1				
	Codiaceae	*Codium duthieae*	Green alga	1				
		Codium galeatum	Green alga					1
		Codium lucasii	Green alga	1				
	Ulvaceae	*Ulva* sp.	Sea lettuce				1	1
Total green algae				**16**	**0**	**0**	**3**	**2**
Brown algae	Alariaceae	*Ecklonia radiata*	Common kelp	1		1	1	
	Cladostephaceae	*Cladostephus spongiosus*	Brown alga				1	1
	Cystoseiraceae	*Acrocarpia paniculata*	Brown alga	1			1	
		Carpoglossum confluens	Brown alga	1				
		Cystophora congesta	Brown alga	1				
		Cystophora expansa	Brown alga	1				
		Cystophora grevillei	Brown alga	1				
		Cystophora monilifera	Brown alga	1			1	
		Cystophora moniliformis	Brown alga	1			1	1
		Cystophora platylobium	Brown alga	1				
		Cystophora retorta	Brown alga				1	
		Cystophora retroflexa	Brown alga	1				
		Cystophora siliquosa	Brown alga	1				
Brown algae		*Cystophora subfarcinata*	Brown alga	1				
	Dictyotaceae	*Chlanidophora microphylla*	Brown alga	1				
		Dictyopteris acrostichoides	Brown alga	1			1	1
		Dictyopteris muelleri	Brown alga	1			1	
		Dictyota dichotoma	Brown alga	1				
		Dictyota diemensis	Brown alga	1				1
		Dilophus angustus	Brown alga	1				
		Dilophus marginatus	Brown alga				1	
		Distromium flabellatum	Brown alga	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Distromium sp.	Brown alga	1			1	1
		Glossophora nigricans	Red alga	1				
		Homeostrichus olsenii	Brown alga	1				
		Homeostrichus sinclairii	Brown alga	1				1
		Lobophora variegata	Brown alga	1				
		Lobospira bicuspidata	Brown alga	1				
		Pachydictyon polycladum	Brown alga	1				
		Padina sp.	Brown alga				1	1
		Zonaria angustata	Brown alga	1				
		Zonaria crenata	Brown alga					1
		Zonaria sp.	Brown alga	1				
		Zonaria spiralis	Brown alga	1				
		Zonaria turneriana	Brown alga	1			1	1
	Durvillaeaceae	*Durvillaea potatorum*	Bull kelp			1		
	Fucaceae	*Xiphophora chondrophylla*	Brown alga	1				
	Hormosiraceae	*Hormosira banksii*	Neptune's necklace	1				
	Lessoniaceae	*Macrocystis angustifolia*	Kelp	1		1	1	
	Sargassaceae	*Sargassum decipiens*	Brown alga	1				
		Sargassum fallax	Brown alga	1				
		Sargassum sonderi	Brown alga	1				
		Sargassum sp.	Brown alga	1			1	
		Sargassum spinuligerum	Brown alga	1				
		Sargassum varians	Brown alga	1				
		Sargassum verruculosum	Brown alga	1			1	
		Sargassum vestitum	Brown alga	1			1	
	Scytosiphonaceae	*Colpomenia peregrina*	Brown alga					1
Brown algae	Seirococcaceae	*Phyllospora comosa*	Brown alga	1		1	1	1
		Seirococcus axillaris	Brown alga	1				
	Sporochnaceae	*Austroneraia australis*	Brown alga			1		
		Carpomitra costata	Brown alga	1		1	1	1
		Perithalia caudata	Brown alga	1				
		Sporochnus sp.	Brown alga	1			1	
	Stypocaulaceae	*Halopteris funicularis*	Brown alga	1				
		Halopteris sp.	Brown alga	1			1	1
		Phloiocaulon foecundum	Brown alga			1		

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
	UnknownFamily	Unidentified brown algae	Brown alga	1			1	1
	Valoniaceae	*Dictyota* sp. (fine)	Brown alga	1				
Total brown algae				**50**	**0**	**7**	**21**	**14**
Red algae	Areschougiaceae	*Acrotylus australis*	Red alga	1			1	1
		Areschougia congesta	Red alga	1				
		Callophycus laxus	Red alga	1				
		Erythroclonium sonderi	Red alga	1				
		Rhabdonia coccinea	Red alga			1		
	Bonnemaisoniaceae	*Asparagopsis armata*	Red alga	1				
		Asparagopsis sp.	Red alga	1				
		Delisea pulchra	Red alga	1		1	1	1
		Leptophyllis conferta	Red alga					1
		Ptilonia australasica	Red alga	1				
	Ceramiaceae	*Acrothamnion pressii*	Red alga	1				
		Antithamnion biarmatum	Red alga					1
		Ballia callitricha	Red alga	1				1
		Callithamnion obstipum	Red alga					1
		Ceramium pusillum	Red alga					1
		Dasyphila preissii	Red alga	1				
		Euptilota articulata	Red alga	1				
		Griffithsia elegans	Red alga					1
		Griffithsia teges	Red alga	1				
		Heterothamnion muelleri	Red alga	1				
		Involucrana crassa	Red alga					1
		Ochmapexus minimus	Red alga					1
		Pterothamnion nodiferum	Red alga	1				
Red algae	Champiaceae	*Champia* sp.	Red alga	1				
	Corallinaceae	*Amphiroa anceps*	Red alga	1				1
		Arthrocardia wardii	Red alga	1				1
		Cheilosporum sagittatum	Red alga	1				
		Corallina officinalis	Red alga	1				
		Haliptilon roseum	Red alga	1		1	1	1
		Jania pulchella	Red alga					1
		Lithophyllum chamberlainianum	Red alga	1				
		Mastophoropsis canaliculata	Red alga	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Melobesia membranacea	Red alga					1
		Metagoniolithon radiatum	Red alga	1				
		Metagoniolithon stelliferum	Red alga	1				
		Metamastophora flabellata	Red alga	1				
		Unidentified coralline algae	Red alga	1				1
		Unidentified encrusting corallines	Red alga	1		1	1	1
		Unidentified erect corallines	Red alga	1				
	Cystocloniaceae	*Austroclonium charoides*	Red alga	1				
		Craspedocarpus ramentaceus	Red alga	1		1		
		Craspedocarpus tenuifolius	Red alga	1				
		Craspedocarpus venosus	Red alga			1		
		Rhodophyllis multipartita	Red alga					1
	Dasyaceae	*Dasya ceramioides*	Red alga	1				
		Dasya comata	Red alga					1
		Thuretia australasica	Red alga	1				
	Delesseriaceae	*Hemineura frondosa*	Red alga	1			1	1
	Galaxauraceae	*Galaxaura marginata*	Red alga				1	1
	Gelidiaceae	*Gelidium asperum*	Red alga	1				
		Gelidium australe	Red alga	1				1
		Gelidium sp.	Red alga	1				
		Pterocladia capillacea	Red alga	1			1	1
		Pterocladia lucida	Red alga	1				1
	Gracilariaceae	*Curdiea angustata*	Red alga	1				
		Gracilaria secundata	Red alga	1			1	
		Melanthalia abscissa	Red alga	1				
		Melanthalia fastigiata	Red alga	1				
Red algae		*Melanthalia obtusata*	Red alga	1				
	Halymeniaceae	*Halymenia plana*	Red alga	1				
		Polyopes constrictus	Red alga	1			1	1
		Thamnoclonium dichotomum	Red alga	1				
		Sinkoraena tasmanica	Red alga				1	
	Hypneaceae	*Hypnea ramentacea*	Red alga	1				
	Kallymeniaceae	*Callophyllis lambertii*	Red alga	1				
		Callophyllis rangiferina	Red alga	1				1
	Mychodeaceae	*Mychodea marginifera*	Red alga					1

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
	Nizymeniaceae	*Nizymenia australis*	Red alga	1			1	
	Peyssonneliaceae	*Peyssonnelia novae-hollandiae*	Red alga	1				1
		Sonderopelta coriacea	Red alga	1				
	Phacelocarpaceae	*Phacelocarpus alatus*	Red alga	1				
		Phacelocarpus peperocarpos	Red alga	1			1	1
	Phyllophoraceae	*Ahnfeltiopsis fastigata*	Red alga	1				
		Stenogramma leptophylla	Red alga	1				
	Plocamiaceae	*Plocamium angustum*	Red alga	1		1	1	1
		Plocamium cartilagineum	Red alga	1				1
		Plocamium costatum	Red alga	1				
		Plocamium dilatatum	Red alga	1		1	1	1
		Plocamium leptophyllum	Red alga	1			1	1
		Plocamium mertensii	Red alga	1				1
		Plocamium patagiatum	Red alga	1			1	
		Plocamium preissianum	Red alga	1				
	Rhodomelaceae	*Echinothamnion hystrix*	Red alga	1				
		Laurencia elata	Red alga	1				
		Laurencia filiformis	Red alga	1				
		Laurencia sp.	Red alga	1				
	Rhodymeniaceae	*Cordylecladia furcellata*	Red alga	1			1	
		Hymenocladia chondricola	Red alga	1				
		Rhodymenia australis	Red alga	1		1	1	1
		Rhodymenia leptophylla	Red alga	1				
		Rhodymenia linearis	Red alga			1	1	1
		Rhodymenia obtusa	Red alga	1				
		Rhodymenia prolificans	Red alga					1
Red algae		*Rhodymenia* sp.	Red alga	1				
		Rhodymenia verrucosa	Red alga					1
		Rhodymenia wilsonii	Red alga			1		1
	UnknownFamily	Unidentified filamentous red algae	Red alga	1				
		Unidentified thallose red algae	Red alga	1		1	1	1
Total red algae				**78**	**0**	**12**	**20**	**40**
Seagrasses	Cymodoceaceae	*Amphibolis antarctica*	Seagrass	1				
	Hydrocharitaceae	*Halophila decipiens*	Seagrass					1
		Halophila ovalis	Seagrass					1

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
	Zosteraceae	*Zostera muelleri*	Seagrass					1
Total seagrasses				**1**	**0**	**0**	**0**	**3**
Cnidaria	Actiniidae	*Actinia tenebrosa*	Anemone	1				
		Aulactinia veratra	Anemone	1				
Total cnidarians				**2**	**0**	**0**	**0**	**0**
Polychaetes	Serpulidae	*Galeolaria caespitosa*	Tubeworm	1				
Total polychaetes				**1**	**0**	**0**	**0**	**0**
Barnacles	Catophragmidae	*Catomerus polymerus*	Surf barnacle	1				
	Chthamalidae	*Chamaesipho tasmanica*	Honeycomb barnacle	1				
		Chthamalus antennatus	Acorn barnacle	1				
	Tetraclitidae	*Tesseropora rosea*	Acorn barnacle	1				
		Tetraclitella purpurascens	Acorn barnacle	1				
Total barnacles				**5**	**0**	**0**	**0**	**0**
Decapod crustaceans	Alpheidae	*Alpheus australosulcatus*	Snapping shrimp	1				
		Alpheus socialis	Smooth snapping shrimp					1
	Crangonidae	*Aegaeon lacazei*	Shrimp	1				
	Hippolytidae	*Tozeuma elongatum*	Hippolytid shrimp	1				
	Hymenosomatidae	*Halicarcinus* sp. MoV 746	Spider crab			1		
	Leucosiidae	*Phlyixia intermedia*	Pebble crab			1		
	Majidae	*Notomithrax ursus*	Spider crab	1				
	Oziidae	*Ozius truncatus*	Reef crab				1	
	Palaemonidae	*Palaemon debilis*	Shrimp					1
	Penaeidae	*Parapenaeus australiensis*	Red prawn					1
	Pilumnidae	*Pilumnus fissifrons*	Tasselled crab			1		
	Portunidae	*Scylla serrata*	Mud crab					1
	Rhynchocinetidae	*Rhynchocinetes kuiteri*	Hinge-back shrimp	1				
Decapod crustaceans	Upogebiidae	*Upogebia australiensis*	Mud shrimp					1
Total decapod crustaceans				**5**	**0**	**3**	**1**	**5**
Chitons	Acanthochitonidae	*Acanthochitona kimberi*	Chiton			1		
		Acanthochitona retrojectus	Chiton					1
		Notoplax speciosa	Chiton	1				
	Chitonidae	*Chiton (Chiton) pelliserpentis*	Chiton			1		
		Chiton (Rhyssoplax) bednalli	Chiton			1		
		Chiton (Rhyssoplax) jugosus	Chiton				1	
	Ischnochitonidae	*Ischnochiton elongatus*	Chiton	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Ischnochiton variegatus	Chiton	1				
	Mopaliidae	*Plaxiphora albida*	Chiton	1				
Total chitons				**4**	**0**	**3**	**1**	**1**
Gastropods	Anabathridae	*Pisinna albizona*	Sea snail				1	
		Pisinna columnaria	Sea snail	1				
		Pisinna frauenfeldi	Sea snail					1
		Pisinna frenchiensis	Sea snail	1				
		Pisinna laseroni	Sea snail				1	
		Pisinna tumida	Sea snail	1				
		Pisinna vincula	Sea snail					1
	Buccinidae	*Fax molleri*	Whelk				1	
	Cerithiidae	*Glyptozaria euglypta*	Gastropod				1	
	Conidae	*Conus papilliferus*	Gastropod					1
	Cyclostrematidae	*Liotella vercoi*	Gastropod	1				
	Cymatiidae	*Cabestana spengleri*	Triton (Trumpet shell)	1				
	Cystiscidae	*Cystiscus halli*	Gastropod	1				
	Eulimidae	*Eulima styliformis*	Gastropod	1				
		Eulima victoriae	Gastropod	1				
	Fissurellidae	*Clypidina rugosa*	Keyhole limpet	1				
		Emarginula gabensis	Keyhole limpet					1
		Scutus antipodes	Keyhole limpet	1				
	Haliotidae	*Haliotis coccoradiata*	Abalone					1
	Littorinidae	*Afrolittorina praetermissa*	Periwinkle	1				
		Austrolittorina unifasciata	Periwinkle	1				
		Bembicium melanostoma	Periwinkle	1				
		Bembicium nanum	Periwinkle	1				
Gastropods	Lottiidae	*Notoacmea petterdi*	Limpet	1				
		Patelloida alticostata	Limpet	1				
		Patelloida latistrigata	Limpet	1				
	Muricidae	*Dicathais orbita*	Gastropod	1				
		Lepsiella reticulata	Gastropod	1				
		Lepsiella vinosa	Gastropod	1				
	Nacellidae	*Cellana tramoserica*	Limpet	1				
	Neritidae	*Nerita atramentosa*	Nerite	1				
	Onchidiidae	*Onchidella patelloides*	Pulmonate sea slug	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Onchidina australis	Pulmonate sea slug				1	
	Siphonariidae	*Siphonaria diemenensis*	Pulmonate limpet	1				
		Siphonaria funiculata	Pulmonate limpet	1				
	Triphoridae	*Aclophoropsis festiva*	Gastropod					1
		Aclophoropsis maculosa	Gastropod					1
		Eutriphora tricolor	Gastropods					1
	Trochidae	*Austrocochlea constricta*	Ribbed top shell	1				
		Clanculus floridus	Top shell					1
		Diloma concamerata	Wavy top shell	1				
	Turbinidae	*Turbo undulatus*	Common warrener (Turban shell)	1				
	Turridae	*Austroturris steira*	Gastropod					1
		Splendrilla subviridus	Gastropod					1
	Turridae	*Vexitomina torquata*	Gastropod				1	
Total gastropods				**28**	**0**	**0**	**6**	**11**
Bivalves	Mytilidae	*Brachidontes rostratus*	Beaked mussel	1				
		Xenostrobus pulex	Mussels	1				
Total bivalves				**2**	**0**	**0**	**0**	**0**
Cephalopods	UnknownFamily	Unidentified Squid	Squid					1
Total cephalopods				**0**	**0**	**0**	**0**	**1**
Echinoderms	Amphiuridae	*Amphiura dolia*	Brittle Star	1				
	Antedonidae	*Euantedon paucicirra*	Feather Star	1				
	Asterinidae	*Nepanthia troughtoni*	Sea Star	1				
		Patiriella calcar	Sea Star	1				
		Patiriella exigua	Sea Star	1				
	Brissidae	*Spatagobrissus incus*	Heart Urchin	1				
	Cidaridae	*Goniocidaris impressa*	Sea Urchin	1				
Echinoderms	Diadematidae	*Centrostephanus rodgersii*	Sea Urchin	1				
	Echinothuriidae	*Araeosoma thetidis*	Sea Urchin					1
	Fibulariidae	*Fibularia nutriens*	Sand Dollar			1		
	Goniasteridae	*Tosia magnifica*	Sea Star					1
	Isocrinidae	*Metacrinus cyaneus*	Featherstar				1	
	Ophiactidae	*Ophiactis tricolor*	Brittle Star			1		
	Ophiotrichidae	*Macrophiothrix spongicola*	Brittle Star	1				
	Ophiuridae	*Ophioplocus bispinosus*	Brittle Star	1				
	Oreasteridae	*Nectria macrobrachia*	Sea Star	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Nectria multispina	Sea Star	1				
	Spatangidae	*Spatangus luetkeni*	Heart Urchins	1				
	Temnopleuridae	*Amblypneustes ovum*	Sea Urchin			1		
		Holopneustes porosissimus	Sea Urchin	1				
		Microcyphus compsus	Sea Urchin	1				
		Pseudechinus notius	Sea Urchin				1	
Total echinoderms				**15**	**0**	**3**	**2**	**2**
Ascidian	Pyuridae	*Pyura stolonifera*	Cunjevoi	1				
Total ascidians				**1**	**0**	**0**	**0**	**0**
Fish	Aplodactylidae	*Aplodactylus arctidens*	Marblefish	1			1	1
		Crinodus lophodon	Rock Cale			1	1	1
	Apogonidae	*Vincentia conspersa*	Southern Cardinalfish	1				
	Aracanidae	*Aracana aurita*	Shaw's Cowfish	1				
	Aracanidae	*Aracana ornata*	Ornate Cowfish	1				
	Arripidae	*Arripis georgiana*	Australian Herring	1			1	
	Aulopodidae	*Aulopus purpurissatus*	Sergent baker	1				
	Bovichtidae	*Pseudaphritis* sp.	Congolli	1				
	Callanthiidae	*Callanthias allporti*	Rosy Perch	1				
	Carangidae	*Pseudocaranx dentex*	White Trevally	1			1	1
		Trachinops taeniatus	Eastern Hulafish					1
		Trachurus declivis	Common Jack Mackerel	1			1	
		Trachurus novaezelandiae	Yellowtail Scad	1			1	1
	Cheilodactylidae	*Cheilodactylus nigripes*	Magpie Perch	1				
		Cheilodactylus spectabilis	Banded Morwong	1		1	1	1
		Dactylophora nigricans	Dusky Morwong	1				
		Nemadactylus douglassii	Grey Morwong	1			1	1
Fish		*Nemadactylus macropterus*	Jackass Morwong	1				
	Chironemidae	*Chironemus georgianus*	Tasselled Kelpfish	1				
		Chironemus marmoratus	Kelp Fish					1
	Clinidae	*Cristiceps aurantiacus*	Yellow Crested Weedfish	1				
		Heteroclinus adelaide	Adelaide Weedfish	1				
		Heteroclinus eckloniae	Kelp Weedfish	1				
		Heteroclinus johnstoni	Johnston's Weedfish	1				
		Heteroclinus macrophthalmus	Large-eye Weedfish	1				
		Heteroclinus perspicillatus	Common Weedfish			1		

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Heteroclinus puellarum	Little Weedfish	1				
		Ophiclinops varius	Variegated Snake Blenny	1				
		Ophiclinus gabrieli	Frosted Snake Blenny	1				
		Ophiclinus ningulus	Variable Snake Blenny	1				
	Dasyatididae	*Dasyatis brevicaudata*	Smooth Stingray				1	
	Dinolestidae	*Dinolestes lewini*	Longfin Pike	1			1	1
	Dinolestidae	*Diodon nichthemerus*	Globefish	1			1	
	Engraulididae	*Herklotisichtchys castelnaui*	Fish	1				
	Enoplosidae	*Enoplosus armatus*	Old Wife	1				1
	Galaxiidae	*Galaxias brevipinnis*	Climbing Galaxias	1				
		Galaxias truttaceus	Spotted Galaxias	1				
	Girellidae	*Girella elevata*	Black Drummer	1			1	1
		Girella tricuspidata	Luderick	1			1	1
		Girella zebra	Zebrafish	1			1	
	Gnathanacanthidae	*Gnathanacanthus goetzeei*	Red Velvetfish	1				
	Gobiesocidae	Undescribed Genus clingfish	Brown spotted spiny clingfish	1				
	Gobiidae	*Gobiopterus semivestitus*	Glass Goby	1				
	Heterodontidae	*Heterodontus portusjacksoni*	Port Jackson Shark	1			1	1
	Kyphosidae	*Kyphosus sydneyanus*	Silver Drummer	1			1	
	Labridae	*Achoerodus viridis*	Eastern Blue Groper	1			1	1
		Dotalabrus aurantiacus	Castelnau's Wrasse	1				1
		Eupetrichthys angustipes	Snakeskin Wrasse	1			1	
		Notolabrus fucicola	Purple Wrasse	1		1	1	1
		Notolabrus gymnogenis	Crimsonband Wrasse					1
		Notolabrus tetricus	Bluethroat Wrasse	1		1	1	1
		Ophthalmolepis lineolata	Maori Wrasse	1		1	1	1
Fish		*Pictilabrus laticlavius*	Senator Wrasse	1		1	1	1
		Pseudolabrus luculentus	Orange Wrasse				1	
		Pseudolabrus psittaculus	Rosy Wrasse	1		1	1	
	Latridae	*Latridopsis forsteri*	Bastard Trumpeter	1			1	
	Loliginidae	*Sepioteuthis australis*	Southern Calamari Squid	1				
	Monacanthidae	*Acanthaluteres vittiger*	Toothbrush Leatherjacket	1		1	1	1
		Brachaluteres jacksonianus	Southern Pygmy Leatherjacket	1				
		Eubalichthys bucephalus	Black Reef Leatherjacket					1
		Eubalichthys gunnii	Gunn's Leatherjacket	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Meuschenia australis	Brownstriped Leatherjacket	1			1	
		Meuschenia flavolineata	Yellowstriped Leatherjacket	1				
		Meuschenia freycineti	Sixspine leather jacket	1		1	1	1
		Meuschenia galii	Bluelined Leatherjacket	1				
		Meuschenia hippocrepis	Horseshoe Leatherjacket	1				
		Meuschenia scaber	Velvet Leatherjacket	1				
		Meuschenia trachylepis	Yellowfin Leatherjacket	1				
		Scobinichthys granulatus	Rough Leatherjacket	1				
		Thamnaconus degeni	Bluefin Leatherjacket	1				
	Moridae	*Pseudophycis bachus*	Red Cod	1				
		Pseudophycis barbata	Bearded Rock Cod	1				
	Mullidae	*Upeneichthys vlamingii*	Bluespotted Goatfish	1			1	1
	Myliobatidae	*Myliobatis australis*	Southern Eagle Ray	1			1	
	Odacidae	*Neoodax balteatus*	Little Weed Whiting	1				
		Odax acroptilus	Rainbow Cale	1			1	1
		Odax cyanomelas	Herring Cale	1		1	1	1
		Siphonognathus attenuatus	Slender Weed Whiting	1				
		Siphonognathus beddomei	Pencil Weed Whiting	1				
		Siphonognathus caninus	Sharpnose Weed Whiting	1				
		Siphonognathus radiatus	Longray Weed Whiting	1				
		Siphonognathus tanyourus	Longtail Weed Whiting	1				
	Parascyllidae	*Parascyllium variolatum*	Varied Carpetshark	1				
	Pataecidae	*Aetapcus maculatus*	Warty Prowfish	1				
	Pemperididae	*Pempheris multiradiata*	Bigscale Bullseye	1			1	1
	Pentacerotidae	*Parequula melbournensis*	Silverbelly	1		1		
		Pentaceropsis recurvirostris	Longsnout Boarfish	1			1	1
Fish	Platycephalidae	*Platycephalus bassensis*	Cliff Flathead	1				
		Platycephalus fuscus	Dusky Flathead	1				
	Plesiopidae	*Paraplesiops alisonae*	Alison's Blue Devil	1				
		Paraplesiops meleagris	Southern Blue Devil	1				
		Trachinops caudimaculatus	Southern Hulafish	1				
	Pomacentridae	*Chromis hypsilepis*	Onespot Puller	1		1	1	1
		Parma microlepis	White-ear	1		1	1	1
		Parma victoriae	Scalyfin	1				1
	Pristiophoridae	*Pristiophorus nudipinnis*	Southern Sawshark	1				

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
	Prototrocitidae	*Prototroctes maraena*	Australian Grayling	1				
	Rhincodontidae	*Rhincodon typus*	Whale Shark				1	
	Scorpaenidae	*Maxillicosta scabriceps*	Little Gurnard Perch	1				
		Scorpaena papillosa	Southern Red Scorpionfish				1	
	Scorpididae	*Atypichthys strigatus*	Mado	1			1	1
		Scorpis aequipinnis	Sea Sweep	1			1	1
		Scorpis lineolata	Silver Sweep	1		1	1	1
		Tilodon sexfasciatus	Moonlighter	1				
	Scyliorhinidae	*Cephaloscyllium laticeps*	Draughtboard Shark	1			1	
	Sepiidae	*Sepia apama*	Giant Cuttlefish	1				
	Serranidae	*Acanthistius ocellatus*	Eastern Wirrah	1				
		Caesioperca lepidoptera	Butterfly Perch	1		1	1	
		Caesioperca rasor	Barber Perch	1		1		
		Hypoplectrodes annulatus	Blackbanded Seaperch	1				
		Hypoplectrodes maccullochi	Halfbanded Seaperch	1				
		Sillago flindersi	Eastern School Whiting	1				
	Soleidae	*Synaptura nigra*	Black Sole	1				
	Sphyraenidae	*Sphyraena novaehollandiae*	Snook					1
	Synodontidae	*Synodus variegatus*	Variegated Lizardfish	1				
	Tetraodontidae	*Contusus brevicaudus*	Prickly Toadfish				1	1
		Tetractenos glaber	Smooth Toadfish	1			1	1
	Tripterygiidae	*Forsterygion varium*	Variable Threefin	1				
		Norfolkia incisa	Notched Threefin	1				
	Urolophidae	*Trygonoptera testacea*	Common Stingaree				1	
		Urolophus paucimaculatus	Sparsely-spotted Stingaree	1				
Total fish				**108**	**0**	**17**	**46**	**37**
Birds	Acanthizidae	*Gerygone mouki*	Brown Gerygone				1	
	Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	1	1	1	1	1
	Anatidae	*Cygnus atratus*	Black Swan	1	1			1
	Ardeidae	*Ardea ibis*	Cattle Egret	1			1	1
		Ardea intermedia	Intermediate Egret				1	
		Ardea modesta	Eastern Great Egret	1	1		1	
		Ardea pacifica	White-necked Heron	1				1
		Botaurus poiciloptilus	Australasian Bittern					1
		Nycticorax caledonicus	Nankeen Night Heron		1			

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
	Charadriidae	*Charadrius bicinctus*	Double-banded Plover		1		1	
		Charadrius ruficapillus	Red-capped Plover	1	1	1		1
		Elseyornis melanops	Black-fronted Dotterel				1	
		Pluvialis fulva	Pacific Golden Plover		1			
		Pluvialis squatarola	Grey Plover		1			
		Thinornis rubricollis	Hooded Plover	1	1	1	1	1
		Vanellus miles	Masked Lapwing	1	1		1	1
	Ciconiiformes	*Egretta garzetta*	Little Egret		1			
		Egretta novaehollandiae	White-faced Heron	1	1	1	1	1
		Egretta sacra	Eastern Reef Egret			1		1
	Diomedeidae	*Diomedea exulans*	Wandering Albatross			1		1
		Thalassarche cauta	Shy Albatross	1		1	1	1
		Thalassarche chlororhynchos	Yellow-nosed Albatross	1		1		1
		Thalassarche melanophris	Black-browed Albatross	1			1	1
	Haematopodidae	*Haematopus fuliginosus*	Sooty Oystercatcher	1		1	1	1
		Haematopus longirostris	Pied Oystercatcher	1	1	1	1	1
	Hydrobatidae	*Pelagodroma marina*	White-faced Storm-Petrel	1				1
	Laridae	*Chlidonias leucopterus*	White-winged Black Tern		1			
		Chroicocephalus novaehollandiae	Silver Gull	1	1	1	1	1
		Hydroprogne caspia	Caspian Tern	1	1	1	1	1
		Larus dominicanus	Kelp Gull	1				
		Larus pacificus	Pacific Gull	1	1	1	1	1
		Sterna bergii	Crested Tern	1	1	1	1	1
		Sterna hirundo	Common Tern	1	1	1	1	1
		Sterna paradisaea	Arctic Tern	1	1			
		Sterna striata	White-fronted Tern		1	1	1	1
Birds		*Sternula albifrons*	Little Tern		1			1
		Sternula nereis	Fairy Tern		1		1	
	Meliphagidae	*Epthianura albifrons*	White fronted Chat		1			1
	Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican	1	1	1	1	1
	Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant	1	1	1	1	1
		Phalacrocorax carbo	Great Cormorant	1	1	1	1	1
		Phalacrocorax fuscescens	Black-faced Cormorant	1			1	1
		Phalacrocorax sulcirostris	Little Black Cormorant	1	1	1	1	1
		Phalacrocorax varius	Pied Cormorant	1	1	1	1	1

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
	Podicipedidae	*Poliocephalus poliocephalus*	Hoary-headed Grebe	1	1			1
	Procellariidae	*Ardenna grisea*	Sooty Shearwater	1	1			1
		Ardenna pacifica	Wedge-tailed Shearwater					1
		Ardenna tenuirostris	Short-tailed Shearwater	1	1	1	1	1
		Daption capense	Cape Petrel	1				
		Fulmarus glacialoides	Southern Fulmar	1				1
		Macronectes halli	Northern Giant Petrel				1	
		Pachyptila belcheri	Slender-billed Prion	1				
		Pachyptila turtur	Fairy Prion	1	1	1	1	1
		Pelecanoides urinatrix	Common Diving-petrel	1			1	
		Pterodroma lessonii	White-headed Petrel				1	
		Pterodroma macroptera	Great-winged Petrel				1	
		Puffinus gavia	Fluttering Shearwater	1	1	1	1	1
	Psittacidae	*Neophema chrysostoma*	Blue-winged Parrot	1				
	Rallidae	*Fulica atra*	Eurasian Coot		1			
	Rallidae	*Gallirallus philippensis*	Buff-banded Rail	1				
	Recurvirostridae	*Cladorhynchus leucocephalus*	Banded Stilt		1			
		Himantopus himantopus	Black-winged Stilt					1
	Scolopacidae	*Actitis hypoleucos*	Common Sandpiper					1
		Arenaria interpres	Ruddy Turnstone			1		1
		Calidris acuminata	Sharp-tailed Sandpiper		1			
		Calidris alba	Sanderling	1				
		Calidris canutus	Red Knot		1			1
		Calidris ferruginea	Curlew Sandpiper		1			1
		Calidris ruficollis	Red-necked Stint		1			1
		Calidris tenuirostris	Great Knot		1			
Birds		*Gallinago hardwickii*	Latham's snipe	1	1			1
		Heteroscelus brevipes	Grey-tailed Tattler					1
		Limosa lapponica	Bar-tailed Godwit		1		1	1
		Numenius madagascariensis	Eastern Curlew					1
		Tringa nebularia	Common Greenshank		1			
		Tringa stagnatilis	Marsh Sandpiper		1			
	Spheniscidae	*Eudyptula minor*	Little Penguin	1	1	1	1	1
	Stercorcariidae	*Stercorarius parasiticus*	Arctic Jaeger			1		1
		Stercorarius pomarinus	Pomarine Jaeger					1

Biotic group	Family	Species	Common Name	WP	NMB	BR	PH	CH
		Stercorarius skua	Great Skua					1
	Sulidae	*Morus serrator*	Australasian Gannet	1	1	1	1	1
	Threskiornithidae	*Platalea regia*	Royal Spoonbill		1	1		
		Threskiornis molucca	White Ibis	1	1		1	
Total birds				**44**	**49**	**29**	**38**	**53**
Reptiles	Cheloniidae	*Chelonia mydas*	Green Sea Turtle					1
		Eretmochelys imbricata	Hawksbill Turtle					1
	Hydrophiidae	*Pelamis platurus*	Yellow-bellied Sea Snake			1		1
Total reptiles				**0**	**0**	**1**	**0**	**3**
Mammals	Balaenidae	*Eubalaena australis*	Southern Right Whale	1	1		1	1
	Balaenopteridae	*Balaenoptera acutorostrata*	Minke Whale					1
		Megaptera novaeangliae	Humpback Whale	1		1	1	1
	Delphinidae	*Delphinus delphis*	Common Dolphin	1				
		Orcinus orca	Killer Whale	1			1	1
		Tursiops truncatus	Bottlenose Dolphin			1		
	Otariidae	*Arctophoca forsteri*	New Zealand Fur-seal	1				1
		Arctocephalus pusillus	Australian Fur-seal	1		1	1	1
	Phocidae	*Hydrurga leptonyx*	Leopard Seal	1		1		
		Mirounga leonina	Southern Elephant Seal			1		
	Physeteridae	*Kogia breviceps*	Pygmy Sperm Whale			1	1	
		Physeter macrocephalus	Sperm Whale	1		1		
	Ziphiidae	*Ziphius cavirostris*	Cuvier's Beaked Whale	1				
Total mammals				**9**	**1**	**7**	**5**	**6**

5 Appendix 2

Completed research and monitoring projects carried out under *National Parks Act 1975* research permits in or relevant to Flinders and Twofold Shelf MPAs with associated reports. Research Partner Panel (and RPP-like) research 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. Wilsons Prom 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.
Monash University: Janosch Hoffmann, Richard Reina, André Chiaradia Diet and breeding ecology of little penguins, *Eudyptula minor*, on Rabbit Island, Wilsons Promontory National Park. Hoffmann, J. (2006). The diet and foraging movements of the Little Penguin at Rabbit Island, Victoria. Honours Thesis. School of Biological Sciences, Monash University.
University of Melbourne: Jan Carey, Mark Burgman Risk Assessment for Marine National Parks and Sanctuaries. Carey, J.M., Burgman, M.A., Boxshall, A., Beilin, R., Flander, L., Pegler, P. and White, A.K. (2007). *Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries.* Parks Victoria Technical Series No.33. Parks Victoria, Melbourne. Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries*. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne. Carey, J.M., Beilin, R., Boxshall, A. Burgman, M.A. and Flander, L. (2007). Risk-Based Approaches to Deal with Uncertainty in a Data-Poor System: Stakeholder Involvement in Hazard Identification for Marine National Parks and Marine Sanctuaries in Victoria, Australia. *Risk Analysis* 27(1), 271-281. Carey, J.M. and Burgman, A. (2008) Linguistic Uncertainty in Qualitative Risk Analysis and How to Minimize It. *Annals of the* New York *Academy of Sciences* 1128: 13–17.
Department of Primary Industries: Simon Heislers, Greg Parry Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast. Heislers, S. and Parry, G.D. (2007). Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast. Parks Victoria Technical Paper Series No. 53. Parks Victoria, Melbourne.
Deakin University: John Arnould Support for research on island in Wilsons Promontory National Park and Marine National Park. Arnould, J.P.Y., Cherel, Y., Gibbens, J., White, J. G. and Littnan, C. L. (2011). Stable isotopes reveal inter-annual and inter-individual variation in the diet of female Australian fur seals. *Marine Ecology Progress Series* 422: 291–302. Arnould, J.P.Y. and Kirkwood, R. (2008). Habitat selection by female Australian fur seals (*Arctocephalus pusillus doriferus*). Aquatic Conservation: Marine and Freshwater Ecosystems 17: S53–S67.

Atkinson, S., Arnould, J.P.Y. and Mashburn, K.L. (2011). Plasma cortisol and thyroid hormone concentrations in pre-weaning Australian fur seal pups. *General and Comparative Endocrinology* 172(2): 277-281.

Costa, D.P., Robinson, P.W., Arnould, J.P.Y., Harrison, A-L., Simmons, S.E., Hassrick, J.L., Hoskins, A.J., Kirkman, S.P., Oosthuizen, H., Villegas-Amtmann, S. and Crocker, D.E. (2010). Accuracy of ARGOS Locations of Pinnipeds at-Sea Estimated Using Fastloc GPS. *PLoS ONE* 5(1): 1-9.

Deacon, N.L. and Arnould, J. P. Y. (2009). Terrestrial apnoeas and the development of cardiac control in Australian fur seal (*Arctocephalus pusillus doriferus*) pups. *Journal of Comparative Physiology B* 179:287–295.

Gibbens, J. and Arnould, J.P.Y (2007). Age-specific growth, survival and population dynamics of female Australian fur seals. *Canadian Journal of Zoology* 87: 902-911.

Gibbens, J. and Arnould, J.P.Y. (2009). Interannual variation in pup production and the timing of breeding in benthic foraging Australian fur seals. *Marine Mammal Science* 25(3): 573–587.

Gibbens, J., Parry, L.J. and Arnould, J.P.Y. (2010). Influences on fecundity in Australian fur seals (*Arctocephalus pusillus doriferus*). *Journal of Mammalogy*, 91(2): 510–518.

Kirkwood, R., Pemberton, D., Gales, R., Hoskins, A.J., Mitchell, T., Shaughnessy, P.D. and Arnould, J.P.Y. (2010). Continued population recovery by Australian fur seals. *Marine and Freshwater Research* 61: 695–701.

Kirkwood, R., Warneke, R.M. and Arnould, J.P.Y. (2009). Recolonization of Bass Strait, Australia, by the New Zealand fur seal, *Arctocephalus forsteri. Marine Mammal Science* 25(2): 441-449.

Lancaster, M. L., Arnould, J. P. Y. and Kirkwood, R. (2010). Genetic status of an endemic marine mammal, the Australian fur seal, following historical harvesting. *Animal Conservation* 13: 247-255.

Littnan, C.L., Arnould, J.P.Y. and Harcourt, R.G. (2007). Effect of proximity to the shelf edge on the diet of female Australian fur seals. *Marine Ecology Progress Series* 338: 257-267.

Lynch, M., Duignan, P., Taylor, T., Nielsen, O., Kirkwood, R., Gibbens, J. and Arnould, J.P.Y. (2011). Epizootiology of *Brucella* infection in Australian fur seals. *Journal of Wildlife Diseases* 47(2): 352-363.

Lynch, M., Kirkwood, R., Mitchell, A., Duignan, P. and Arnould, J.P.Y. (2011). Prevalence and significance of an alopecia syndrome in Australian fur seals (*Arctocephalus pusillus doriferus*). *Journal of Mammalogy* 92(2):342–351.

Lynch, M., Nielsen, O., Duignan, P.J. Kirkwood, R., Hoskins, A. and Arnould, J.P.Y. (2011). Serologic survey for potential pathogens and Assessment of disease risk in Australian fur seals. *Journal of Wildlife Diseases* 47(3): 555-565.

Spence-Bailey, L.M., Verrier, D. and Arnould, J.P.Y. (2007). The physiological and behavioural development of diving in Australian fur seal (*Arctocephalus pusillus doriferus*) pups. *Journal of Comparative Physiology B* 177: 483-494.

Tripovich, J.S., Canfield, R. Rogers, T.L. and Arnould, J.P.Y. (2009). Individual variation of the female attraction call produced by Australian fur seal pups throughout the maternal dependence period**.** *Bioacoustics* 18: 259-276.

Tripovich, J.S., Rogers, T.L., Canfield, R. and Arnould, J.P.Y. (2006). Individual variation in the pup attraction call produced by female Australian fur seals during early lactation. *Journal of the Acoustical Society of America* 120(1): 502-509.

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott

Ecological performance measures for Victorian Marine Protected Areas: Review of the existing

biological sampling program.

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

University of Melbourne: Madhavi Colton, Stephen Swearer

The Conservation Status of Reef Fish Communities in Victorian Waters.

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

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

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

Deakin University: Nicole Schumann, John Arnould.

Support for survey of nesting seabirds on islands around Wilsons Promontory.

Schumann, N. Arnould, J.P.Y. and Dann, P. (2008). Diet of Common Diving-petrels (*Pelecanoides urinatrix urinatrix*) in Southeastern Australia During Chick Rearing. *Waterbirds* 31(4): 620-624.

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.

Completed Monitoring Surveys and Associated Reports

Subtidal Reef Monitoring Program

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

Edmunds, M., Crozier, J., Judd, A. and Gilmour, P. (2007). *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Wilsons Promontory Marine National Park (Volume 3)*. Parks Victoria Technical Series No. 50. Parks Victoria, Melbourne.

Edmunds, M., Hart, S., Jenkins, S. and Elias, J. (2003). Victorian Subtidal Reef Monitoring Program: The Reef Biota at Wilsons Promontory Marine National Park. Parks Victoria Technical Series No. 6. Parks Victoria, Melbourne.

Lindsay, M. and Edmunds, M. (2006). *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Wilsons Promontory Marine National Park.* Parks Victoria Technical Series No. 27. Parks Victoria, Melbourne.

Power, B. and Boxshall, A. (2007). Marine National Park and Sanctuary Monitoring Plan

2007-2012. Parks Victoria Technical Series No. 54. Parks Victoria, Melbourne.

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

Brunton, D. and Baling, M. (2005). Conservation genetics of the New Zealand fairy tern *(Sterna nereis davisae).* Auckland Uniservices Limited, University of Auckland.

Costa, D.P., Robinson, P.W., Arnould, J.P.Y., Harrison, A-L., Simmons, S.E., Hassrick, J.L., Hoskins, A.J., Kirkman, S.P., Oosthuizen, H., Villegas-Amtmann, S. and Crocker, D.E. (2010). Accuracy of ARGOS Locations of Pinnipeds at-Sea Estimated Using Fastloc GPS. PLoS ONE 5(1): e8677. doi:10.1371/journal.pone.0008677.

Edmunds, M., Zavalas, R., Pritchard, K. and Stewart, K. (2009). Port Phillip Bay Channel Deepening Project. Deep Reef Impact and Recovery Assessment. Appendices. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 410 v1.0 A, Melbourne.

Edmunds, M., Stewart, K., Pritchard, K., Cutajar, J., Zavalas, R., Sheedy, B., Ong, J., Kerrigan, J. and Lewis, Z. (2009). Port Phillip Bay Channel Deepening Project. Deep Reef Impact and Recovery Assessment. Appendices. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 410. Melbourne.

Edmunds, M., Stewart, K., Pritchard, K., Cutajar, J., Zavalas, R., Sheedy, B., Ong, J., Kerrigan, J. and Lewis, Z. (2009) Port Phillip Bay Channel Deepening Project. Deep Reef Impact and Recovery Assessment - Field Report. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 407. Melbourne.

Gorfine, H. (2005). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

Gorfine, H. (2011). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

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

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.

2. Ninety Mile Beach MNP

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

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

Marine Natural Values Study. Victorian Marine National Parks and Sanctuaries.

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

University of Melbourne: Jan Carey, Mark Burgman

Risk Assessment for Marine National Parks and Sanctuaries.

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

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

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

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

University of Melbourne: 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.

Monitoring Reports

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

3. Point Hicks MNP

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

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

Marine Natural Values Study. Victorian Marine National Parks and Sanctuaries.

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

University of Melbourne: Jan Carey, Mark Burgman

Risk Assessment for Marine National Parks and Sanctuaries.

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

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

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

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

Department of Primary Industries: Simon Heislers, Greg Parry

Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast.

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

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott

Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program.

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

University of Melbourne: Masters students from Industry Project in Science program

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

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

Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake

Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries.

Ball, D. and Blake, S. (2007). Shallow habitat mapping in Victorian Marine National Parks and Sanctuaries, Volume 2: Eastern Victoria. Parks Victoria Technical Series No. 37. Parks Victoria, Melbourne.

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

University of Western Australia / Fugro / Deakin University / Department of Primary Industries:

Karen Holmes, Ben Radford, Kimberly Van Niel, Gary Kendrick, Simon Grove, Brenton Chatfield

Mapping the Benthos in Victoria's Marine National Parks (Deep Water Mapping).

Holmes, K.W., Radford, B., Van Niel, K.P., Kendrick, G.A. and Grove, S.L. (2007) *Mapping the Benthos in Victoria's Marine National Parks, Volume 2: Point Hicks.* Parks Victoria Technical Series No. 41. Parks Victoria, Melbourne.

Completed Monitoring Surveys and Associated Reports

Subtidal Reef Monitoring Program

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

Edmunds M., Stewart, K. and Pritchard, K. (2011). Victorian subtidal reef monitoring program: the reef biota within the Twofold Shelf Bioregion. Parks Victoria Technical Series No. 68. Parks Victoria, Melbourne.

Edmunds, M., Hart, S. and Ingwersen, C. (2005). Victorian Subtidal Reef Monitoring Program: The Reef Biota at Marine Protected Areas in the Twofold Shelf Region. Parks Victoria Technical Series No. 23. Parks Victoria, Melbourne.

Edmunds, M., Stewart, K., Pritchard, K., and Zavalas, R. (2010). Victorian Subtidal Reef Monitoring Program: The reef biota at Marine Protected Areas within the Twofold Shelf. Volume 3. Parks Victoria Technical Series No. 62. Parks Victoria, Melbourne.

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

Williams, J., Gilmour, P. and Edmunds, M. (2007). Victorian Subtidal Reef Monitoring: The Reef Biota Within the Twofold Bioregion, (Volume 2). Parks Victoria Technical Series No. 45. Parks Victoria, Melbourne.

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

Gorfine, H. (2005). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

Gorfine, H. (2011). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

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

Hidas, E.Z., Ayre, D.J. and Minchinton, T.E. (2010). Patterns of demography for rocky-shore, intertidal invertebrates approaching their geographical range limits: tests of the abundant-centre hypothesis in south-eastern Australia. *Marine and Freshwater Research* 61: 1243–1251.

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

4. Cape Howe MNP

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

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

Marine Natural Values Study. Victorian Marine National Parks and Sanctuaries.

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

University of Melbourne: Jan Carey, Mark Burgman

Risk Assessment for Marine National Parks and Sanctuaries.

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

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

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

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

University of Western Australia: Cordelia Moore, Euan Harvey, Gary Kendrick, Kimberly Van Niel

Spatial Ecology of Demersal Fish Assemblages in Victorian Marine National Parks: Establishing Baselines.

Moore, C.H., Van Neil, K. and Harvey, E. (2011). The effect of landscape composition and configuration on the spatial distribution of temperate demersal fish. *Ecography* 34(3): 425-435.

Moore, C.H., Harvey, E.S. and Van Niel, K.P. (2009). Spatial prediction of demersal fish distributions: enhancing our understanding of species–environment relationships. ICES Journal of Marine Science, 66: 2068–2075.

Moore, C. H., Harvey, E. S., and Van Niel, K. P. (2010). The application of predicted habitat models to investigate the spatial ecology of demersal fish assemblages. *Marine Biology* 157: 2717-2729.

Department of Primary Industries: Simon Heislers, Greg Parry

Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast.

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

University of Melbourne: Kate York, Belinda Appleton, Ary Hoffman

Genetics and Recruitment of Invertebrates in MPAs.

York, K. (2008). Taxonomy, biogeography and population genetic structure of the southern Australian intertidal barnacle fauna. Ph.D. Thesis. Department of Genetics, University of Melbourne.

York, K.L., Blacket, M.J. and Appleton, B.R. (2008). The Bassian Isthmus and the major ocean currents of southeast Australia influence the phylogeography and population structure of a southern Australian intertidal barnacle *Catomerus polymerus* (Darwin). *Molecular Ecology* 17: 1948-1961.

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott

Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program.

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

University of Melbourne: Madhavi Colton, Stephen Swearer

The Conservation Status of Reef Fish Communities in Victorian Waters.

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

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

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

University of Melbourne: Masters students from Industry Project in Science program

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

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

Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake

Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries.

Ball, D. and Blake, S. (2007). Shallow habitat mapping in Victorian Marine National Parks and Sanctuaries, Volume 2: Eastern Victoria. Parks Victoria Technical Series No. 37. Parks Victoria, Melbourne.

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

University of Western Australia / Fugro / Deakin University / Department of Primary Industries:

Karen Holmes, Ben Radford, Kimberly Van Niel, Gary Kendrick, Simon Grove, Brenton Chatfield

Mapping the Benthos in Victoria's Marine National Parks (Deep Water Mapping).

Holmes, K.W., Radford, B., Van Niel, K.P., Kendrick, G.A., Grove, S.L. and Chatfield, B. (2007). Mapping the Benthos in Victoria's Marine National Parks, Volume 1: Cape Howe. Parks Victoria Technical Series No. 40. Parks Victoria, Melbourne.

Completed Monitoring Surveys and Associated Reports

Subtidal Reef Monitoring Program

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

Edmunds, M., Hart, S. and Ingwersen, C. (2005). Victorian Subtidal Reef Monitoring Program: The Reef Biota at Marine Protected Areas in the Twofold Shelf Region. Parks Victoria Technical Series No. 23. Parks Victoria, Melbourne.

Edmunds, M., Stewart, K., Pritchard, K., and Zavalas, R. (2010). Victorian Subtidal Reef Monitoring Program: The reef biota at Marine Protected Areas within the Twofold Shelf. Volume 3. Parks Victoria Technical Series No. 62. Parks Victoria, Melbourne.

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

Williams, J., Gilmour, P. and Edmunds, M. (2007). Victorian Subtidal Reef Monitoring: The Reef Biota Within the Twofold Bioregion, (Volume 2). Parks Victoria Technical Series No. 45. Parks Victoria, Melbourne.

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

Gorfine, H. (2005). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

Gorfine, H. (2011). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

5. Beware Reef MS

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

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

Marine Natural Values Study. Victorian Marine National Parks and Sanctuaries.

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

Monash University: David Hurst, Sharron Pfueller.

Engaging communities in monitoring park values and threats.

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

University of Melbourne: Jan Carey, Mark Burgman

Risk Assessment for Marine National Parks and Sanctuaries.

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

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

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

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

University of Melbourne: Kate York, Belinda Appleton, Ary Hoffman

Genetics and Recruitment of Invertebrates in MPAs.

York, K. (2008). Taxonomy, biogeography and population genetic structure of the southern Australian intertidal barnacle fauna. Ph.D. Thesis. Department of Genetics, University of Melbourne.

York, K.L., Blacket, M.J. and Appleton, B.R. (2008). The Bassian Isthmus and the major ocean currents of southeast Australia influence the phylogeography and population structure of a southern Australian intertidal barnacle *Catomerus polymerus* (Darwin). *Molecular Ecology* 17: 1948–1961.

University of Adelaide: Abby Sims, John Tibby

The Environmental History of Tamboon Inlet: using sediment-based techniques to understand human impact.

Sims, A. (2006). A palaeoecological reconstruction of Tamboon Inlet, eastern Victoria: shortcomings of classification. Bachelor of Environmental Studies Honours thesis,

Geographical and Environmental Studies University of Adelaide.

University of Melbourne: Mick Keough, Jeff Ross, Nathan A. Knott

Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program.

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

University of Melbourne: Madhavi Colton, Stephen Swearer

The Conservation Status of Reef Fish Communities in Victorian Waters.

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

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

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

University of Melbourne: Masters students from Industry Project in Science program

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

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

Completed Habitat Mapping Projects and Associated Reports

Department of Primary Industries: David Ball, Sean Blake

Shallow Water Habitat Mapping at Victorian Marine National Parks and Sanctuaries.

Ball, D. and Blake, S. (2007). Shallow habitat mapping in Victorian Marine National Parks and Sanctuaries, Volume 2: Eastern Victoria. Parks Victoria Technical Series No. 37. Parks Victoria, Melbourne.

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

Completed Monitoring Surveys and Associated Reports

Subtidal Reef Monitoring Program

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

Edmunds, M., Hart, S. and Ingwersen, C. (2005). Victorian Subtidal Reef Monitoring

Program: The Reef Biota at Marine Protected Areas in the Twofold Shelf Region. Parks Victoria Technical Series No. 23. Parks Victoria, Melbourne.

Edmunds, M., Stewart, K., Pritchard, K., and Zavalas, R. (2010). Victorian Subtidal Reef Monitoring Program: The reef biota at Marine Protected Areas within the Twofold Shelf. Volume 3. Parks Victoria Technical Series No. 62. Parks Victoria, Melbourne.

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

Williams, J., Gilmour, P. and Edmunds, M. (2007). Victorian Subtidal Reef Monitoring: The Reef Biota Within the Twofold Bioregion, (Volume 2). Parks Victoria Technical Series No. 45. Parks Victoria, Melbourne.

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

Gorfine, H. (2005). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

Gorfine, H. (2011). Assessment of abalone populations in Victorian marine protected areas. Department of Primary Industries.

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.

Healthy Parks Healthy People

For more information contact the **Parks Victoria Information Centre** on **13 1963**, or visit **www.parkweb.vic.gov.au**

State Government Victoria

Parks VICTORIA

Healthy Parks Healthy People®