VNPA Nature Conservation Review: Marine Conservation Priorities and Issues for Victoria

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Report No. 405

Version 10

April 2010

Nature Conservation Review:
Marine and Coastal Issues Paper

Document Control Sheet

Abstract
Review and analysis of marine and coastal conservation status and priorities in Victoria for the Victorian National Parks Association.

Keywords
Nature conservation review, Victoria, marine, coastal, threats, priorities, values, gap analysis, marine protected areas, conservation management.

Citation
Edmunds M, Mustoe S, Stewart K, Sheedy E and Ong J (2009) *VNPA Nature Conservation Review: Marine Conservation Priorities and Issues for Victoria*. Report to Victorian National Parks Association. Australian Marine Ecology Report 405, Melbourne.

Amendments

No	Section	Date	Amendment Details
0.1	All	20-10-08	Draft outline
0.4	All	18-05-09	Restructuring of report
0.5	All	04-07-09	Revised draft with hazard analysis
0.10	All	18-04-10	Final draft for VNPA review.

Distribution

Copy	Holder	Section/Organisation
1	Library	Australian Marine Ecology
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File:	405-04-R0405-010	**Version**:	0.10	**Pages**:	203
Approved:	Managing director, 18-04-10	**Issued**:	18-04-10		

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1 Introduction

1.1 Purpose of the Review

Australian Marine Ecology Pty Ltd was commissioned by the Victorian National Parks Association (VNPA) to produce this *Marine and Coastal Issues Paper*, as part of its fourth Nature Conservation Review since 1971. The third Review in 2000 put forward values requiring protection and contributed to the establishment of a marine protected area system for Victoria in 2002, which now covers approximately 5 % of coastal waters. This compares to protection of 18 % of Victoria's land.

This Review builds on the third review, seeking an approach to build biodiversity resilience in the face of environmental threats. The Victorian marine and coastal environment is impacted upon by many threats, the most significant of which is likely to be associated with climate change. While many changes are inevitable, their extent and consequences will depend on what strategies are put in place now.

Since the third review, there has been a spate of systematic investigations of marine habitats and biodiversity along the Victorian coast. This review uses this new information to update our understanding of Victorian marine natural values, biodiversity, ecosystem services and conservation status. There have also been considerable recent developments in approaches to marine biodiversity management and conservation.

During this fourth review, we have concentrated on habitat as the central component that supports and regulates the ecosystem. All other services that the ecosystem provides, such as fisheries, tourism and culture, depend on landscape-scale habitat integrity and biodiversity. It is widely acknowledged that loss of habitat contributes significantly to societal failure (Diamond 2005). Natural capital is divided between biodiversity and the human economy, so the more we draw on habitat for direct economic gain, the more we limit the ability of the ecosystem to resist cumulative pressures we impose on the environment as a whole (Figure 1.1; Czech 2000, 2003).

The effects of climate change are addressed in a dedicated chapter as this is one of the most pressing and compelling examples of where exploitation of natural capital is beyond the environment's ability to regulate atmosphere and climate. Because global warming cannot be avoided, at least in the short-term, human adaptation will be needed to build biodiversity resilience, as climate change directly impacts on species and ecosystems, whilst compounding existing stresses such as reduced water quality, pest invasion, marine infrastructure and over harvesting.

As signatories to the World Summit on Sustainable Development and the World Parks Congress, Australia has pledged to protect 20-30 % of coastal habitats. This report will provide VNPA with fresh evidence of environmental threats, priority habitats and management strategies that will hopefully inform decisions to augment the state's existing marine protection policies.

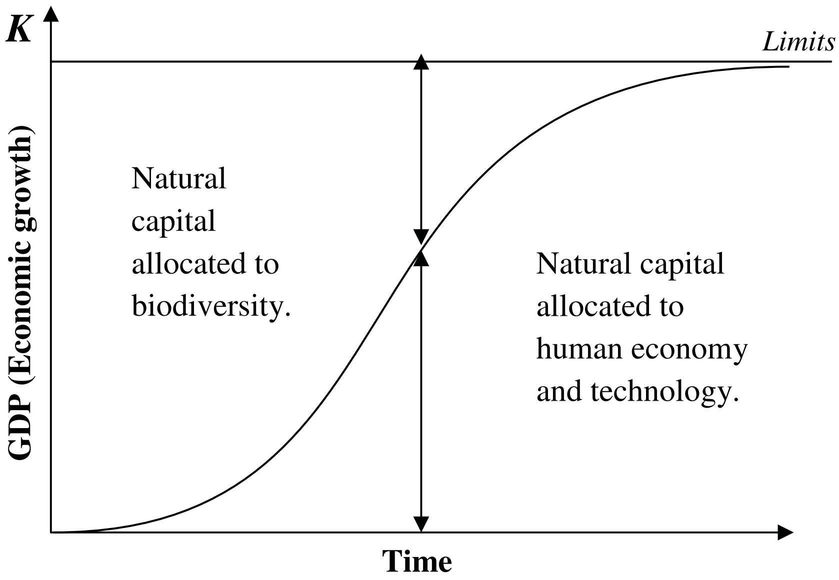


Figure 1.1. Relationship between human economy and natural capital.
As the economy grows, more natural capital is drawn from nature and used by the human economy. The breadth of the human niche is at the expense of nature and biodiversity. *K* is the carrying capacity for the human economy. A sustainable economy would be sufficiently below this limit so that the natural extent of habitat is adequate to maintain ecosystem function and, therefore, also support the human economy (Czech 2000).

1.2 Report Structure

This review compiles available information for habitats, communities, species and ecosystem processes and aspects of high conservation value for regions of Victoria. An overview of key findings from this analysis is provided in *Chapter 2 Victorian Marine Natural Values*. This information was an input to the later analysis for determining priority conservation areas.

General threats to marine and coastal values were identified and are described in *Chapter 3: Threats*. The location and general level of threats was an input to the analysis for determining priority conservation areas.

Chapter 4: Conservation Priorities provides an analysis of areas of high priority for protection, using a semi-quantitative approach. *Chapter 4* describes both the methods and results for ranking the conservation values of habitats and areas throughout Victoria. This ranking was then combined with information on threats to identify habitats and areas of greatest conservation concern and priority.

Chapter 5: Conservation Status and Gap Analysis describes the status of existing marine conservation management in Victoria, including the application of marine protected areas. The existing conservation measures are then compared with the identified conservation priorities to determine conservation status and identify areas of particular conservation concern (gap analysis).

Climate change is an emergent threat with profound implications for Victorian marine natural values. As such, the implications for climate change for marine conservation and management were addressed in more detail in its own chapter: *Chapter 6: Climate Change and Implications for Ecosystems.*

Key findings of this review are summarized in *Chapter 7: Discussion.* This chapter summarizes key marine natural values, threats, areas and ecosystems of high conservation priority and existing conservation strategies. It also identifies key knowledge gaps. This information, along with a brief discussion of advances in conservation approaches, is used to formulate recommendations and suggest directions that have the greatest confidence of providing improved outcomes for marine conservation in Victoria.

1.3 Analysis Approach

To identify areas and habitats requiring greater management and protection, the review required a synthesis of available information and knowledge at an appropriate spatial resolution. This involved identifying the principal components for the assessment, including the natural values of the Victorian marine environment, and the hazards that threaten it. The available information was complied into tables of:

- Bioregions;
- Biounits – coastal segments or habitat regions within bioregions;
- Habitat types within biounits;
- Ecosystem services;
- Ecological processes (biological, chemical and physical);
- Listed species,
- Threats; and
- Threatening processes.

A database, the VNPA Coastal Issues Database, was developed. This linked ecosystem services, processes, habitats, threats and threatening processes together according to a logical model and was used to assess habitats based on their natural values and threat exposure (Figure 1.2; *Chapter 4*).

The relative importance of individual habitats for building ecosystem resilience was calculated (Figure 1.3; *Section 4.2.2*). Habitats were also assessed according to their importance to ecosystem processes and their vulnerability to threats, and then assigned semi-quantitative values based on that assessment (Figure 1.3; *Section 4.2.3*). By combining the scores for ecosystem resilience with the scores for importance and vulnerability, a conservation value ranking was calculated for each habitat type (Figure 1.3; *Section 4.2.4*).

The conservation value of habitat types, the distribution of those habitats and the areas' naturalness, uniqueness and isolation were used to identify areas of high conservation value (Figure 1.3; *Section 4.3*). By assessing the conservation value of areas together with their degree of exposure to active threatening processes, areas of high conservation priority were identified (Figure 1.3; *Section 4.5*).

The areas our analysis deemed as being of high conservation priority were compared to the coverage of the Victorian marine protected area network. From this comparison, gaps in the existing system were identified and recommendations made as to how to best remedy them (Figure 1.3; *Chapters 5-7*).

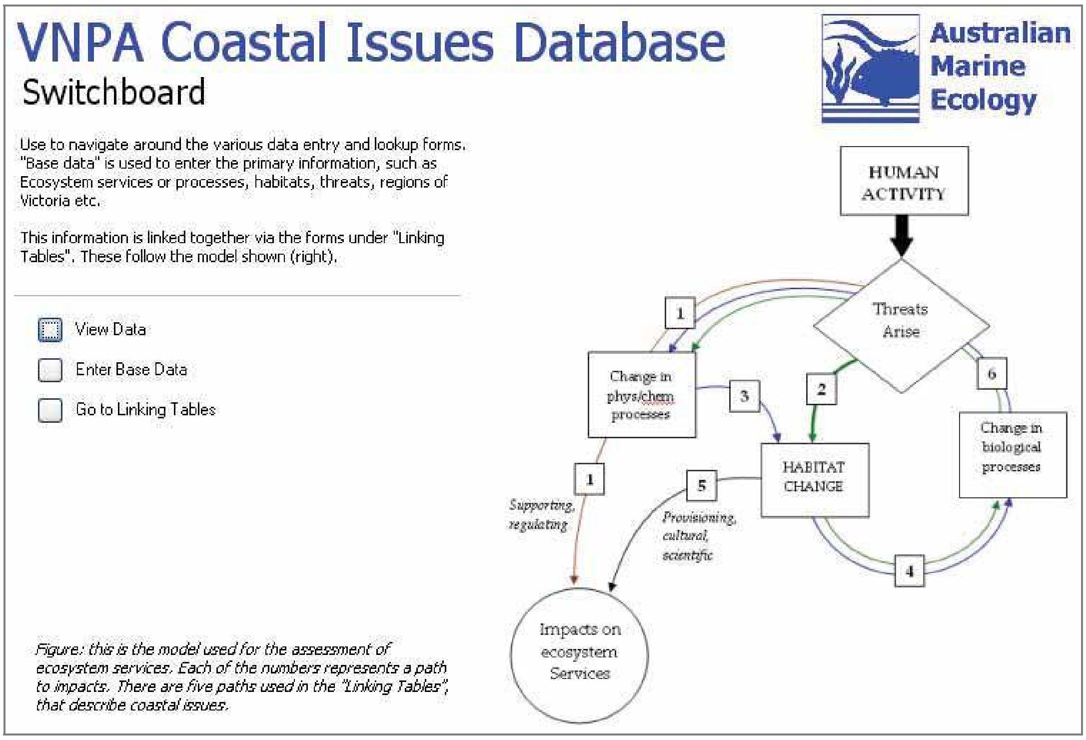


Figure 1.2. VNPA Coastal Issues Database. Database for linking issues with habitats and locations for identifying priority areas of conservation concern.

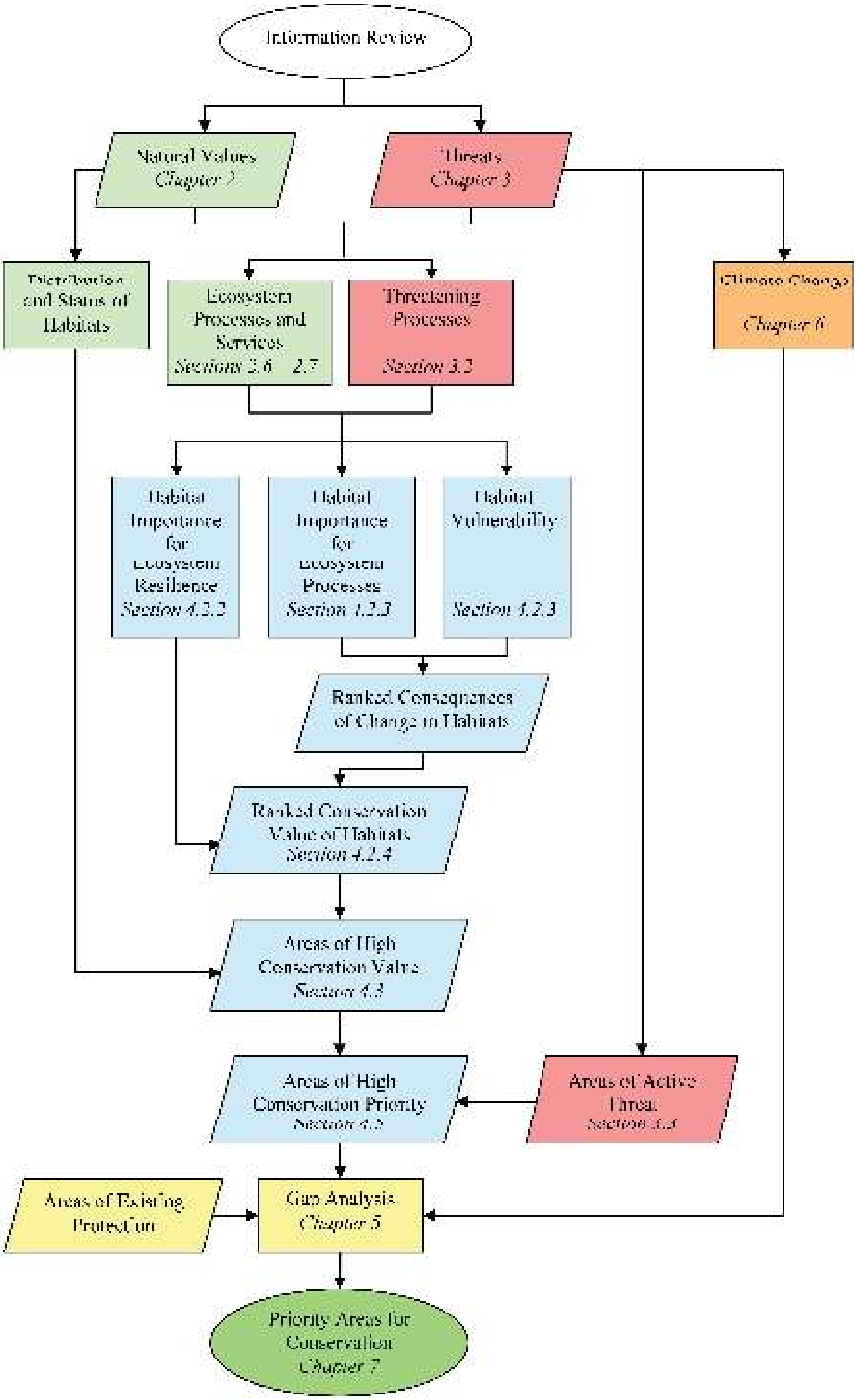


Figure 1.3. Diagram of the analysis process used in this review to identify areas of conservation priority.

2 Victorian Marine and Coastal Natural Values

2.1 Introduction

Victoria's offshore environment covers almost 7 000km^2 (about 20 % of the combined land-sea surface area of the state). It extends 3 nautical miles from the coast to depths of about 120 m off East Gippsland.

Victoria is at the boundary of the Southern and Pacific Oceans, so many species have their southern limit in eastern Victoria and their eastern limit in central Victoria. The narrow Bass Strait, which forms the boundary between these oceans, is influenced by massive oceanographic features, in summer when the East Australian Current is at strength and winter when the South Australian Current is influencing eastern waters. Important, nutrient rich upwellings occur in Discovery Bay (Bonney Upwelling) and along east Gippsland (Bass Canyon Upwelling).

Located at the southern tip of the Australian mainland, Victoria's marine habitats are unusually species rich compared to similar cool temperate habitats elsewhere in the world. Further, the percentage of endemic marine species in this part of southern Australia (including Tasmania) is much higher than for example, the Great Barrier Reef. The richness of Victoria's coastal environment is enhanced by regional-scale variations in geology and geomorphology. For example, Ninety Mile Beach dominates the coast for much of East Gippsland, supporting species rich sub-tidal sandbed communities. Coastal estuaries of international importance occur mostly in Central Victoria and include Corner Inlet, Western Port and Melbourne's Port Phillip Bay. There are substantial rocky headlands, most notably Wilsons Promontory, and offshore islands such as Deen Maar (Lady Julia Percy), Gabo Island and Lawrence Rocks. In western Victoria, the coast is dominated by limestone cliffs and prevailing Southern Ocean swells.

When characterizing any environment, it is easy to under-state complexity by concentrating on these larger-scale processes. It is also easy to understate the influence of human activity on existing conditions. If it were not for problems such as climate change, it could be fairly suggested that ecosystem productivity is not the consequence of large-scale processes at all, but the combination of countless over-lapping small-scale processes evolved to maximum ecological productivity.

However, environmental change is happening. Even in the face of skepticism about climate change, there is overwhelming evidence of rapid physical changes in the environment and that habitats are having to adapt, resetting an ecological balance that has been mostly stable for thousands of years. The obvious example is coastal erosion and the effects this has on coastal ecosystems as well as towns and residences. Critical processes such as geomorphology and erosion depend on habitat function but cannot succeed if subject to existing human pressure. Habitat removal and even more significantly, suppression of regeneration / adaptation, may be amongst the most significant factors to shape the future of Victoria's marine environment. Yet, habitat adaptation is necessary for Victoria's marine biodiversity to be allowed to build resilience against impending problems.

So, in the past, it may have been adequate to describe a snapshot of Victoria's biodiversity in 'natural' terms and seek to protect remnants but that is no longer appropriate. Victoria's marine environment is to a large degree shaped by natural processes from the scale of metres up to hundreds of kilometres but human activities, particularly in the catchments, rivers and coast, have the most significant potential effect on coastal ecosystem complexity and processes. Over time, these effects are also likely to erode values further offshore, in protected areas and other areas of high conservation value that may or may not be currently under threat.

In the past, it may also have been adequate to divide Victoria into locations, habitats and species, assigning each of these a value irrespective of the other. This is no longer appropriate. If a species goes extinct, it indicates collapse in important processes attributed to its habitat. If a species is exploited to extinction, processes within its habitat will change as species have a substantial role to play in trophic dynamics and ecological succession. If a habitat is lost, even if it is common and widespread, its real 'value' may be in terms of ecosystem functions such as erosion control. The importance of a habitat or species is not to do with its rarity but to do with its location and function in relation to the seascape and adjacent landscape.

In summary, to identify priorities for conservation today, it is appropriate to take a forward view, to speculate on the rate and direction of change and to build resilience through enhanced ecosystem integrity. It is also necessary to take a balanced and objective view of the ecosystem's components. Species and habitats may be more or less threatened but this does not mean they are equally more or less important. The 'value' of biodiversity is measured in terms of its structure, function and composition.

Therefore, in the following sections, we describe Victoria's marine environment in terms of how it operates. By understanding the components of the environment in regard to their habitat and the processes that occur there, we can better appreciate what needs to be done for ecosystem management across Victoria's five bio-regions (Figure 2.1).

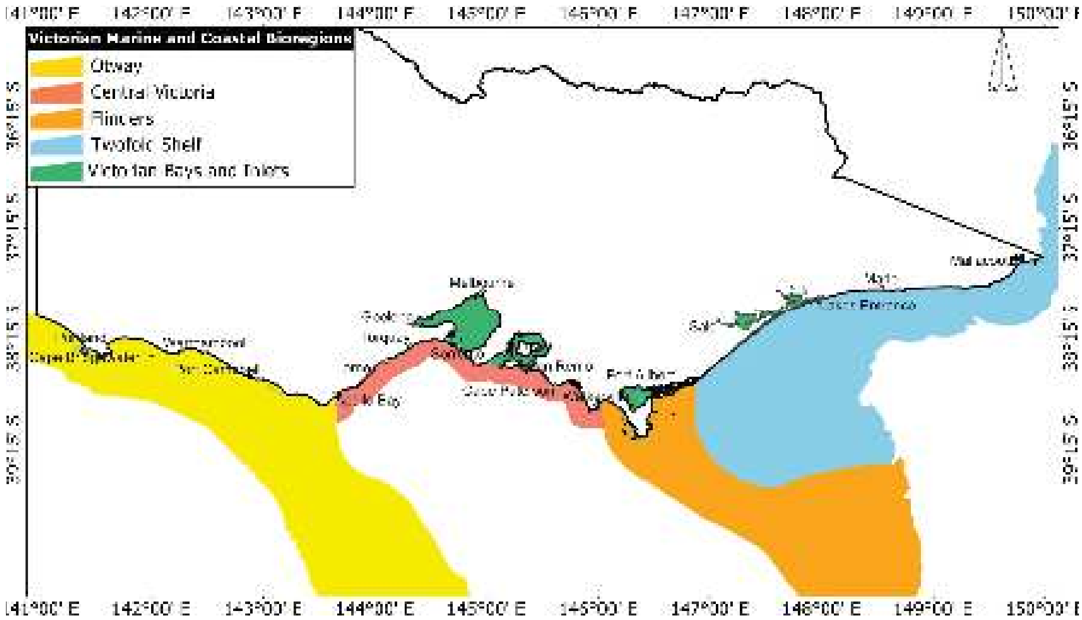


Figure 2.1. Marine and coastal bioregions of Victoria.

2.2 Environments and Bioregions

Bioregions have been defined as 'assemblages of flora, fauna and the supporting geophysical environment contained within distinct but dynamic spatial boundaries' (Welsh 1994 in CSIRO Division of Fisheries and CSIRO Division of Oceanography, 1996). Understanding and delineating these boundaries and the functioning of bioregions are integral for effective ecological management. Species distributions are closely linked to specific environmental parameters, and further influenced by a complex network of environmental and biological variables. The response of organisms to altered environmental factors is manifested in the distributional boundaries of these organisms. Studies of species distributions may therefore lead to a more comprehensive understanding of the dynamics of marine regions (CSIRO Division of Fisheries and CSIRO Division of Oceanography, 1996). Victoria's marine environment has been classified into five bioregions according to a nationally agreed scheme based on physical and biological attributes (IMCRA 1997).

2.2.1 Otway Bioregion

The coastline along the Otway bioregion has high cliffs and sand dunes, which act as a coastal barrier and protects against flooding and storms. The sandy beaches and dunes along the western coastline provide ecosystem services in the form of recreation and tourism as well as habitat provision for a variety of organisms. The Bonney coast, from South Australia to Discovery Bay, is a productive area because of upwellings. These greatly influence primary productivity and maintain commercially important fisheries species such as abalone and the southern rock lobster. High productivity in the Bonney coast is also an important feeding ground for seabirds, fur seals and whales. The coastal heath and scrubs along the coast provide habitats and help to stabilize the shoreline and prevent erosion. Estuaries along the Otway bioregion, such as Yambuk Lake estuary provides shelter for estuarine plants and animals, and is an important nursery area for juvenile fish. The numerous wetland habitats along the Otway bioregion (at Yambuk Lake and along Shipwreck coast) help act as nitrogen and phosphate sinks, reducing coastal water pollution. The Shipwreck coast along the eastern side of the Otway bioregion is a major tourism area, with the Great Ocean Road and the rock formations such as the Twelve Apostles attracting many visitors. Lawrence Rocks, off the coast at Portland, is a popular diving site and the island supports the largest colony of gannets in Australia, as well as breeding colonies of other seabirds.

2.2.2 Central Victoria Bioregion

The area in between Apollo Bay to Torquay has long stretches of sandy beaches backed by dunes and interspersed with high cliffs. The sandy beaches serve as popular recreational areas, with Bells Beach and Torquay being popular as surfing spots, boosting tourism in those areas. The cliffs and dunes form a natural barrier, protecting against floods and coastal storms. Coastal heathland and scrub are also common in this area, including the threatened coastal Moonah Woodland community. The coastal heathland and scrub vegetation are important stabilizers of the coastline, helping to prevent erosion. Intertidal reefs occur along Bells Beach, Port Phillip Heads and Bunurong. These reefs serve as recreational and educational research areas as well as provide habitat for numerous marine invertebrates and algal species. The sandy beaches, cliffs, dunes and coastal vegetation at Bunurong is an important habitat for shore birds, in particular the vulnerable Hooded Plover. Extensive subtidal reefs occur from Aireys Inlet to Point Addis, Point Danger to Point Lonsdale, at Port Phillip Heads, from Cape Schanck to West Head and at Phillip Island. Subtidal reefs provide sheltered habitats and food for fish and invertebrate species. These reefs serve as recreational areas and provide opportunities for research to be done. Seagrass beds occur at Port Phillip Heads and also at Bunurong, helping to stabilize sediments and contributing to water quality. Seagrass beds are also important nursery areas for commercially important juvenile fish and invertebrates. Some salt marsh habitats occur between Cape Paterson and Inverloch, providing habitat for aquatic plants and animals as well as shore birds. Salt marshes have an important role in nutrient cycling of nitrogen and phosphorus, essential biological regulators. Salt marshes also help in pollution control by acting as a sink for pollutants such as pesticides and heavy metals.

2.2.3 Flinders Bioregion

Beaches with vegetated dunes degrading to coastal heathland and scrubs line the western Flinders bioregion. The dunes and coastal heathland form a coastal barrier protection, helping to stabilize the shoreline, prevent erosion and protect against floods. The high cliffs that line the coast of the Flinders bioregion, mainly on the western side of Wilsons Promontory also offer protection against flooding and storms. The small estuaries along the coast at Shallow Inlet and Tidal River provide habitat and serve as nurseries for commercially important juvenile fish and invertebrates. A major ecosystem service provided by the Flinders bioregion and especially from Wilsons Promontory is for recreation and tourism. The many sandy beaches along the coast provide recreational areas and the coastal and estuarine waters off the Flinders bioregion (outside the marine parks) also provide recreational fishing spots. The coastal waters off Wilsons Promontory are unique, being a region under the influence of the South Australia Current, East Australia Current, Northern Bass Strait and subantarctic surface waters. The coastal waters provide important habitats for many species at the end of their normal ranges. The seagrass beds at Shellback Island, Glennie Island and some bays (Norman Bay, Oberon Bay, Waterloo Bay and Refuge Cove) provide important nursery areas for juvenile species, help to stabilize sediment beds and improve water quality by trapping suspended sediments from the water column. The subtidal, intermediate and deep reefs off the coast and around the islands provide habitats for many species and help the tourism industry through nature-based tourism such as scuba diving and snorkelling.

2.2.4 Twofold Shelf Bioregion

A long stretch of sandy beaches backed by dune barriers with scrub vegetation and enclosing a complex of coastal lakes, lagoons and swamps occurs at the Ninety Mile Beach region, including from Red Bluff to Point Ricardo. The sandy beaches serve as recreational areas while the vegetated dunes help stabilize the coastline, prevent erosion and protect against flooding. The enclosed lagoons and wetlands provide sheltered habitats for fish, invertebrates and shorebirds. Coastal wetlands in these areas and at Mallacoota Inlet also capture and filter sediments and organic waste from the land to the ocean, helping to regulate water quality and reduce coastal water pollution. A number of estuarine lagoons occur along Croajingolong coast such as Sydenham Inlet and Tamboon Inlet. These estuarine environments, along with Mallacoota Inlet, are high in nutrients because of inputs from both freshwater and marine sources. Estuaries also serve as nurseries for juvenile fish and invertebrates. The Twofold Shelf region is a productive, nutrient-rich area because of the upwellings that occur along the coast between Lakes Entrance and Gabo Island. Primary productivity in this area is greatly influenced by upwelling events and serves as important feeding grounds for seabirds, fish and marine mammals. The sandy beaches along this bioregion and the low profile reefs that occur parallel to the shore along the Ninety-mile beach area serve as important recreational and fishing spots.

2.2.5 Victorian Bays and Inlets

Extensive salt marsh areas can be found in Port Phillip Bay (example at Swan Bay and Northern Port Phillip Bay which is an important habitat for the endangered Orange-Bellied Parrot), Corner Inlet, Gippsland Lakes and Western Port (for example French Island, Phillip Island and Sandy Point). Salt marshes provide several ecosystem services, the first of which is as a natural barrier. Salt marsh vegetation stabilizes the shoreline and limits flooding of coastal cities and towns. Salt marshes also help in pollution control by acting as sinks for a number of pollutants such as pesticides and heavy metals. Pollution regulation coupled with trapping of sediments by salt marsh vegetation help to improve water quality of coastal and estuarine ecosystems. Healthy salt marsh habitats have an important role in nutrient cycling of nitrogen and phosphorus, necessary for regulating biological productivity.

In Port Phillip Bay, mangroves can be found in Limeburners Bay and in Jawbone marine sanctuary in Williamstown. Mangrove pockets also occur at several places in Corner Inlet (such as Chalk Cliffs and Millers Landing), Western Port (example French Island, Phillip Island, Barallier Island and Sandy Point) and parts of Nooramunga. Mangroves help absorb pollutants through processes involving the mangrove plants, microorganisms and sediments. Mangrove habitats are also sources of nutrients to marine and terrestrial ecosystems through active and passive transport, and provide habitats for aquatic life.

Large seagrass beds can be found in the Geelong Arm, southern Port Phillip Bay, Corner Inlet, Western Port, Nooramunga and Gippsland Lakes. Seagrass beds help stabilize and trap sediments, helping to improve water quality. They also provide nursery areas for commercially important juvenile fish and invertebrates, as well as supporting a variety of marine and estuarine species.

Swamp areas are present in Gippsland Lakes and at Yallock Creek in Western Port. These habitats help to trap sediments and provide habitats for waterbirds, fish and crustaceans.

Numerous stretches of sandy beaches occur in southern Port Phillip Bay, Western Port (example Phillip Island), Corner Inlet and Nooramunga. These provide recreational ecosystem services to human populations and also help the tourism industry.

Sediment channels are limited in area but support unique faunal communities. Important channels occur in areas near ports where they are used for transport. In Port Phillip Bay, South Channel and the Port of Melbourne Channel are used by big commercial ships to transport goods in and out of Melbourne. The North Arm in Western Port is used for transport to and from the Port of Hastings, another important port in Victoria.

2.3 Ecosystems and Habitats

2.3.1 Knowledge Base

The Victorian shallow reefs were first mapped using aerial photography and ground truthing information from abalone fishers (McShane *et al.* 1986). The first systematic investigation of Victorian deeper reef habitats was in 1995 (Roob and Currie 1996). This study was at selected points along the coast to provide information for the selection of marine protected areas (LCC 1996). The methods used single-beam acoustic benthic mapping and drop-video inspections to map and describe substratum classes and associated biota. Deep reef habitat classes and the presence/absence of habitat-forming biota was documented for selected sites at Cape Bridgewater, Deen Maar (Lady Julia Percy Island), Lake Gillear, Port Campbell, Moonlight Head, Point Addis, Cape Liptrap, Point Hicks, Ram Head and Cape Howe. The information is limited in its spatial coverage, but remains the only available information for most of these places. This mapping was later bolstered by surveys at other sites using similar methods, including Cape Nelson, Cape Grant, Twelve Apostles and Bunurong (Roob and O'Hara 1996; Roob *et al.* 1999; Roob 2000; Ferns and Hough 2002). Over the same period there was detailed mapping of habitats and communities within the bays and inlets throughout Victoria (Roob *et al.* 1998; Blake *et al.* 2000; Blake and Ball 2001a, 2001b).

The second systematic coastal statewide investigation was from 2004 to 2006 to map deeper habitats within Discovery Bay, Twelve Apostles, Point Addis, Point Hicks and Cape Howe Marine National Parks (Holmes 2007 volumes 1 to 5). This study involved collaborations between Parks Victoria, University of Western Australia, Deakin University and Fugro Survey Pty Ltd. The bathymetry was mapped using high resolution swathe mapping techniques to provide invaluable information on the distribution of different reef and sediment habitats. These findings have not been formally reported or made publicly available yet, however various example images are in the public domain (*e.g.* Fugro 2005 – Victoria Coastal Habitat Mapping; Kennedy 2005). Towed video and still cameras were used to provide information on biological classes. Nearshore habitats within marine protected areas were also mapped using aerial photography and towed video ground truthing (Ball and Blake 2007, volumes 1 and 2).

The deep reef habitats of Port Phillip Heads were mapped at a high resolution as part of the Channel Deepening Project baseline studies. These investigations used hydroacoustics and ROV video to provide descriptions of bathymetry, substratum structures and biogenic habits (Elias *et al.* 2004; Edmunds, Gilmour *et al.* 2007; Edmunds, Shimeta *et al.* 2007).

Other deep reef habitat mapping is presently being done by Deakin University along with the CRC for Coastal, Estuary and Waterway Management, the Glenelg Hopkins CMA and (formerly) the Marine and Coastal Community Network. High resolution bathymetry mapping has been done by Fugro for the Cape Nelson, Deen Maar, Tyrendarra and Hopkins Estuary areas (Fugro 2005 – Victoria Coastal Habitat Mapping). Fisheries Victoria is presently mapping rock lobster habitat (Fisheries Victoria 2008). Lobster habitat is predominantly deep reef and this study is likely to be informative from a nature conservation perspective.

An airborne light detection and ranging (LiDAR) system has been used to construct a digital elevation model of Victorian coastal bathymetry. This project, funded by the Victorian State Government, was scheduled for completion in early 2009, however the data was unavailable at the time of this reports preparation. This model will dramatically increase our knowledge of the distribution of environmental habitats types. This method is limited by water clarity and there remain considerable areas of deeper habitat without finer scale bathymetry mapping.

Table 2.1.: Key habitat mapping studies and publications used as source information for this study.

	Source	Type of data	Region
Habitat Mapping	Ball and Blake (2007a, 2007b)	Shallow water habitat mapping	All Marine National Parks
	Blake and Ball (2001b)	Aerial seagrass mapping	Port Phillip Bay
	Blake and Ball (2001a)	Seagrass mapping	Western Port
	Blake *et al.* (2000)	Seagrass mapping	Anderson, Shallow, Sydenham, Tamboon, Wingan and Mallacoota Inlets
	Deakin Uni, DSE (unpublished)	Deep water mapping of biota and substrate	Cape Nelson, Discovery Bay, Dean Maar, Hopkins, Pt Grey, 12 As, Tyrendarra, Anglesea, Pt Hicks
	Native Vegetation (2005)	Native vegetation spatial datasets	Statewide
	OzCoasts (unpublished)	Victorian Coastal Waterways Geomorphic Habitat Mapping	Statewide
	Roob and Ball (1997)	Seagrass mapping	Gippsland Lakes
	Roob and Currie (1996); Roob and O'Hara (1996); Roob *et al.* (1999)	High resolution habitat maps of selected nearshore areas	Statewide
	Roob *et al.* (1998)	Seagrass mapping	Corner Inlet and Nooramunga
Key Features	Environment Conservation Council (2000)	Victorian marine natural values and key features	Statewide
	O'Hara and Barmby (2000)	Marine invertebrates of conservation concern	Statewide

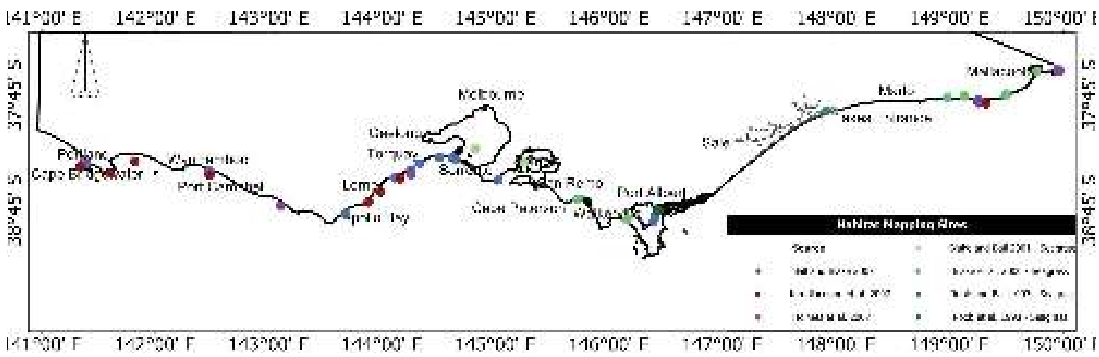


Figure 2.2. The locations of key habitat mapping studies used as source information for this study.

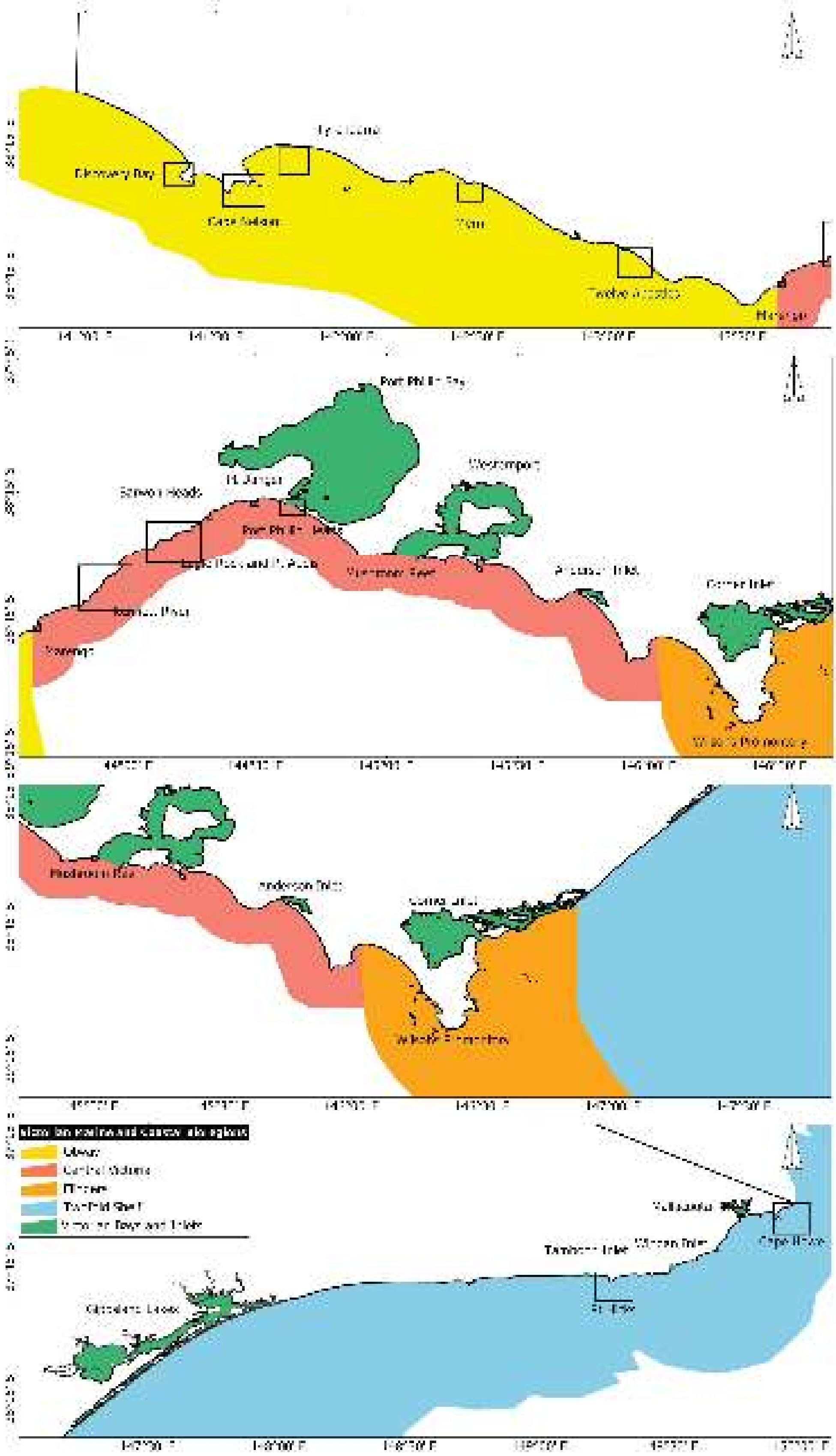


Figure 2.3. Marine and coastal Victorian bioregions. The areas of habitat mapping studies outlined in this report are indicated by black squares. Marine bio-regions are shown as areas of colour.

2.3.2 Habitats

The following hierarchical list of habitats was developed for the review database (Table 2.2). Habitats were assigned to regions of Victoria based on a combination of level 2 and level 4. When considering habitats against ecosystem processes and threats, this was done at either level 3, level 4 or “all marine” / “all habitats”. The choice to use different groupings of habitat reflected the need to keep the total number of permutations to a reasonable minimum, whilst producing useful information about habitat function, in relation to processes. Where it has been necessary to extract data at different habitat resolutions, the relationships shown in this table have been used.

The following sections briefly describe these Victorian marine habitats and their role and function in the ecosystem.

Table 2.2.: Marine habitats described in the VNPA Coastal Issues Database

Habitat Level 1	Habitat Level 2	Habitat Level 3	Habitat Level 4
Coastal	Coastal	Coastal Sand	Dune
		Coastal Vegetation	Grasses
			Heaths
			Moonah
			Woodland
		Structural Habitat / Processes	Islands
	Artificial	Structural Habitat / Processes	Artificial Habitats (Wood/Rock)
Intertidal	Sheltered littoral (estuaries and wetlands)	Coastal Vegetation	Saltmarsh
		Marine Sediment	Mudflats
			Sandflats
		Marine Vegetation Communities	Mangrove
			Ruppia/estuarine grass
			Seagrass
		Structural Habitat / Processes	Bird roosts
	Exposed littoral	Coastal Sand	Beach
			Dune
		Reefs	Intertidal reef
Subtidal Shallow	Sheltered subtidal (bays and estuaries)	Marine Non-veg Communities	Pyura
			Sponge clump
		Marine Sediment	Sediment beds
		Marine Vegetation Communities	Caulerpa
			Drift weed
			Seagrass
		Reefs	Subtidal reef
		Structural Habitat / Processes	Channels
	Exposed subtidal	Marine Sediment	Sediment beds
		Reefs	Subtidal reef
Subtidal	Subtidal to state limit	Marine Non-veg Communities	Pelagic fauna aggregations
			Plankton and nekton
			Sponge clump
		Marine Sediment	Sediment beds
		Marine Vegetation Communities	Seagrass
		Reefs	Deep reef
			Intermediate reef
			Subtidal reef
		Structural Habitat / Processes	Pinnacle/Canyon
			Upwellings
Not specific	Not specific	Marine Non-veg Communities	Pelagic fauna aggregations
			Plankton and nekton
			Sponge clump

2.3.3 Coastal Dune Grasses, Heaths, Moonah, Scrub and Woodland

Coastal vegetation typically occurs on sandy, nutrient poor soils and is exposed to strong, salt-laden winds and sea spray. The types of vegetation present vary depending on environmental factors including the degree of exposure to salt spray, wind, soil type and rainfall. It usually occurs in bands of different vegetation type parallel to shore.

Closest to shore, the fore dunes of ocean beaches are inhabited by dune grasses and succulents. This gradates to low, salt affected scrub, with a ground layer of sedges, grasses and herbs. Behind the primary dunes, where there is some protection from wind, emergent taller shrubs become more common.

In swales between dunes and on the landward side of primary dunes the tea-tree moonah *Melaleuca lanceolata* may occur as a scrub or low forest with an understorey of small shrubs, grasses and herbs. Coastal moonah is a threatened plant community (Flora & Fauna Guarantee Act 1988) that supports a range of threatened understorey plant species.

Coastal heaths are often associated with headlands, on areas of poor soil where the vegetation is still exposed to strong winds and sea spray. This dense, low shrubland often has an extremely diversity of plant species.

Behind the coastal scrub, low woodland is often present. In the Twofold bioregion, this is often dominated by coast banksia *Banksia integrifolia*. Elsewhere, eucalypts and casuarinas are more prominent species. Around Cape Nelson, in the Otway bioregion, coast gum *Eucalyptus diversifolia* dominates a coastal mallee scrub habitat unique to this region.

Coast vegetation habitats are foraging, breeding and roosting habitat for numerous birds, small mammals and reptiles, many of which are of conservation importance. They provide breeding habitat for large colonies of seabirds little penguin *Eudyptula minor* and short-tailed shearwater *Puffinus tenuirostris*. Coastal vegetation also stabilises coastal dunes and soils, providing erosion protection, and has important aesthetic, recreational and historical values.

As human populations increase in coastal areas, coastal vegetation is under increasing pressure from urban sprawl, coast development, weed invasion, disease, recreational activities and changing fire regimes. Many habitats have become highly fragmented and some, such as coastal moonah woodland, exist only in a small portion of their pre-settlement range.

2.3.4 Coastal Islands

Coastal islands incorporate many marine, intertidal and coastal habitats, but are distinctly important for several reasons.

The species composition of island communities is largely determined the islands size and isolation. These affect the rate of species immigration, emigration and extinction on the island. Island communities are often unique as key influential species have either never immigrated to the island, or have become locally extinct.

The relative isolation of islands in many cases helps to conserve more pristine habitats than occur elsewhere. There has often been limited human disturbance by land clearing and grazing. Many islands are free from the introduced predators and competitors that have devastated many mainland species populations, such as, cats, dogs, foxes and, to some extent, rabbits, mice and rats.

Protected coastal islands can potentially be used as ‘arks’ to conserve species that are threatened in their natural range. Species translocation to predator-free islands has been used extensively in recovery programmes elsewhere in Australia and overseas.

Coastal islands are home to breeding colonies of fur seal and seabirds, including Australasian gannets *Morus serrator*, little penguins *Eudyptula minor* and short-tailed shearwater *Puffinus tenuirostris.*

2.3.5 Coastal and Exposed Supralittoral Dunes

Dunes often occur adjacent to beaches, between the high tide line and established coastal vegetation. Formed by the accumulation of wind-blown sand, dunes are above the reach of waves and tides but are subject to salt spray and occasional inundation during storms. They are characterised by shifting bare sands, low nutrients and little fresh water.

Few plants inhabit these dunes. Hardy grasses are usually the first colonisers. Once these become established and stabilize the dune, other coastal vegetation may be able to take hold.

Supralittoral dunes are an important natural sea defence in low-lying areas. Many Victorian estuaries and wetlands are protected from storm surge flooding by coastal dune systems.

2.3.6 Exposed Littoral Beach

Long, narrow areas of beach habitat, exposed to waves and wind, occur along the northern margin of all four oceanic Victorian bioregions. These beaches are the primary interface between the ocean and coastal environment.

Exposed beaches are characterised by great mobility and instability. Organisms in this habitat must survive wave action, sand deposition, erosion, high and low temperatures, regular inundation with sea water and exposure to desiccation.

Beaches have an important role in cycling nutrients between coastal and near-shore environments. Primary productivity on beaches is relatively low, however accumulations of deposited marine algae support a high diversity of microbes and invertebrate fauna. Commercially and recreationally important fish species prey on this fauna, particularly as juveniles. Exposed beaches are also important foraging and breeding habitat for shorebirds, some of high conservation status, such as Hooded Plover *Thinornis rubricollis rubricollis*.

2.3.7 Intertidal Reefs

Areas of exposed rock in the intertidal zone range from steep sloping rock faces to relatively flat or gently sloping rock platforms and boulder fields. In Victoria, intertidal reefs predominantly occur around headlands and points and are often isolated from each other by stretches of sandy beach. There is little intertidal reef habitat in the Twofold bioregion.

As intertidal reefs are alternately inundated and exposed by the tide, they experience rapid changes in environmental conditions, including swell, temperature, salinity and exposure to air, causing desiccation stress. Consequently, these reefs are inhabited by specialist intertidal species adapted to survive in this extreme environmental variability. The distribution of these species on a reef is often highly stratified according to height on the reef.

Intertidal reefs often appear uncovered by algae, however a thin layer of microscopic algae grows directly on the rock surface and this is an important food source for grazing molluscs. Where macroalgae is present, it is typically dominated by the mat forming brown algae Neptune's necklace *Hormosira banksii*. The green algae sea lettuce *Ulva* spp and *Enteromorpha* spp and other small turfing species are also often present. These provide mobile invertebrates with food and a refuge from exposure at low tide.

Gastropod molluscs are the dominant faunal taxa on intertidal reefs. Herbivorous species include the limpet *Cellana tramoserica*, top shells *Austrocochlea* spp and conniwinks *Bembicium* spp. Common predators include the whelk *Cominella lineolata* and murex *Lepsiella vinosa*. Other invertebrates on intertidal reefs include small crustaceans such as barnacles and crabs, the seastar *Parvulastra exigua* and tubeworm *Galeolaria caespitosa*. Intertidal reefs are important foraging habitats for shorebirds at low tide and fishes at high tide.

Intertidal reefs on the open coast generally have higher species richness than those in embayments. Mushroom Reef, at Flinders, and Honeysuckle Reef, near Point Leo, are regarded as supporting the most diverse intertidal reef communities in Victoria.

Intertidal reefs are one of the most accessible habitats of the marine environment and consequently have important aesthetic, recreational and historical values. Because of their accessibility, intertidal reefs are also subject to human pressures, including collection of animals for fishing bait and food, trampling and pollution.

2.3.8 Subtidal Reefs

Kelp and other seaweeds are the predominant biogenic habitat structure on shallow subtidal reefs in Victoria. The nature and composition of algae cover varies considerably within and between reefs, depending on the depth, exposure to swell and waves, currents, water clarity, nutrient regime and presence of sand (*e.g.* Choat and Schiel 1982; Edgar 1984; Edmunds *et al.* 2000a, 2000b).

On the shallowest subtidal reefs, that are most exposed to wave and swell, bull kelp *Durvillea potatorum* dominates. This very large, robust species excludes other foliose algae and there is no understorey. A hard encrusting layer of pink crustose coralline algae is usually present on rock surfaces.

On sub-maximally exposed reefs, other large brown algae, such as the common kelp *Ecklonia radiata* and crayweed *Phyllospora comosa*, are usually present in a canopy 0.5-2 m above the substratum. Beneath the canopy, foliose macroalgae and filter-feeding sessile invertebrates form a 5-30 cm high understorey. The sessile invertebrates present include sponges, corals, bryozoans, hydroids and ascidians. A layer of crustose coralline algae is often also present. As depth and the degree of shelter increases, kelps become less dominant and other algae and sessile invertebrates make up a greater proportion of the cover.

Shallow reefs are a very important component of the marine environment because of their high biological complexity, species diversity, biomass and productivity. Dense seaweed beds typically have 10-20 kg of plant material (wet weight) per square metre and produce approximately 18 kg of plant material per square metre per year (Kirkman 1984; Larkum 1986). This makes them equivalent to the most productive habitats in the world, including grasslands and seagrass beds,

Seaweeds and sessile invertebrates provide important habitat structure for other organisms on the reef. The type and abundance of species varies in accordance with the environmental conditions, including exposure to swell and waves, depth, currents, reef structure, seaweed habitat structure and many other ecological variables (*e.g.* Choat and Ayling 1987; Edmunds 1990; Edmunds *et al.* 2000a). Gastropods, crustaceans, echinoderms and fishes are all presented on shallow subtidal reefs. These include the ecologically important, and commercially and recreationally fished, blacklip and greenlip abalone *Haliotis rubra* and *H. laevigata*, sea urchins *Heliocidaris erythrogramma* and *Centrostephanus rodgersii,* southern rock lobster *Jasus edwardsii*, and reef fishes such as wrasses, morwongs and snapper *Pagrus auratus*.

Subtidal reef habitats also have other important social and cultural values, including indigenous, aesthetic, recreational and historical aspects.

2.3.9 Intermediate Depth Reefs

On intermediate depth reefs, between approximately 15 m and 30 m depth, the amount of available light and the degree of exposure to swell decreases as depth increases. Changes in reef biota correspond to this gradient in environmental conditions. Kelps become less dominant as depth increases and other algae, particularly thallose red algae make up a greater proportion of the cover. Sessile invertebrates, including bryozoans, ascidians and sponges also become more abundant. There have been few surveys of intermediate depth communities in Victoria.

2.3.10 Deep Reefs

The logistical difficulties associated with working at depth have limited the ecological study of deep reef habitats in Victoria. Recent technological advances have made this environment somewhat more accessible and there are currently numerous Victorian deep reef studies in progress. The ecological information from large deep reef systems is currently available from Point Addis and the Twelve Apostles (Holmes *et al.* 2007 vol 3 – 4, although observations are not presented), Port Phillip Heads and Wilsons Promontory (Edmunds *et al.* 2006, 2007, 2009).

The biota of Victorian temperate deep reefs is dominated by sessile invertebrates, particularly sponges, cnidarians, ascidians and bryozoans. Most of the invertebrate species on the reefs are suspension feeders, capturing small plankton and detritus from the water. Small crustaceans, echinoderms and molluscs are commonly found in the spaces around the large suspension. Fishes are also abundant in deep reef areas, taking refuge within the reef structure or feeding on the wide range of organisms from within the reef environment.

Physical characteristics and processes are important determinants of deep reef assemblages. The primary environmental influences include sedimentation, geological structure, water movement, light climate and depth (Edmunds *et al.* 2007). There is considerable variation in these parameters, both within and between the areas of deep reef from which biological information is available. It is likely that this variation contributes to the uniqueness of deep reef assemblages observed in these areas.

Deep reef habitat at Point Addis is low profile calcarenite reef with little vertical structure. It is interspersed with patches of sand and rocky rubble and much of it is affected to some degree of sedimentation (Holmes *et al.* 2007). The biota of deep reefs at Point Addis typically includes a low coverage of erect sponges, including flabellate, arborescent and massive forms. Erect crustose bryozoans are relatively common and large hydroids mostly absent (Edmunds *et al.* 2006).

Calcarenite deep reef is also present between Points Lonsdale and Nepean at Port Phillip Heads. Unlike Point Addis, this is a very high relief reef system. High currents have eroded a deep subsea canyon between the Heads, with features including steep drop offs, overhangs, pinnacles and more gentle slopes. The canyon walls drop from 15 m to 100 m in depth, and reef in the bottom of the canyon are the deepest in Victoria (Edmunds *et al.* 2006). Deep reef assemblages in the canyon are characterised by a high coverage of encrusting sponges and a few species of large hydroids, and the absence of sea whip corals and the gorgonian *Pteronisis* spp. (Edmunds *et al.* 2006).

Deep reefs at Wilsons Promontory are massive granite reef structures. The substratum structures vary considerably from large expanses of very steep, smooth bedrock to interstices created by accumulations of boulders and large slabs of rock. The reefs generally extend from the surface at the shoreline, down to sand at 30-50 m depth. Deep reef assemblages at Wilsons Promontory commonly include sea whip coral *Primnoella australasiae* and the gorgonian *Pteronisis* spp., but have only a relatively low coverage of sponges (Edmunds *et al.* 2006, 2009).

Sessile invertebrate assemblages alter the texture of the reef, creating drag and slowing near-bottom currents. This biogenic affect influences the mass transfer of particulate food, nutrients, oxygen, carbon dioxide and wastes, to and from the reef organisms (Thomas and Atkinson 1997). Almost all sessile invertebrates on deep reefs are suspension feeders, filtering small plankton and detritus from the water. Sessile invertebrates can filter large volumes of seawater (Riisgard *et al.* 1993) and play a key role in marine trophodynamics (Gili and Coma 1998). these communities may filter 10s to 100s of litres of ocean water per square metre of reef every day. Deep reef communities are therefore a potentially vital link for the cycling of nutrients and energy in the marine ecosystem.

Sessile invertebrates provide biogenic habitat, creating small physical spaces that are inhabited by small fishes and invertebrates, both mobile and sessile. Mobile reef fauna include deposit feeders, predators, and some smaller suspension feeders. Some mobile predators, such as gastropods, sea stars, and fishes, prey upon the sessile suspension feeders and others feed on their waste and detritus (Ayling 1981). Mobile invertebrates and small fishes are linked to higher trophic levels by predatory fishes. The importance of deep reef biota in supporting high trophic-level carnivores is unknown.

Deep reef biota, particularly sponges, provide natural biochemicals that are of value to people (Munro *et al.* 1999; Faulkner 2000). They produce a range of secondary metabolites that provide protection against fouling, predation, bacteria and parasites. Some of these metabolites may be used as antifouling agents, while others have potential medical applications as treatments for diseases, including cancer and AIDS (Sipkema *et al*. 2005, Haar *et al*. 1996; Munro *et al.* 1999, O'Hanlon 2005).

2.3.11 Plankton and Nekton

The water column provides habitat for plankton and pelagic animals including fishes and sharks (nekton). Water column habitat is obviously present throughout the Victorian marine environment, but the habitat varies considerably along environmental gradients.

The temperature of marine and coastal waters fluctuates seasonally. There are greater temperature ranges in bays and estuaries as the smaller bodies of water are more quickly heated and cooled. Ocean temperature is modulated by currents and upwellings. The east of the state is influenced by the warmer East Australia Current. The Otway and Central bioregions are influenced by the temperate South Australia Current and Northern Bass Strait waters. The Flinders bioregion is under the influence of the South Australia Current, East Australia Current, Northern Bass Strait and cold subantarctic surface waters

Other important environmental gradients include greater wave action in shallower waters and greater turbidity closer to shore. In bays and estuaries the habitat is highly influenced by nutrient runoff, suspended particulates and freshwater inputs from rivers and other drainages.

Plankton

Plankton are a major source of food for benthic invertebrates and nekton. They also play a key role in the carbon, nitrogen and other nutrient cycling in marine systems.

The photosynthesising fraction of plankton, phytoplankton, is highly productive. In Port Phillip Bay it is responsible for at least two-thirds of primary production (Harris *et al*. 1996).

Diatoms and dinoflagellates are the most dominant phytoplankton taxa. The phytoplankton communities in Victoria show strong seasonal variation in abundance, with peaks during summer and lowest concentrations occurring during winter (Magro *et al.* 1996; Arnott *et al.* 1997). This is likely a result of increased light and temperature during summer, factors that appear to be limiting during colder months (Beardall *et al.* 1996; Beattie *et al.* 1996). Phytoplankton abundance is also limited by the availability of nutrients, particularly nitrogen. Concentrations of phytoplankton are often highest in estuaries and river mouths, where there is greater input of nutrient from terrestrial runoff.

Phytoplankton are preyed upon by small floating animals, zooplankton. Zooplankton includes a wide variety of organisms, including amoeboids, crustaceans, jellyfish, invertebrate larvae and fish larvae. Crustaceans, particularly copepods and cladocerans make up a large proportion of the zooplankton in Port Phillip (Wood and Beardall, 1996). The composition of the zooplankton, similar to the phytoplankton, shows some influence of seasonality.

Nekton

In Victoria, active-swimming pelagic organisms, nekton, are predominantly fishes and cephalopods, but also include marine mammals, penguins and crustaceans (*e.g.* krill).

Nekton play an important role in the trophic pathways of Victorian marine ecosystems. They facilitate the transfer of energy from plankton, through trophic levels, to higher order organisms; i.e. plankton provide a food source for small nektonic species which in tern are prey for middle and higher order predators. High abundances of nekton are often associated areas of high phytoplankton productivity, such as upwellings (see section 2.3.18; Ward *et al.* 2008).

In Victorian, nektonic fishes and cephalopods support significant recreational and commercial fisheries. Marine mammals have high scientific, social, historical and tourism value.

2.3.12 Pelagic fauna aggregations

Pelagic fauna may aggregate for different reasons. Many pelagic fishes school as a mechanism of protection against predators. Aggregations may result from a convergence of individuals to a favourable habitat. For example orange roughy *Hoplostethus atlanticus* aggregate around seamounts, pinnacles and canyons as they seek out habitats with particular hydrologic profiles. Southern right whales migrate from the Antarctic to Victorian waters and aggregate in preferred nursery areas along the western Victorian coast to give birth and nurse calves.

Seabirds, predatory fishes and marine mammals all congregate in areas were there is a reliable food supply, such as the upwellings (see section 2.3.18). The Bonney coast is one of only 13 known areas of frequent aggregation for blue whales *Balaenoptera musculus*.

The aggregation of pelagic species, for whatever reason, also provides opportunities for courtship and breeding in normally scattered species. For example blue whales which have congregated along the Bonney coast to feed, have also been observed engaging in courtship behaviours (Gill and Morrice 2003).

Species that aggregate are often more vulnerable to targeted recreational and commercial fishing pressures, diseases and localised environmental disturbances.

2.3.13 Seagrass, *Ruppia*, Drift Weed, *Caulerpa*

Seagrass and Estuary grass

Seagrasses are flowering plants (angiosperms) that grow in the intertidal and subtidal zones. They disperse seeds and grow vegetatively from horizontal rhizomes. Some species occur as meadows in Victoria's bays and estuaries, while others occur in shallow, sheltered areas along the open coast. In Victoria, the main types of seagrass are: eelgrasses (*Heterozostera tasmanica*, *Heterozostera nigricaulis* and *Zostera muelleri*), sea-nymph (*Amphibolis antarctica*), paddlegrass (*Halophila australis*) and strapweed (*Posidonia australis*). Eelgrasses and *Amphibolis* are the most prevalent species in Victoria.

The eelgrass *Zostera muelleri* occurs on sheltered intertidal mudflats. The two *Heterozostera* eelgrasses occur on subtidal sediments, *Heterozostera nigricaulis* predominantly in bays and estuaries; and *Heterozostera tasmanica* in sheltered coastal waters. *Amphibolis antarctica* occurs on moderately exposed sand and sand inundated reefs. It is not known to occur east of Wilsons Promontory. *Halophila australis* is most common on sheltered sands and *Posidonia australis* is restricted to sheltered subtidal sediments in Corner Inlet and Nooramunga, where it forms extensive beds (Roob *et al.* 1998).

Estuary grass *Ruppia megacarpa* are related to true seagrass and often considered analogous habitat. *Ruppia* occurs in shallow estuaries, coastal lagoons and salt lakes.

Seagrass communities are important to ecological processes, including primary productivity, nutrient cycling, trophic pathways and biogenic habitat (*e.g.* Crawford *et al.* 1992; Light and Woelkerling 1992).

Seagrasses provide significant biogenic structure in soft sediment habitats. They provide substrata for attachment of epiphytic algae and sessile invertebrates and refuge for mobile invertebrates. Seagrass beds are primary habitat for many syngnathids, including pipefishes, seahorses and seadragons, these taxa are of conservation significance. Seagrasses are also important nurseries for many ecologically, commercially and recreationally important fishes, including king george whiting *Sillaginodes punctata*, southern sea garfish *Hyporhamphus melanochir* and bream *Acanthopagrus butcheri* (Bell *et al.* 1978; Bell and Pollard 1989; Bird and Jenkins 1999; Hindell 2006).

There have been dramatic declines in seagrass habitat in recent decades, both globally and within Victoria. There is no clear single cause of this decline and it is likely this is because of a combination of factors.

Drift Weed

Many macroalgae species do not need to be attached to the substratum to survive, provided they remains in suitable environmental conditions. Unattached macroalgae, predominantly red algae, is carried by tides and currents, accumulating into extensive mats. The size and distribution of drift algae mats depends on prevailing weather conditions and can be highly variable.

In Port Phillip Bay, drift algae form extensive mats along the northwest shore, where it can cover up to 90 % of the seabed. In these mats, algal density may be as high as 4 kg/m^2 (Chidgey and Edmunds 1997). The high biomass of drift algae in this part of Port Phillip Bay may be related to nutrient discharge from the Western Treatment Plant.

Drift algae are important to local ecological processes, including primary productivity, nutrient cycling, trophic pathways and biogenic habitat.

Caulerpa

Caulerpa are a common and diverse family of green algae that occur on subtidal reefs and sediments. *Caulerpa* species typically have feathery or bubble-like fronds growing from a horizontal stolon. They are fast growing and can quickly spread into adjacent areas by vegetative growth. Once established, *Caulerpa* may form dense monospecific meadows that exclude other algae species.

Caulerpa taxifolia is an invasive species, originally recorded in the Mediterranean Sea, it is widespread along the Australian coast and it's range is increasing.

Macroalgal assemblages in depths less than 3 m along the northwest shore of Port Phillip Bay are dominated by *Caulerpa* species and other green algae (Chidgey and Edmunds 1997). *Caulerpa* are common on shallow and intermediate reef habitats throughout the state.

Caulerpa are important to ecological processes, including habitat provision, primary productivity, nutrient cycling and trophic pathways.

2.3.14 Saltmarsh and Mangrove

Coastal saltmarsh plants and mangroves grow on the intertidal sand and mudflats of protected bays and estuaries. Saltmarsh and mangrove habitats commonly occur in parallel zones, with saltmarsh vegetation growing inshore of the mangroves. There are successional and competitive relationships between mangroves and saltmarsh. Typically mangrove habitat advances seawards and is replaced by saltmarsh along its inshore margin. The reverse may also occur, with the incursion of mangroves into saltmarsh recorded in some areas (Ross 2000)

Saltmarsh vegetation includes succulent shrubs and herbs, grasses and sedges. In Victoria, saltmarshes are often dominated by just a few plant species, particularly glassworts *Sarcocornia* and *Sclerostegia*.

Mangroves in Victoria are at the southern limit of their range and the habitat is neither as diverse nor as extensive as it is in northern Australia. Of the nearly 200 species of mangrove world-wide, and approximately 50 species in Australia, only one species, Grey Mangrove *Avicennia marina*, grows in Victoria (Bridgewater and Cresswell, 1999). This species may grow up to 10 m tall in the tropics, though in Victoria its maximum height is typically less than 3 m.

In Victoria, saltmarsh and mangroves occur at Barwon Heads, Westernport, Corner Inlet and Andersons Inlet. Small remnant habitats also occur in northern Port Phillip Bay. The most extensive saltmarsh-mangrove habitat occurs in Westernport, where it grows in a band up to 1 km wide, though more typically 100 m to 300 m wide.

In Victoria, the area and distribution of saltmarsh and mangrove has declined, primarily due to human activities. The deliberate introduction of northern hemisphere saltmarsh species in the early to mid twentieth century has degraded some native saltmarshes. Mangroves were cleared as part of land reclamation and port development. Swamp drainage for agriculture has been linked to saltmarsh and mangrove decline by increasing freshwater runoff and decreasing salinity. Cattle grazing in areas bordering saltmarsh and mangrove damage these habitats through trampling and pasture encroachment.

Coastal saltmarshes and mangroves provide foraging and nursery habitat for marine and estuarine fauna. They are important foraging, breeding and roosting habitat for many shorebird species and the orange-bellied parrot is dependent on saltmarshes for its winter food.

Mangrove and saltmarsh habitats trap and stablize coastal sediments and protect against coastal erosion, as they form a barrier against the effects of flooding, currents, waves and storms. Climate change models predict an increase in sea level, storm frequency and storm intensity (see chapter 5). Consequently, the coastal defence services provided by coastal vegetation such as mangroves and saltmarsh will become even more important.

2.3.15 Estuaries and coastal wetlands

Estuary habitats are subject influences from both marine and riverine environments. These include saltwater and freshwater input, sedimentation, tides and periodic flooding.

Estuaries contain a wide variety of sheltered habitat types, including intertidal and subtidal reef, channels, seagrass, *Ruppia*, mangroves and saltmarshes. These are all considered elsewhere in this chapter. Estuaries are dominated by intertidal sandflats and mudflats, and subtidal sediment beds. These are associated with diverse and productive infaunal invertebrate communities. Estuary mud and sand flats are important feeding grounds for local and migratory shorebirds, and nurseries for ecologically, recreationally and commercially important fishes, such as Australian salmon *Arripis trutta*, king george whiting *Sillaginodes punctata* and bream *Acanthopagrus butcheri*.

2.3.16 *Pyura* and Sponge Clumps

Pyura stolonifera is a solitary ascidian (seasquirt). It occurs in intertidal and subtidal habitats on both hard and soft substratum. *Pyura* anchors itself into sediments with a long root-like structure and aggregated clumps of *Pyura* provide stable substratum elevated from the sediments.

In subtidal soft sediment habitats, limited hard substrata for sessile invertebrate and algal attachment limit their abundance *Pyura* beds, therefore, provide important habitat for sponges, other sessile invertebrates and algae. These in turn provide substratum for further attachment, forming large clumps of biogenic reef. Species commonly associated with *Pyura*-sponge clumps include the encrusting colonial ascidian *Botrylloides leachii*, green algae *Caulerpa* spp and red algal species such as *Rhodoglossum proliferum* and *Ceramium* spp.

Pyura beds also provide habitat for mobile invertebrates that more typically inhabit subtidal reefs, and species richness is often higher in *Pyura* bed habitats than in comparable seagrass or bare sediment habitats. These species included brittlestars, the sea urchin *Heliocidaris erythrogramma,* the seastar *Tosia australis* and the nudibranch *Ceratosoma brevicaudatum*. *Pyura* bed habitats also support large numbers of cryptic organisms that inhabit the interstitial spaces within the clumps.

Pyura and sponge clumps are a prominent feature of the channel environments of Corner Inlet (O'Hara *et al*. 2002). High density *Pyura* aggregations occur throughout Port Phillip Bay on medium to coarse sediments, between 7 and 12 m depth. Prominent beds occur in Corio Bay and the Geelong Arm, the southeast of the bay, between Capel Sound and Sorrento Bank, and along the northwest coast, between Point Cooke and Altona and at Point Ormond (Hart *et al.* 2004).

The recovery of *Pyura* beds after disturbance is slow or non-existent. This should increase their priority for protection (Chidgey 2001).

2.3.17 Channels

Soft sediment channel are a prevalent subtidal habitat throughout sheltered bays and inlets in Victoria. Major embayments in Victoria, including Port Phillip Bay, Corner Inlet, Nooramunga and especially Western Port, are dominated by soft sediment substrate that forms intertidal and subtidal flats interwoven with deeper channels.

The tidal currents that create channels also carry suspended food particles. As ebbing tides drain from tidal flats there is an influx of food for filter and deposit feeding invertebrates. Mobile fauna that feed on adjacent mudflats during high tide are concentrated in channels as the tide ebbs and become prey for middle and higher order predators that utilise channel habitats.

The species richness and diversity of channel communities is often undervalued as many species are cryptic and the distribution of benthic species can be patchy (Morrisey *et al* 1992). However, many species occur only in channel habitats and species assemblages are often unique. In Western Port, the most abundant infaunal taxa of the deep channels are polychaetes, crustaceans and bivalve molluscs, but also include high densities of the seapen *Virgularia mirabilis* and the brachiopod *Magellania flavescens*.

Brachiopods and some mollusc species are locally abundant within Western Port channel habitats but have very restricted ranges, so these populations are of particular conservation importance.

2.3.18 Upwellings

Between November and April, offshore along the Bonney Coast in the Otway bioregion, an oceanographic process called ocean upwelling occurs. Seasonal prevailing winds drive warm, nutrient-depleted surface water away from the coast. This draws deeper, colder water to the surface to replace it.

The deep water is nutrient rich and, as it reaches sunlit surface waters, it promotes high productivity of phytoplankton. These phytoplankton are the base of a highly productive food chain that sustains a high biomass of zooplankton and nekton, including krill and commercially important pelagic fishes such as tuna, sardines and anchovies (Ward *et al.* 2008). The krill and small fishes are an important food source for pelagic sharks, and seabirds and fur seals during the summer breeding season. The krill also support a significant population of blue whales *Balaenoptera musculus* along the Bonney coast (Gill 2002).

2.3.19 Pinnacles and Canyons

A pinnacle is a steep-sided peak, rising sharply from the seabed, often reaching close to the ocean surface. A canyon is a steep-sided gorge between two areas of shallower seabed. Both provide a high incidence of vertical and overhanging substratum, often with strong prevailing currents.

Pinnacles and canyons are inhabited by highly diverse, filter-feeding, sessile invertebrate communities, typically dominated by sponges along aside colonial ascidians, hydroids, soft corals, gorgonian fans and bryozoans. These communities are stratified by depth and also varying along gradients of current, aspect and slope. They support a high diversity of mobile invertebrates, including molluscs, crustaceans, polychaetes and echinoderms, as well as fishes.

Pinnacles are important feeding grounds for local and migratory vertebrates. They are associated with high density aggregations of seabirds, pelagic fauna including whales, dolphins and often have higher densities of fishes.

Pinnacle and canyon habitats are often relatively small in area and isolated from other similar habitats. This has resulted in a high frequency of endemism, as species have evolved in isolation from other populations. It also makes these habitats particularly vulnerable to disturbance, as an entire patch is likely to be affected by an event and there is unlikely to be a nearby source of recruits from which recolonisation and subsequent recovery can occur.

2.3.20 Artificial Habitats

Artificial habitats are a conspicuous component of the ecosystem, particularly in built-up areas. They include constructions but also processes, artificially enhanced by human activity. Port Phillip Bay is a notable example. Many seabirds are dependent on artificial constructions to breed, as they provide shelter and protection from human disturbance.

Popes Eye and South Channel Fort are artificial islands in Port Phillip Bay, constructed for the fortification of the bay in the 19th century. These forts provide artificial reef habitat. The fish assemblage at Popes Eye is particularly rich and diverse, including many species more typical of deeper waters. It is one of six component areas in the Port Phillip Heads Marine National Park. Additional artificial reef habitats are provided by shipwrecks, particularly in the Ships' Graveyard area between Port Phillip Heads and Torquay, where around 50 wrecks are located.

White-faced storm petrels *Pelagodroma marina* nest only on South Channel Fort. Australasian gannets *Morus serrator* nest at Popes Eye and on numerous channel markers throughout the southern Bay. Australian fur seals *Arctocephalus pusillus doriferus* only haul out regularly at the purpose-built Chinaman's Hat. Little penguins *Eudyptula minor* breed on the breakwater built at St Kilda.

The largest winter-breeding population of Pied Cormorants *Phalacrocorax varius* in Victoria nests in and around Lake Borrie at Melbourne Water's Western Treatment Plant (WTP). The gradual decline in the state of drowned timber has caused a population drop and necessitated the construction of specially designed artificial nest areas.

The WTP is a primary source of nutrients into Port Phillip Bay and the Geelong Arm in winter, which may explain why Pied Cormorants choose to winter nest here and nowhere else. At the same time of year, over 15 000 mostly adult breeding Little penguins from Phillip Island, forage in Port Phillip Bay, perhaps for the same reasons.

In general, artificial habitats are less ecologically complex than natural systems. Care must be taken not to assume that a single artificially maintained and permanent structure is a replacement for other colonies, with enhanced processes. Seabird colonies are a good example. Overall carrying capacity is limited by breeding productivity and dependent on a *combination* of breeding site and local access to food. A network of different sites provides the flexibility needed for one population to decline, while another increases, thus maintaining viability.

With that in mind, artificial habitats may not always be disadvantageous within the context of the present day environment. In Western Port for example, seagrass has been all but lost. Now the primary source of nutrient input, which supports benthic processes and internationally significant shorebird numbers, may be agricultural run off. In this case and in the case of little penguins *Eudyptula minor* in Port Phillip Bay, reducing nutrient input could have just as much impact on ecosystem processes as maintaining the status quo.

This all serves to further indicate how the functioning of the environment in many cases, interweaved with human development, economic and environmental policy.

2.4 Biodiversity

Southern Australia, and in particular the southeast, has high species richness and high endemicity of species across most marine taxa, often around 90 % of species (Wilson and Allen 1987; Poore 1995). Victorian marine biodiversity is particularly high with respect to;

- marine sediment infauna (Poore and Wilson 1993; Coleman *et al.* 2007) ;
- seaweeds (Womersley 1990; Phillips 2001);
- hydroids (Watson 1982);
- bryozoans (Bock 1982); and
- sponges (Wiedenmayer 1989).

For example, Port Phillip Heads has approximately a third the presently documented sponge species of Australia (Hooper 2005) and has a more diverse bryozoan fauna than that of Europe (Cook and Bock, cited in Ponder *et al.* 2002). New marine species are continually being discovered (*e.g.* Kraft 2001; McLoughlin 2007) and it is estimated that less than half of the marine invertebrate species have been described for Australia in general (Ponder *et al.* 2002).

While Victoria has considerable species richness, biodiversity also occurs in the form of communities, habitats, ecosystems and bioregions. Different regions and habitat types were described in the previous sections. Within each habitat, there is considerable diversity of the type and abundance of species that comprise different communities. For example, the fish and seaweed assemblages within kelp bed habitats vary considerably between the western and eastern sides of Wilsons Promontory (Edmunds *et al.* 2000). Variations in community structure are often in conjunction with physical variables, particularly depth, wave exposure and substratum morphology (Edmunds *et al.* 2000a, 2007). Other community structures are biologically driven and a particular sediment bed, reef or habitat can have a succession of different communities through time, such as kelp forests dominated by string kelp *Macrocystis angustifolia*, kelp beds dominated by common kelp *Ecklonia radiata* or sea urchin barrens dominated by the long spined urchin *Centrostephanus rodgersii*.

Systematic surveys and descriptions of Victorian marine communities include sediment infauna (Coleman *et al.* 2007); subtidal reefs (Wilson *et al.* 1983; Turner and Norman 1998; O'Hara 2000; Edmunds *et al.* 2000); deep reefs (Edmunds *et al.* 2009) and intertidal reefs (O'Hara, Museum Victoria unpublished data). Of these, only the O'Hara intertidal reef survey had comprehensive coverage of that habitat throughout Victoria. Intermediate depth reef, deep reef, pelagic and phytoplankton communities are largely undescribed in Victoria. Communities of particular uniqueness include: sponge gardens of the Port Phillip Heads deep canyon (Ponder *et al.* 2002; Edmunds *et al.* 2009); fishes of Popes Eye (Gilmour *et al.* 2007); seaweeds and invertebrates of Crawfish Rock (Watson 1982; Shepherd *et al.* 2009); and lampshell communities of Western Port sediment channels (Smith *et al.* 1975).

2.5 Listed Species and Communities

A comprehensive review of the relationship between Victorian habitats and marine species could not have been usefully done within the scope of this project. Unlike in the terrestrial environment, there has been no adequate or comprehensive analysis of the distribution and habitat requirements of marine species. Further, there are no comprehensive existing lists of marine-dependent or threatened marine species. There is a general lack of research knowledge but notwithstanding this, there is a great deal of information in the public domain, including a vast amount held privately or intellectually, plus historic atlas data. It would be possible to review this information but it would require a separate consultation exercise.

Table 2.3 is an annotated list of all listed threatened marine fauna considered either a) marine-dependent or b) having important populations within coastal habitats of Victoria. It includes lists of known threatened marine invertebrates but notably, most of these are not listed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) as the listing is currently focused on terrestrial species and higher taxa.

Coastal terrestrial flora have not been listed in this review as they are well documented at the Ecological Vegetation Class (EVC) level and will be covered by the review of terrestrial values. At a community level, one coastal community, Coastal Moonah Woodland, is listed as threatened under the Flora and Fauna Guarantee Act 1988 (FFG Act). It belongs to the Ecological Vegetation Class *Coastal Alkaline Scrub* (EVC 858). It is found only on the Yanakie Isthmus at the base of Wilsons Promontory.

Marine communities are very poorly documented and there is no EVC equivalent. Two marine communities are listed as threatened under the FFG Act: the San Remo Marine Community, at the eastern entrance to Western Port; and the Port Phillip Bay Entrance Deep Canyon Marine Community.

The San Remo Marine Community is a species rich assemblage dominated by opisthobranch molluscs and bryozoans. The community occurs in just a 9 ha area of patchy basalt, sand and mud. This community is subject to potential threats from dredging, pest invasion and coastal development.

The Port Phillip Bay Entrance Deep Canyon Marine Community is a unique, highly diverse community, with a high proportion of endemic species. The community is dominated by sessile invertebrates, characterised by a high coverage of sponges and large hydroids. This community is restricted to the 120 ha canyon between Port Phillip Heads. It is subject to active threats from rock dredging and marine pest introductions, as well as potential shipping accidents and sub-sea infrastructure developments.

Table 2.3. Annotated list of statutorily threatened fauna in the Victorian marine and coastal environment.

Group	Common Name	Scientific Name	DSE Advisory list status	EPBC status	FFG status	Marine	Coastal	Notes
Mammals	Blue Whale	*Balaenoptera musculus*	Critically Endangered	Endangered	Listed threatened	■		Seasonally uncommon summer visitor that occurs often near the coast associated with the Bonney Coast Upwelling off Western Victoria but also seasonally as far east as Port Phillip Heads.
Mammals	Smoky Mouse	*Pseudomys fumeus*	Critically Endangered	Endangered	Listed threatened		■	Coastal heath in far East Gippsland between Marlo and Point Hicks
Mammals	Southern Right Whale	*Eubalaena australis*	Critically Endangered	Endangered	Listed threatened	■		Ranges seasonally (winter) throughout coastal Victoria, inhabiting shelf waters and breeding within the surf zone, most notably near Warrnambool.
Mammals	Long-nosed Potoroo	*Potorous tridactylus tridactylus*	Endangered	Vulnerable	Listed threatened		■	Widespread in coastal and near-coastal Victoria including the Otway Range, Wilson's Promontory, Western Port and far East Gippsland. Inhabit variety of wet forest and scrub mostly on sandy loam soils.
Mammals	Humpback Whale	*Megaptera novaeangliae*	Vulnerable	Vulnerable	Listed threatened	■		Winter migrant widespread and relatively abundant throughout Victoria during northward migration.
Mammals	New Holland Mouse	*Pseudomys novaehollandiae*	Vulnerable		Listed threatened		■	Some near-coastal sites in the Otway Ranges, Western Port, Corner Inlet and the Gippsland Lakes.
Birds	Grey-tailed Tattler	*Heteroscelus brevipes*	Critically Endangered		Listed threatened		■	A very heavily declining species in Victoria, now virtually extinct. Associated with rocky areas in subtidal zones of Western Port and Corner Inlet.
Birds	Australasian Bittern	*Botaurus poiciloptilus*	Endangered		Listed threatened		■	Low lying and sometimes coastal sites with reeds, particularly during winter (likely to require inland freshwater to breed).
Birds	Eastern Bristlebird	*Dasyornis brachypterus brachypterus*	Endangered	Endangered	Listed threatened		■	Southern edge of range in coastal heath of Croainjingalong and east of Mallacoota.

Table 2.3. (Continued) Annotated list of statutorily threatened fauna in the Victorian marine and coastal environment.

Group	Common Name	Scientific Name	DSE Advisory list status	EPBC status	FFG status	Marine	Coastal	Notes
Birds	Fairy Tern	*Sterna nereis nereis*	Endangered		Listed threatened	■		Breeds on sand and shingle beaches in Gippsland Lakes, Lake Tyer's beaches. Used to breed in Port Phillip Bay. Very sensitive to nest disturbance, storm surge and tides.
Birds	Great Knot	*Calidris tenuirostris*	Endangered		Listed threatened		■	Seasonal migrant shorebird, over-winters in northern Australia. Rare in Victoria, but occasionally locally abundant in coastal areas.
Birds	Ground Parrot	*Pezoporus wallicus*	Endangered		Listed threatened		■	Low-lying and coastal heathland.
Birds	Gull-billed Tern	*Sterna nilotica macrotarsa*	Endangered		Listed threatened		■	Predominantly summer visitor to coastal southeast Australia
Birds	King Quail	*Coturnix chinensis victoriae*	Endangered		Listed threatened		■	Low-lying areas of French Island particularly.
Birds	Little Egret	*Egretta garzetta nigripes*	Endangered		Listed threatened		■	Feeds coastally in estuarine habitat.
Birds	Terek Sandpiper	*Xenus cinereus*	Endangered		Listed threatened		■	Uncommon migrant shorebird of central Victoria bays and estuaries.
Birds	Wandering Albatross	*Diomedea exulans*	Endangered	Vulnerable	Listed threatened	■		Very uncommon in Vic coastal waters.
Birds	Grey-headed Albatross	*Thalassarche chrysostoma*	Vulnerable	Vulnerable	Listed threatened	■		Very uncommon in Vic coastal waters.
Birds	Hooded Plover	*Thinornis rubricollis rubricollis*	Vulnerable		Listed threatened		■	Beach nesting resident shorebird. Very sensitive to habitat disturbance.
Birds	Lewin's Rail	*Rallus pectoralis pectoralis*	Vulnerable		Listed threatened		■	Secretive rail. Quite widespread but also found in salt water creeks in coastal saltmarsh and occasionally in associated heath.
Birds	Little Tern	*Sterna albifrons sinensis*	Vulnerable		Listed threatened		■	Breeds on sand and shingle beaches in Gippsland Lakes, Lake Tyers beaches. Used to breed in Port Phillip Bay. Very sensitive to nest disturbance, storm surge and tides.

Table 2.3. (Continued) Annotated list of statutorily threatened fauna in the Victorian marine and coastal environment.

Group	Common Name	Scientific Name	DSE Advisory list status	EPBC status	FFG status	Marine	Coastal	Notes
Birds	Royal Albatross	*Diomedea epomophora*	Vulnerable	Vulnerable	Listed threatened	■		Very uncommon in Vic coastal waters.
Birds	Shy Albatross	*Thalassarche cauta*	Vulnerable	Vulnerable	Listed threatened	■		Relatively common in coastal waters, particularly in rich shelf waters
Birds	Southern Giant-Petrel	*Macronectes giganteus*	Vulnerable	Endangered	Listed threatened	■		Very uncommon in Vic coastal waters.
Birds	White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Vulnerable		Listed threatened		■	Widespread and coastal mostly east of Port Phillip Bay. Stronghold in Gippsland Lakes.
Birds	Yellow-nosed Albatross	*Thalassarche chlororhynchus*	Vulnerable	Vulnerable	Listed threatened	■		Seasonally common in Vic coastal waters, especially off Western Vic.
Birds	Orange-bellied Parrot	*Neophema chrysogaster*	Critically Endangered	Critically Endangered	Listed threatened		■	Conservation dependent species with a global population of <200 individuals. Saltmarsh dependent, mostly regularly seen in vicinity of the Western Treatment Plant (Port Phillip Bay) with very occasional records elsewhere, though scarcity elsewhere could reflect low level of effort. Winters in Victoria.
Reptiles	Leathery Turtle	*Dermochelys coriacea*	Critically Endangered	Vulnerable	Listed threatened	■		Uncommon but regularly encountered in rich coastal waters of Victoria. Has been recently seen off Port Phillip Heads. Range widely but most likely associated with strong upwellings and other oceanographic features.
Fishes	Australian Grayling	*Prototroctes maraena*	Vulnerable	Vulnerable	Listed threatened	■	■	Migratory species associated with coasts and rivers throughout coastal Victoria east of the Hopkins River
Fishes	Great White Shark	*Carcharodon carcharias*	Vulnerable	Vulnerable	Listed threatened	■		Wide ranging pelagic shark frequently reported from coastal Victoria.

Table 2.3. (Continued) Annotated list of statutorily threatened fauna in the Victorian marine and coastal environment.

Group	Common Name	Scientific Name	DSE Advisory list status	EPBC status	FFG status	Marine	Coastal	Notes
Fishes	Southern Bluefin Tuna	*Thunnus maccoyii*	Not listed	Not listed	Listed threatened	■		Globally depleted population (<15%). Slow growing and late maturing. Migratory species usually occurring on the seaward side of the continental shelf but recorded nearer shore. In Victorian waters, predominantly pre-adults up to 9 years old.
Fishes	Orange Roughy, Deep-sea Perch, Red Roughy	*Hoplostethus atlanticus*	Not listed	Conservation dependent	Not listed	■		Depleted populations (<10%), vulnerable to overexploitation. Long-lived, slow growing and late maturing. A deep water fish, predominantly found on the middle and lower continental slope and around seamounts.
Fishes	Ewens Pygmy Perch, Golden Pygmy Perch, Variegated Pygmy Perch	*Nannoperca variegate*	Endangered	Vulnerable	Listed threatened	■		Distribution restricted to fast-flowing, freshwater tributaries of the Glenelg River system.
Marine Invertebrate	stalked hydroid species	*Ralpharia coccinea*	Vulnerable	Not listed	Listed threatened	■		Known only from Crawfish Rock, Western Port.
Marine Invertebrate	Marine opisthobranch	*Platydoris galbana*	Vulnerable	Not listed	Listed threatened	■		Endemic to south-eastern Australia. Habitat requirements are unknown.
Marine Invertebrate	Marine opisthobranch	*Rhodope* sp.	Vulnerable	Not listed	Listed threatened	■		Known only from San Remo, Western Port
Marine Invertebrate	Chiton Species	*Bassethullia glypta*	Vulnerable	Not listed	Listed threatened	■		Very rare and restricted distribution. Occurs on the southern shore of Port Phillip Bay, from Sorrento to Portsea and in Lonsdale Bight. Also at Mushroom Reef MS, Flinders.
Marine Invertebrate	Brittle Star Species	*Amphiura triscacantha*	Vulnerable	Not listed	Listed threatened	■		In Victoria, known only from a single specimen from south of Sunday Island, Nooramunga. Possibly also North Arm, Western Port. Also known from SA and Tas.

Table 2.3. (Continued) Annotated list of statutorily threatened fauna in the Victorian marine and coastal environment.

Group	Common Name	Scientific Name	DSE Advisory list status	EPBC status	FFG status	Marine	Coastal	Notes
Marine Invertebrate	Brittle Star Species	*Ophiocomina australis*	Vulnerable	Not listed	Listed threatened	■		Rare and restricted distribution. In Victoria, known only from Sunday Island, Nooramunga. Also known from SA.
Marine Invertebrate	Sea-cucumber species	*Apsolidium densum*	Vulnerable	Not listed	Listed threatened	■		Rare and restricted distribution. Endemic to Victoria, known from only two locations: Mushroom Reef MS and Skenes Creek.
Marine Invertebrate	Sea-cucumber species	*Pentocnus bursatus*	Vulnerable	Not listed	Listed threatened	■		In Victoria, only known from Cape Patterson. Also known from one location in SA and one in WA.
Marine Invertebrate	Sea-cucumber species	*Apsolidium handrecki*	Vulnerable	Not listed	Listed threatened	■		Found on rock shallow habitat. In Victoria, only known from Merricks, Western Port. Also known from one population in SA and one in WA.
Marine Invertebrate	Sea-cucumber species	*Thyone nigra*	Vulnerable	Not listed	Listed threatened	■		Rare and restricted distribution. Found in shallow, near-shore benthic sediments in seagrass. In Victoria, only known from the north shore of Corio Bay. Also known from one population in SA and two in WA.
Marine Invertebrate	Sea-cucumber species	*Trochodota shepherdi*	Vulnerable	Not listed	Listed threatened	■		Rare and restricted distribution In Victoria, known only from Sunday Island, Nooramunga. Also known from SA.
Marine Invertebrate	Southern Hooded Shrimp	*Athanopsis australis*	Vulnerable	Not listed	Listed threatened	■		Rare and restricted distribution. Endemic to Victoria. Known from four specimens from Port Arlington, Point Wilson and Beaumaris and Bridgewater Bay.
Marine Invertebrate	Ghost shrimp	*Paraglypturus tooradin*	Vulnerable	Not listed	Listed threatened	■		Rare and endemic to Victoria. Known from only two locations; Swan Bay and Crib Point, Western Port
Marine Invertebrate	Ghost shrimp	*Michelea microphylla*	Vulnerable	Not listed	Listed threatened	■		Rare and endemic to Victoria. Known only from a single locality at Crib Point, Western Point

2.6 Ecosystem Processes

2.6.1 What is An Ecosystem Process?

An ecosystem process is any process that occurs in the natural environment that creates biodiversity. Ecological processes can be defined as: 'The interactions and connections between living and non-living systems, including movements of energy, nutrients and other chemical substances such as carbon, and organisms and propagules' (Traill 2007 in McGregor *et al.* 2008). They include water and nutrient flows, climate variability and disturbance regimes and are vital to maintaining nature.

Victoria's marine ecosystem biodiversity is made up of a wealth of life, dependent on processes that maximize habitat diversity at all spatial scales. The integrity of the environment depends on maintaining this diversity by protecting and restoring the *network* of ecosystem processes, on which species and other life (including humans) can thrive. When we refer to "diversity" it encompasses not only diversity of species but also the *structure and function* of the environment. Maintaining the structure, function and composition of the environment (its "integrity") is essential to sustainable management of ecosystems. A focus on ecological processes is therefore a necessary part of effective policy, planning and management.

Ecological processes have serious implications for the success of efforts to sustain biodiversity and the provision of ecosystem services (McGregor *et al.* 2008). Ecosystem integrity depends on a network of overlapping processes. Actions that focus only on particular species, habitats, sites or communities are unlikely to be effective unless the ecological processes that support these 'assets' are sustained (McGregor *et al.* 2008). So for example, protecting the fish on which a fishery depends may not work unless efforts are also made to protect its habitat, that of its prey and all associated components of a healthy ecosystem on which this habitat is formed. This may require management of impacts with origin many miles away, even on land.

It is necessary to build the full consideration of ecological processes into legislative and institutional frameworks, policy and planning processes, and on-ground management of Victoria's marine and coastal environment. This requires a network approach rather than exclusive management of the marine environment as a series of isolated protected areas. Protecting and restoring the "ecological processes" and connections that shape, drive and support our ecosystems and species is essential (McGregor *et al.* 2008).

2.6.2 Key Marine and Coastal Ecosystem Processes

Table 2.4 is a list of all the ecosystem processes identified in this review. Note, in this project we have clearly distinguished ecosystem process from ecological function. Habitats have ecological function (e.g. saltmarsh creates a defence to sea level rise) but the actual process that is benefited by saltmarsh is coastal geomorphology.

We have not sought to value one process above another as all are inter-dependent. The inclusion of a process in the Table 2.4 indicates that it is "critical" to the integrity of the ecosystem.

Table 2.4. Ecosystem Processes used in the VNPA Coastal Issues Database

Ecosystem Process	Type
Light climate (underwater)	Physical
Long-term changes in water temp (El Nino)	Physical
Sea level	Physical
Tides	Physical
Storm frequency	Physical
Large-scale oceanography	Physical
Localised oceanographic fronts	Physical
Upwelling	Physical
Geomorphology	Physical
Bathymetry	Physical
Seasonal changes in water temperature	Physical
Dissolved CO2 levels	Chemical
Catchment processes	Chemical
Geochemistry	Chemical
All biological processes	Biological
Trophic interactions	Biological
Benthic nutrient cycling	Biological
Concentrated primary and secondary production areas	Biological
Ecological succession	Biological
Biogenic habitat	Biological
Competitive interactions	Biological
Community composition	Biological
Primary production	Biological

2.7 Ecosystem Services

Ecosystem services are the direct or indirect benefits that human populations obtain from ecosystems. The Millenium Ecosystem Assessment divided ecosystem services into four categories: supporting, regulating, provisioning and cultural. We have included a fifth, "scientific" which is the ability of humans to understand biodiversity, in order to understand the ecosystem and therefore manage change (Table 2.5; Figure 2.5).

Marine and coastal ecosystems are one of the most productive in the world and provide a range of services to human society, such as food provision, water quality maintenance, nutrient cycling and primary productivity. For this project, we have identified 19 ecosystem services (Table 2.5). These categories were kept deliberately broad such that their input into following analyses of conservation priorities did not become overly complicated.

Different habitats in the marine and coastal ecosystems provide differently for ecosystem services (Table 2.6). This review did not attempt to determine the relative value of different ecosystem services. This has been done elsewhere using estimations of economic value provided by habitat types (Costanza *et al.* 1997). A limitation of economic valuations is that they are generally based on 'willingness to pay' rather than actual implications of benefit or loss. Many of the ecosystem services provided are interdependent between habitat types so, for simplicity, this review treated the services provided by different habitats to be of equal value.

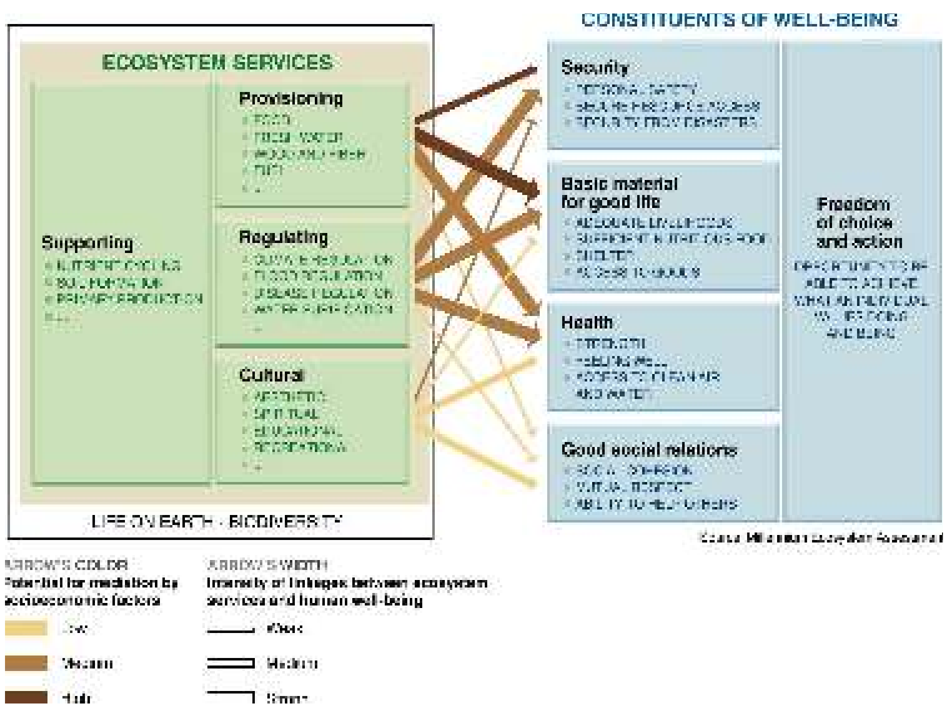


Figure 2.5. Ecosystem Services. Ecosystem services and their relationship to human well-being (Millennium Ecosystem Assessment 2005).

As indicated in Figure 2.5, supporting and regulating services have strong linkages with human well-being. Yet there is a risk of bias towards the provisioning and cultural services, because only these economic benefits are directly felt by humans. For example, people might feel the cost of unsustainable fisheries as fish prices go up and people they know who live in fishing communities lose their jobs. They do not necessarily empathise well with less tangible processes, such as coastal erosion outside inhabited areas or loss of threatened species, even though they are integral to maintaining ecosystem processes that regulate things such as habitats and human disease.

It may be argued that direct economic considerations are irrelevant to determining conservation value. However, although it is convenient to split services into several categories (Table 2.5), all services are interdependent. Impacts on provisioning, cultural and scientific services are always the result of a habitat change or loss, so it can be inferred that supporting and regulating services have also been affected.

It is the fact that humans alter the environment's ability to regulate and support global processes that makes ecosystem services assessment a compelling part of conservation. Hence, we must not over-emphasise the immediate and direct costs or benefits of provisioning, cultural and scientific services and ignore the greater long-term cost of impacts on supporting and regulating services.

The significant 'ecosystem services' provided by Victoria's marine environment are summarized in Table 2.6. While complex to quantify in narrow economic terms, the marine environment provides significant life support for Victorian human society.

Table 2.5. Marine and coastal ecosystem services (adapted from Millennium Ecosystem Assessment, 2005).

Type	Description	Ecosystem Service
Supporting	Ecosystem services that are necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.	Hydrological control and balance
		Habitat provision
		Primary productivity
		Nutrient cycling, water quality
		Biological regulation e.g. habitat structuring
Regulating	The benefits obtained from the regulation of ecosystem processes, including, for example, the regulation of climate, water, and some human diseases.	Coastal barrier / flood protection
		Atmospheric and climate regulation
		Human disease control
		Waste processing
		Erosion control
Provisioning	The products obtained from ecosystems, including, for example, genetic resources, food and fiber, and fresh water.	Fibre, timber, fuel, fertilizer
		Food and Subsistence
		Tourism
		Medicines, biochemistry
		Transport
Cultural	The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including, e.g., knowledge systems, social relations, and aesthetic values.	Cultural and amenity
		Aesthetics
		Recreation
Scientific	The benefits people gain from being able to study the environment and understand better how to manage it.	Education and research

Table 2.6.: Summary of ecosystem services provided by major Victorian marine and coastal habitats.

		Beach	Channels	Deep reef	Drift Weed	Dune	Grasses	Heaths	Intermediate reef	Intertidal reef	Mangrove	Mudflats/ sandflats	Saltmarsh/ estuarine grasses	Scrub/ moonah / woodland	Seagrass / Caulerpa	Sediment beds	Subtidal reef
Supporting	Hydrological control and balance					■	■	■					■	■			
	Habitat provision	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Primary productivity						■	■			■		■	■	■		
	Nutrient cycling, water quality				■						■	■	■	■		■	
	Biological regulation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regulating	Coastal barrier / flood protection	■				■			■		■		■				
	Atmospheric and climate regulation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Human disease control	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Waste processing		■									■					
	Erosion control						■	■			■		■	■	■		
Provisioning	Fibre, timber, fuel, fertilizer	■			■	■	■	■					■	■	■	■	
	Food and Subsistence	■				■	■	■			■		■	■	■		
	Tourism	■	■	■		■	■	■	■	■	■	■		■	■	■	■
	Medicines, biochemistry		■	■					■	■	■		■				■
	Transport		■														
Cultural	Cultural and amenity	■	■			■	■	■		■		■	■	■	■		■
	Aesthetics	■		■		■		■	■	■			■	■			■
	Recreation	■	■	■		■	■	■	■	■	■	■		■	■	■	■
Scientific	Education and research	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

3 Threats and Threatening Processes

3.1 Threats

3.1.1 Threats, Ecosystem Services and Ecosystem Processes

A threat is a specific danger posed by a hazard to the environment, health, life, or property. For example, the discharge of pollution (*e.g.* oil spill) is a specific danger (threat) posed by shipping (hazard) to the environment. Most threats are potential, with a theoretical risk of harm. When a threat is occurring, or is certain to occur, it is often termed an ‘active’ threat.

Active threats cause changes to ecosystem processes that subsequently have impacts on ecosystem services (Figure 3.1). We have defined ecosystem processes as physical, chemical or biological (Table 2.4). Many changes to physical and chemical processes directly affect supporting and regulating services, *e.g.* atmospheric carbon dioxide increase causes climate change. Further, physical and chemical changes may be both caused by, and exacerbated by habitat loss, a physical process on which all biological processes depend. Hence, some of the direct consequences of physical and chemical changes can also be resisted by habitat. For example, the process of coastal erosion can be countered by saltmarsh, which builds resilience against sea level rise as a consequence of climate change.

3.1.2 The Habitat Bottleneck

The feedback loop via change to biological processes is a major problem because it exacerbates all existing problems. As shown in Figure 3.1, the path from threats to impacts on ecosystem services can take three routes. This is exemplified using climate change, as follows.

1) is caused by burning fossil fuel, causing changes in the physical and chemical processes of the atmosphere (brown line), causing climate change global warming, which directly affects ecosystem services .
2) Climate change creates habitat change (blue line). For example, reducing or altering ecological succession or regeneration potential. This gives rise to further impacts on ecosystem services and a plethora of additional changes in biological processes, all of which create additional or renewed threats.
3) Some of the renewed or additional threats are physical and chemical (blue line). For example, a reduction in the ability of forest to sequester carbon, due to lowered ecological regeneration and succession potential. Other threats are biological (green line), leading to further change in habitats which cause impacts on ecosystem services as well as alteration of biological processes, and continue the cycle.

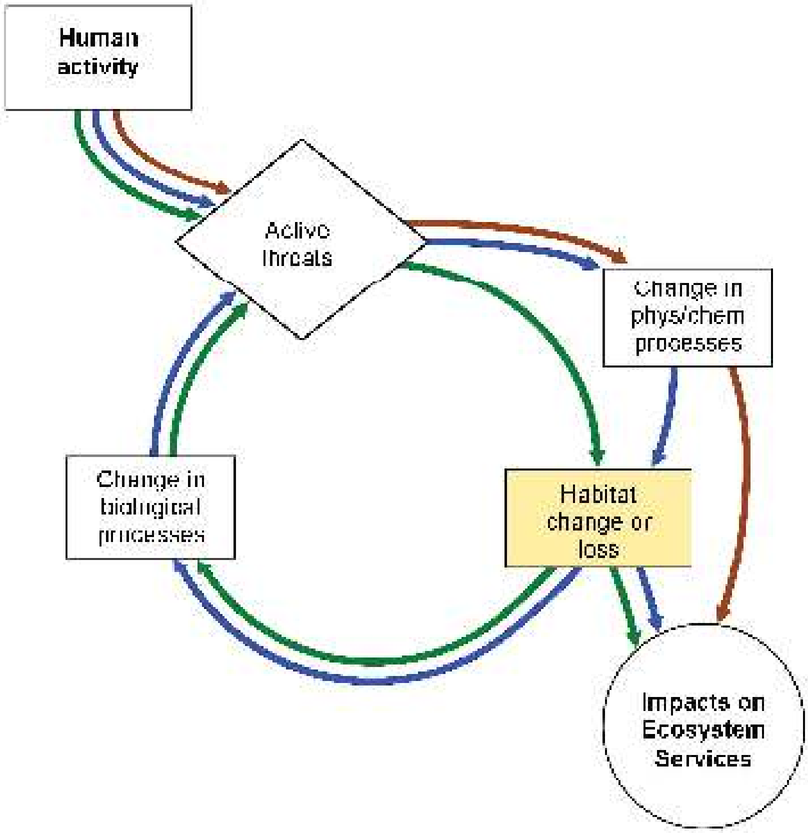


Figure 3.1. Conceptual model of the interaction between threats and ecosystem services, illustrating how habitat loss is a bottle-neck through which all other effects flow.
Pathway 1 = ▬▬; Pathway 2 = ▬▬; Pathway 3 = ▬▬.

This is a simplification of the system but illustrates one fundamental fact. Habitat loss is a bottleneck, through which all other effects flow. Natural habitat and all its associated processes is a containment of 'biodiversity'. Biodiversity is the ultimate driver for all ecosystem processes and services.

Man-made effects on the earth's physical and chemical processes will always have direct consequences for the supporting and regulating ecosystem services, whether or not this means we lose any immediate or direct economic benefit, *e.g.* via provisioning, cultural and scientific services. However, we assume these process changes are 'ecologically sustainable', when biological processes can adequately compensate. For example, burning fossil fuel can be compensated by forest carbon sequestration or saltmarsh can withstand fluctuations in sea level. The point at which changes to ecosystem processes cannot be compensated for by biological processes, is when significant changes start to occur to ecosystem services.

Since biological processes occur within 'habitat', it is the consequence of habitat-change or loss that drives the creation of gross environmental threats. Therefore, habitat is the key focus for this study. In conclusion, habitat change or loss, and associated biodiversity loss, will drive increased rate of decline in supporting and regulating services. This feedback mechanism has created the climate change problem, along with many other macro-environmental problems including rising mainland salinity, declining water availability, urban flooding, etc. Building resilience against such problems requires protecting and, where necessary, reinstating natural habitat and population structures that support critical ecosystem processes.

3.1.3 Identified Threats

In the VNPA Coastal Issues Database we have identified a list of threats (Table 3.1). This table also includes a list of secondary threats that are a byproduct of hazards created by the initial threats. Because the model of interaction between habitat loss and change in processes is cyclical (Figure 3.1), it is important to understand that threats are not isolated but many branch out as many other threats and reoccur. Notably, we excluded direct and indirect habitat loss from the threats table as all threats have the potential to give rise to this effect. To use habitat loss as a primary threat would be imprudent and would risk inflation of risk estimates.

Table 3.1. Threats and secondary threats identified in VNPA Coastal Issues Database

ID	Threat	Secondary Threats (see ID)
4	Habitat disturbance	6, 13, 16, 31, 32, 33, 34, 35, 39, 44
6	Introduction of marine pests	16, 33, 34, 39, 44
7	Sea level rise	31, 32, 34, 36, 37, 38
8	Increased ocean temperature	6, 16, 33, 34, 39, 44
9	Increased El Nino frequency	13, 31, 32, 34, 35, 37, 38
10	Ocean acidification	40
11	Increased storm frequency	6, 13, 16, 31, 32, 33, 34, 35, 39, 41, 44
12	Discharges of pollution	6, 13, 16, 31, 32, 33, 34, 35, 39, 44
13	Sedimentation	31, 32, 35
14	Discharge of marine debris (e.g. plastics)	42, 43
16	Pathogens	42, 43
17	Unsustainable fishing (illegal or otherwise)	6, 13, 16, 31, 32, 33, 34, 35, 39, 44
23	Underwater noise	42, 43
28	Marine / coastal construction and infrastructure[1]	
31	Loss of primary productivity	Affects all other processes
32	Loss of secondary productivity	6, 16, 33, 34, 39, 44
33	Changes to bio-genic habitat	6, 16, 34, 39, 44
34	Change in community composition	6, 16, 33, 39, 44
35	Eutrophication	6, 13, 16, 31, 32, 33, 34, 39, 44
36	Coastal squeeze[1]	
37	Habitat homogenisation	13, 31, 32, 35
38	Habitat fragmentation	6, 16, 33, 34, 39, 44
39	Reduction in ecosystem complexity e.g. food chain	13, 31, 32, 35
40	Total system failure	End of chain effect.
41	Coastal erosion	13, 31, 32, 35
42	Species' population decline	6, 16, 33, 34, 39, 44
43	Decline in species' viability	6, 16, 33, 34, 39, 44
44	Shift to alternative stable state	6, 16, 33, 34, 39

1. Coastal squeeze is linked to coastal construction. It is a threat where it prohibits the reclamation of habitat for natural processes e.g. saltmarsh, and results in lowered resilience to ecosystem changes such as sea level rise.

3.2 Threatening Processes

Although we have identified threats and we consider their relevance in terms of potential to change ecosystem processes (including via habitat loss), we have only assessed the "risk" of threats occurring, based on a series of threatening processes that are known to occur in different areas of Victoria, and the threats that these are likely to cause. The actual "risk" of a threat will of course vary on a case-by-case basis throughout Victoria, depending on the geographic location and scale of any effect.

We also identified a number of threatening processes which give rise to threats (Table 3.2). A list of which threatening processes occur in which regions of Victoria is used to determine risk and help prioritize habitats for protection (Chapter 4).

Table 3.2. Threatening processes and their associated threats.

Threatening Process	Threat (see ID in Table 3.1)
Algal blooms	12,31,32,33,34,
Aquaculture	6,12,14,16,28,33,34,37,39,
Catchment activities	12,13,14,16,31,32,33,35,37,38,39,44
Climate change	7,8,9,10,11
Coastal development	4,12,16,28,31,32,34,35,36,37,38,42,43
Dredging	4,6,12,13,14,23,31,32,34,37,38,39
Fishing - net/line/other	14,17,34,39,42,43
Fishing - recreational	4,12,14,17,23,34,39,42,43
Fishing - scallop	4,6,13,14,17,31,32,33,34,37,38,39
Fishing - selective reef	4,6,14,17,32,34,39,42,43
Fishing - trawl/seine	14,17,32,34,39,42,43
Oil/gas	4,6,12,23,28
Population and visitation	4,6,28,31,38,41,43
Ports and harbours	4,6,12,13,14,23,28,31,32,36
Shipping	4,6,12,13,23
Subsea Infrastructure	6,12,23,28,33,34

3.3 Status and Areas of Threatening Processes

3.3.1 State of the Environment Reviews

Past and present threatening processes are well documented in:

Winstanley R (1996) Issues in the Marine Environment. **In**: *State of the Marine Environment Report for Australia: State and Territory Issues – Technical Annex 3*. Department of the Environment, Sport and Territories, Canberra.

May D and Stephens A (eds 1996) *The Western Port Marine Environment*. Victorian Environment Protection Authority, Melbourne.

CES (2009) *State of the Environment Report, Victoria 2008: Part 4 State of the Environment*. Commissioner for Environmental Sustainability. Melbourne.

A summary of pertinent aspects is provided below.

3.3.2 Algal Blooms

Phytoplankton blooms are a natural phenomenon but their frequency and severity is increased by increased nutrient inputs, introduction of new species (including toxic species) and through alteration of ecosystems such that the standing stocks and nutrient cycling through benthic plants is reduced. The latter cause may not seem intuitive; however sediment microalgae, seagrasses and other estuarine vegetation have a controlling influence on the exchange of nutrients between the water column and sediments. Algal occur naturally throughout Victoria, particularly during late spring and autumn, blooms of conservation concern occur in northern Port Phillip Bay, particularly the blooming of toxic dinoflagellates. Introduced toxic dinoflagellates also occur in Western Port. Algal blooms can persist for months in Gippsland Lakes, severely affecting water quality over much of the area.

3.3.3 Aquaculture

Land-based aquaculture, having seawater exchange with the sea, occurs around Geelong Arm, Phillip Island and Port Fairy regions. The impact of land-based aquaculture varies greatly, depending on the intensity of the aquaculture and the treatment of effluent (or in some cases multiple uses of the seawater occurs, such as algal culture to recapture nutrients before discharge). The greatest risks of this form of aquaculture are the influence on wild-stock genetics and the amplification or introduction of pathogens. There was an abalone disease outbreak from a land-based aquaculture facility at Port Fairy in 2007, causing substantial wild stock declines in the Otway Bioregion.

Sea-based aquaculture occurs predominantly in leases within Geelong Arm, southern Port Phillip Bay (Pinnace Channel) and at Flinders, Western Port. Much of this aquaculture involves passive rearing of molluscs, particularly blue mussels, but potentially also scallops and abalone. The principal risks from existing aquaculture are the translocation of marine pests when transferring stock between farms. Other risks typically associated with sea-based aquaculture include the release of non-native animals, organic enrichment, release of antibiotics and other growth stimulants and harvesting pressures associated with feed production. These issues are generally associated with fish farming. Victoria generally lacks deep-sheltered environments suitable for fish pens, however ocean pens may be implemented in the future, with Portland being identified as a potential area.

3.3.4 Catchment Activities

Catchment activities previously had a profound impact on the Victorian marine environment. The siltation of waters leading into Western Port is thought to have resulted in the large areas of seagrass loss, with turbid conditions persisting as a result. There is also a legacy of pesticides, heavy metals and other contaminants within the sediments of the Victorian Bays and Inlets through previous catchment inputs. Present catchment threatening processes include erosion and inputs of sediment (including from land clearing, forestry and burning), agricultural nutrients and chemicals and urban derived chemicals, nutrients, litter and bacteria. Other concerns include the reduction of freshwater flows and inputs into estuarine and marine environments and the disturbance of acid sulphate soils.

3.3.5 Climate Change

There is evidence climate change effects are presently occurring in at least the Victorian Bays and Inlets, Central Victoria and Twofold Shelf Bioregions. Climate change will ultimately affect the whole of Victoria. Climate change is a threatening process of particular focus and has been addressed in its own in Section 5 *Climate Change and Implications for Ecosystems*.

3.3.6 Coastal Development

Victoria has 96 % of coastal land in public ownership (Crown land). Coastal development is controlled under the Coastal Management Act, however it was noted that there are few indicators to measure the success of management under the Act (CES 2009). The pressures for coastal development are increasing, with the number of applications for consent under the Act increasing by 32 % since 2003/04 (CES 2009).

3.3.7 Dredging and Channel Deepening

Maintenance dredging is required to varying degrees and frequencies at most of the major ports in Victoria, including Portland, Geelong, Melbourne and Port Phillip Bay, Western Port, Port Welshpool (Barry’s Beach) and Lakes Entrance. The principal impact from dredging is the resuspension of sediments, affecting water clarity and causing smothering. Most ports, being in sheltered and estuarine areas, are associated with seagrass habitats which are generally sensitive to dredging effects. Dredging operations are typically controlled through monitoring of water quality measures. There have been few studies in Victoria that directly examined impacts of dredging on flora, fauna, communities or ecosystem processes. The biological consequences of past and present dredging activities are largely unknown.

Channel deepening works have occurred on the rocky seabed at the entrance to Port Phillip Bay since the late 19th century. The works were initially aimed at removing rocky protuberances and then deepening of the Great Ship Channel by blasting, up until 1986. The Great Ship channel was substantially deepened by dredging in 2008. The blasting and dredging resulted in residual rubble which was moved by swell and currents into the adjacent canyon habitats. These works exacerbated natural erosion processes, causing ongoing rubble formation and periodic rock falls into the canyon. although this process is highly spatially confined, the canyon habitat is also highly spatially confined, making the threatening process more significant.

3.3.8 Fishing

Fishing has the most profound influence on marine natural values in Victoria. All large, edible and species have been reduced dramatically in biomass and abundance since white settlement. This initial fish down lead to direct fishery collapses, such as barracouta and elephant seal (which was fished to extinction). Following the fish down of abundances, species were generally maintained at or below what was estimated to be the maximum sustainable fishery production, which was also generally close to the minimum sustainable biomass. This has likely lead to other fishery collapses, such flat oyster, scallop, pilchards and greenlip abalone. Other fisheries remain tenuous, such as for school shark.

Demersal and scallop trawling operates out of Portland and Lakes Entrance and these methods cause substantial seabed habitat damage – the area and recovery of this fishing disturbance is unknown. Most other fishing methods in Victoria are relatively benign in terms of direct habitat disturbance, however the harvesting of biomass can have equally important changes to biodiversity. The severe declines of white shark, grey nurse shark and blue fin tuna are undoubtedly fishing related. Up until the last decade, there has been little data to understand what the ecosystem effects of fishing are. Fishing pressure occurs at or above ecologically sustainable levels throughout all marine habitats, excepting the larger marine national parks. The size and boundary location of many smaller parks and sanctuaries are unlikely to significantly reduce fishing pressure, as discussed in Section 6: *Gap Analysis*.

3.3.9 Oil and Gas

Significant oil and gas is presently extracted from the Gippsland Basin and there is a smaller gas industry in the Otway Basin. The oil production of the Gippsland Basin peaked in 1985 and annual production is declining, however Victoria's gas production is increasing. There are considerable undiscovered gas reserves in both Gippsland and Otway Basins. Threatening processes include discharge of aromatic hydrocarbons into the marine environment, including chronic discharges from process water and pipe leaks and acute discharges form incidents and accidents. The petroleum industry frequently uses seismic surveys, which can impact sensitive marine mammals.

3.3.10 Population and Visitation

Subdivision and urbanization of coastal areas is increasing in accordance with population growth. This is largely occurring around the fringes of existing coastal towns. An immediate consequence has been the reduction of coastal vegetation communities, however there are also direct implications for water quality (storm water, commercial wastes and sewage) and visitation to shore habitats.

3.3.11 Ports and Harbours

The principal ports and harbours are at: Portland, Port Fairy, Warrnambool, Apollo Bay, Melbourne, Geelong, Western Port, Port Welshpool (and Barry's Beach) and Lakes Entrance. Threatening processes associated with ports include dredging (described above), oil spills, land reclamation and modification of estuarine habitats, pollution, establishment of marine pests and recreational fishing. Ports are generally not expanding in Victoria, with the exception of the newly created Barry's Beach terminal.

3.3.12 Shipping

Shipping transport tonnage is continually increasing, in accordance with population and economic growth. Some of the increase in international shipping may be negated through the use of bigger vessels. Associated threatening processes include oil spills, groundings, litter/rubbish and effluent dumping at sea, translocation of marine pests and release of toxic antifouling substances, including tributyl tin. Higher density shipping lanes are within Port Phillip Bay, as well as between Port Phillip Heads and Cape Otway, Wilsons Promontory and northern Tasmania.

3.3.13 Subsea Infrastructure and Pollution

Subsea structures in Victoria are predominantly outfalls for effluent discharge, pipelines for gas and oil transfer from well heads to processing plants on shore and electricity and telecommunications cables. Major discharges from subsea outfalls include sewage at Boags Rocks (Gunnamatta) and Black Rock (Barwon Heads) and for industrial discharges at Corio Bay (Geelong) and at Seaspray (Latrobe Valley). A seawater intake and saline outfall is under construction at Wonthaggi. The nature of effluent discharges is highly varied, with water quality impacts including salinity, nutrients and toxicants. The impacts of undersea cables and pipes is generally minimal, however considerable oil leaks have occurred in the Otway basin, causing unknown impacts.

Subsea infrastructure is likely to increase with population growth, particularly in association with power plants: either for heat exchange (cooling) waters for land-based plants or for renewable energy power plants associated with tidal, wave or wind power. There is presently considerable interest in installing tidal and wave generators at Port Phillip Heads and Portland.

3.3.14 Areas of Existing Threatening Processes

For input into the analysis of priority areas for conservation, the active threatening processes within regions were identified. A summary of these threats are listed in Table 3.3.

Table 3.3. Threatening processes occurring within Victorian marine bioregions. **Note**: the threats are listed in no particular order.

Bioregion	Otway				Central Victoria				Flinders					Twofold Shelf				Victorian Bays and Inlets						
Region – by habitat characteristics	Discovery Bay to Portland Bay	Cape Grant, Lawrance Rocks and Deen Maar	Narrawong to Warrnambool	Port Campbell to Cape Otway	Marengo to Barwon	Port Phillip Heads to Western Channel Flinders	Southern Phillip Is. and Bass Coast	Inverloch to Warratah Bay	Yanakie Isthmus to Shellback Is.	Norman, Glennie, Anser Islands and Seal Islands	Tongue Pt to South Pt	Roaring Meg to Waterloo Bay	Cape Wellington to Whale Rock	Ninety Mile Beach and Croajingalong	Lakes Entrance	Beware Reef, Pt Hicks amd the Skerries	Tullaberga Is. To Cape Howe	Port Phillip Bay - West	Port Phillip Bay – East	Western Port - West Channel to North Arm	Western Port – Northern Channels to San Remo	Anderson, Shallow, Corner and Nooramunga Inlets	Gippsland Lakes	Sydenham, Tamboon and Mallacoota Inlets
Threats																								
Catchment activities	■		■	■	■	■	■	■						■	■			■	■			■	■	■
Discharges and pollution			■		■	■	■	■			■			■				■	■	■	■	■	■	
Oil/gas				■										■				■	■					
Shipping				■	■	■	■			■	■	■			■		■	■	■	■		■	■	■
Ports and harbours			■	■	■	■		■					■		■			■	■	■	■	■	■	■
Dredging						■		■							■			■	■	■				
Pests						■		■										■	■	■		■		■
Pathogens	■	■		■																				
Algal blooms															■			■	■				■	
Fishing - scallop	■													■										
Fishing - trawl/seine	■													■		■								
Fishing - selective reef	■	■	■	■	■	■	■	■	■	■	■		■	■		■	■	■						
Fishing - net/line/other	■	■	■	■	■	■	■	■	■	■	■		■	■		■	■	■	■	■	■	■		
Fishing - recreational	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
Aquaculture			■			■	■											■	■	■	■			
Coastal development	■		■	■	■	■	■	■						■	■			■	■	■	■	■	■	■
Population and visitation	■		■	■	■	■	■	■			■		■	■	■			■	■	■				■
Subsea Infrastructure	■			■	■	■	■	■						■					■					
Climate Change	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

4 Conservation Priorities

4.1 Introduction

The focus of this review is to identify the most important areas to protect within the Victorian marine and coastal environment. To achieve this, the coast of Victoria was split into 90 regions and the conservation value of each habitat within these areas was assessed. The 90 regions were created based on a combination of prior knowledge about distinct ecological features and key landmarks, such as capes, islands and estuaries. In general, these areas each have distinct characteristics that set them apart and make them a useful basis for mapping habitat values.

Ultimately, the aim of conservation is to allow natural processes to regulate and support the ecosystem so that human activity is sustainable. If we protect habitats that are important and vulnerable, we stand the best chance of resisting or reversing large-scale environmental problems such as climate change. This means priority habitats are those that are the most important components of critical ecosystem processes, the most vulnerable to change *and* currently subject to threatening processes (Figure 4.1).

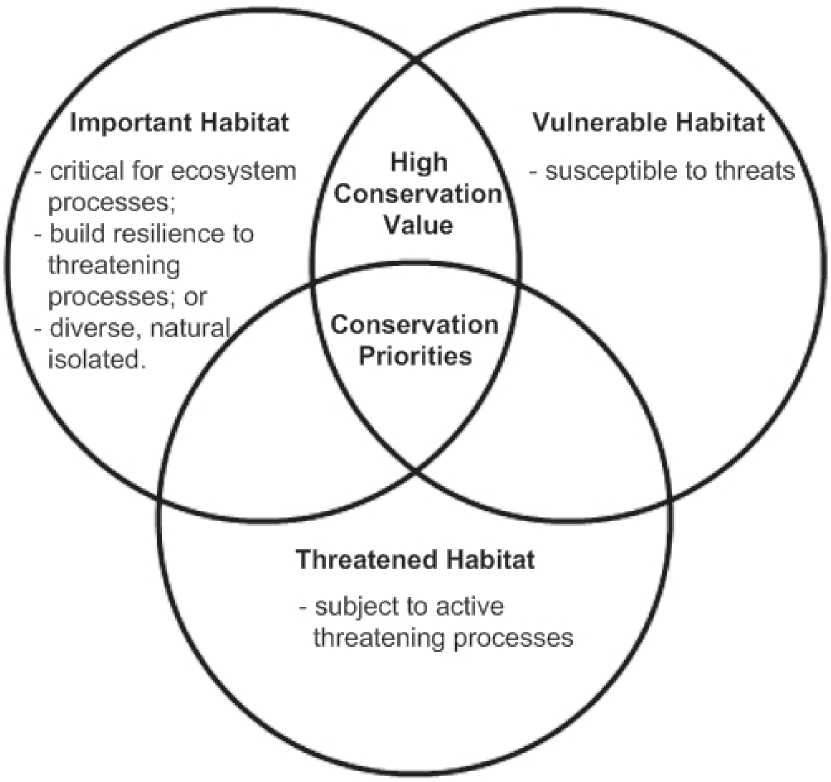


Figure 4.1. Venn diagram illustrating the relationship between importance, vulnerability, threatening processes and priorities for protection for building ecosystem resilience.

For our analysis, we did the following:

1. **Identified the degree of existing threat** = the presence of threatening processes within regions of Victoria, what threats these are likely to cause and the effect this has on ecosystem services and processes.

2. **Established the conservation values of habitats,** including:

   - Ranked the importance of habitats for resilience to ecosystem processes caused by physical and chemical changes in the environment.

   - Ranked the importance of habitats for ecosystem processes and their potential vulnerability to changes in services caused by particular threats.

3. **Established conservation values of areas** = within regions of Victoria, assessed the distribution of important habitats and their degree of naturalness, rarity and diversity.

4. **Established conservation priorities =** within regions of Victoria, assessed the conservation value of habitats present in conjunction with the degree of existing threat.

4.2 Conservation Values

4.2.1 Establishing conservation values of habitats

High conservation value habitats are those that are important for ecosystem sustainability and are vulnerable to threatening processes. Conservation value is independent of the degree of threat, as some habitats are critical to ecosystem processes, whether or not they are actively threatened.

4.2.2 Importance of habitats for building ecosystem resilience

For building ecosystem resilience in the face of climate change and other major environmental changes, some habitats provide a first line of defence. These are likely to be of over-riding importance in establishing a foundation for ecosystem management, as they minimize the degree to which physical and chemical changes will erode management success in future.

Certain habitats that are particularly important for building resilience against changes to these services were identified (Table 2.6).Threats that affect physical and chemical processes cause impacts on supporting and regulating services via pathway 1 (Figure 4.2). After assessing the outcomes of all potential threats via Pathway 1, we calculated the number of times ecosystem services were affected. We then extrapolated to the total number of habitats related to these services (Figure 4.3).

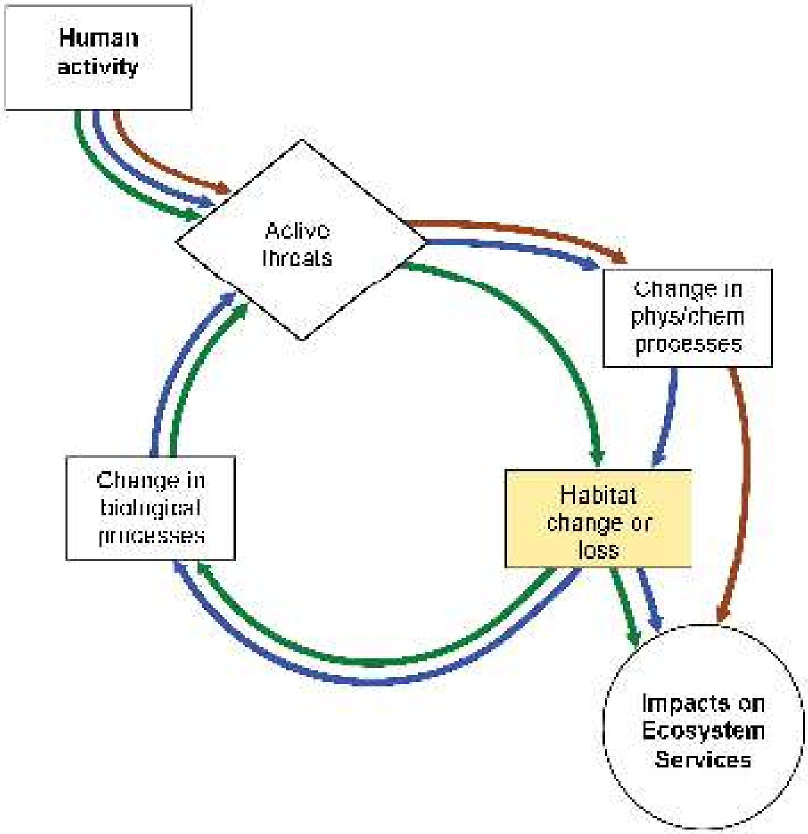


Figure 4.2. Conceptual model of the interaction between threats and ecosystem services, illustrating how habitat loss is a bottle-neck through which all other effects flow.
Pathway 1 = ▬▬; Pathway 2 = ▬▬; Pathway 3 = ▬▬.

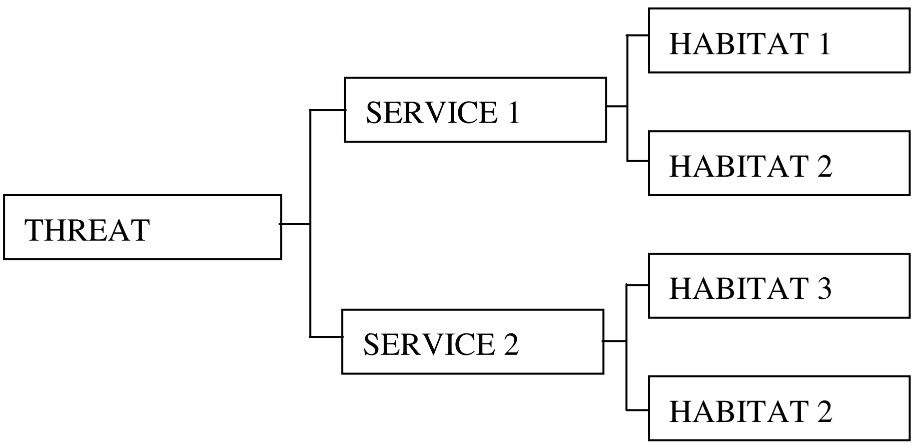


Figure 4.3. Example pathway of threat-habitat linkage used in the analysis to rank habitat importance.

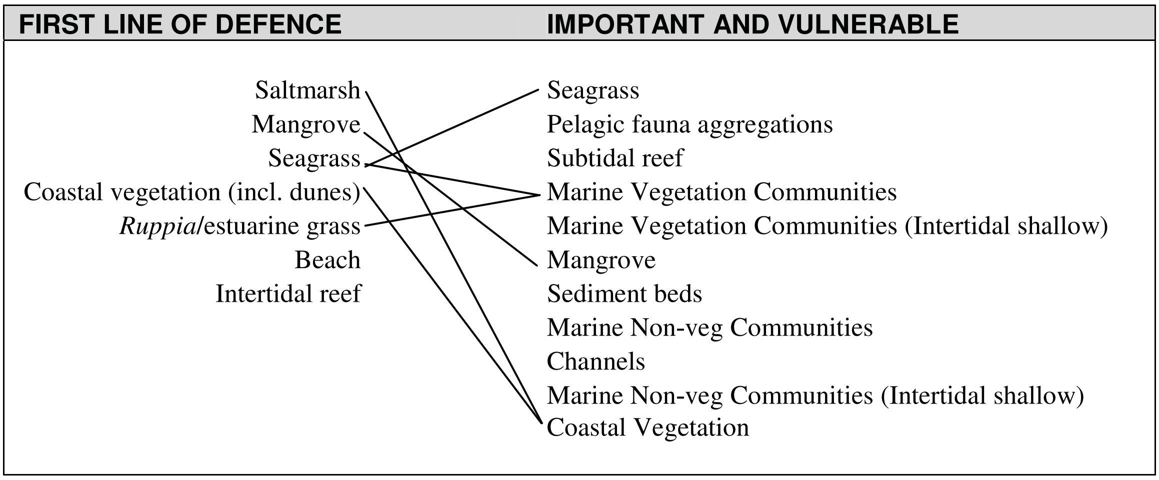


Figure 4.4. Key habitats for building ecosystem resilience.

Habitats were ranked in order of importance for Pathway 1, based on the number of times they appeared linked to affected services. In the above example (Figure 4.3), Habitat 2 would be ranked highest as it appears twice. Habitat vulnerability is not relevant here. If a habitat identified here as a 'first line of defence' is vulnerable to change, this would be identified in the assessment of threats to biological processes (section 4.2.3). The habitats identified by this analysis as the most important for building ecosystem resilience in Victoria are shown in Figure 4.4.

Saltmarsh, mangrove, seagrass, all coastal vegetation and estuarine grasses are particularly important first lines of defence against prevalent threats that cause physical and chemical changes to ecosystem processes. The associated threats, in decreasing order of importance, are:

1. Increased storm frequency
2. Sea level rise
3. Marine / coastal construction and infrastructure
4. Increased El Nino frequency
5. Habitat disturbance
6. Increased ocean temperature
7. Coastal erosion
8. Changes to bio-genic habitat
9. Eutrophication
10. Coastal squeeze

These threats arise from a combination of climate change (resulting in associated threats 1, 2, 4, 6), human development and disturbance (Threats 3, 10) plus two key biological ecosystem processes: the availability of bio-genic habitat (e.g. habitat created by other species) and eutrophication, associated with nutrient overload.

In relation to biological processes, the pattern of threats is different. **Note, the fact these are not "first line of defence" issues does not make them any less important**. We have broken the process into two parts but it is cyclical, so all physical, chemical and biological processes are current, ongoing and interlinked. If habitats are affected by these process changes, then the same habitats cannot successfully persist as a first line of defence. Direct and indirect threats most likely to give rise to changes in biological processes and hence impacts on important and vulnerable habitats, in decreasing order of importance are:

1. *Eutrophication*
2. *Increased El Nino frequency*
3. *Increased storm frequency*
4. *Habitat disturbance*
5. Unsustainable fishing (illegal or otherwise)
6. Loss of secondary productivity
7. Sedimentation
8. *Sea level rise*
9. *Coastal erosion*
10. Underwater noise

This list is different to the first because it captures the influence that biological processes have on regulation of the environment. Eutrophication has a strong influence on vegetation and processes. Increased El Nino and storm frequency are both factors associated with climate change, likely to have a substantial impact on marine habitats and processes. The effect of loss of secondary productivity and unsustainable fishing is linked heavily to pelagic fauna aggregations. The marine environment is large, very patchily resourced and many animals are far-ranging. A lot of biomass and nutrient cycling occurs during secondary production at nutrient fronts and these appear at many different scales, from river mouths to continental upwelling. Climate, hydrological and unsustainable resource use effects can cause profound changes in trophic dynamics. For example, off the US west coast, the substantial increase in large predatory Humboldt squid has been attributed to over-fishing of other marine predators like tuna (Zeidberg and Robison 2007). Changes in marine pelagic communities due to over-fishing and other threat processes are poorly researched and the impact this has on the ecosystem may be grossly underestimated.

Other threats are less notable, with an order of magnitude decrease in the overall score rating between eutrophication and sedimentation. Also note, these only refer to first-order effects based on one theoretical loop in the model (Figure 4.1). As time progresses, each of these threats will recur and branch out. For example, eutrophication is associated with causing nine other threats. For a list of knock-on effects caused by individual threats, see Table 3.1.

Combining the two elements of this assessment suggests that near-coastal and coastal marine and terrestrial habitat is of particular importance for building resilience. The habitats of most immediate concern would be:

1. Saltmarsh
2. Mangrove
3. Seagrass
4. Coastal vegetation (including dunes)
5. *Ruppia*/estuarine grass

4.2.3 Importance of Habitats for Ecosystem Services and Processes

In the VNPA Coastal Issues Database, we have identified a list of primary and secondary threats, including feedback processes due to habitat change, and a list of threatening processes which give rise to threats (Section 3; Tables 3.1 and 3.2). For every threat we listed:

1. Biological processes that were likely to be affected by the threat;
2. Services that were likely to be affected by changes in the process / habitat;
3. Habitats on which the processes depend, including:
    a. A subjective measure of the habitat's importance for that process (high, medium or low (Table 4.2);
4. A concluding 'hazard' that a loss in this habitat would give rise to; and
5. Secondary threats associated with the hazards.

This was done using the form shown in Figure 4.5 and the process shown in Figure 4.6.

Habitat loss caused by changes to biological processes creates a feedback, which can exacerbate problems. This was captured in the process by feeding these secondary threats back into the assessment (Figure 4.6). In the calculation of consequence from changes to biological processes, importance *and* vulnerability were established for habitats, using simple subjective measures, resulting in six result permutations (Table 4.1).

Table 4.1. Consequence rankings of change to biological functions derived from habitat importance and vulnerability.

		Importance		
		High	Medium	Low
Vulnerability	High	6	4	2
	Medium	5	3	2
	Low	1	1	1

A score (1-6) was applied each time a habitat appeared as affected by a process change. The scores were then summated based on the total number of times the habitat appeared in the results.

With these data, we were able to produce a summary of habitats directly or indirectly important for given ecosystem processes and services, along with a qualitative measure of their overall importance and vulnerability.

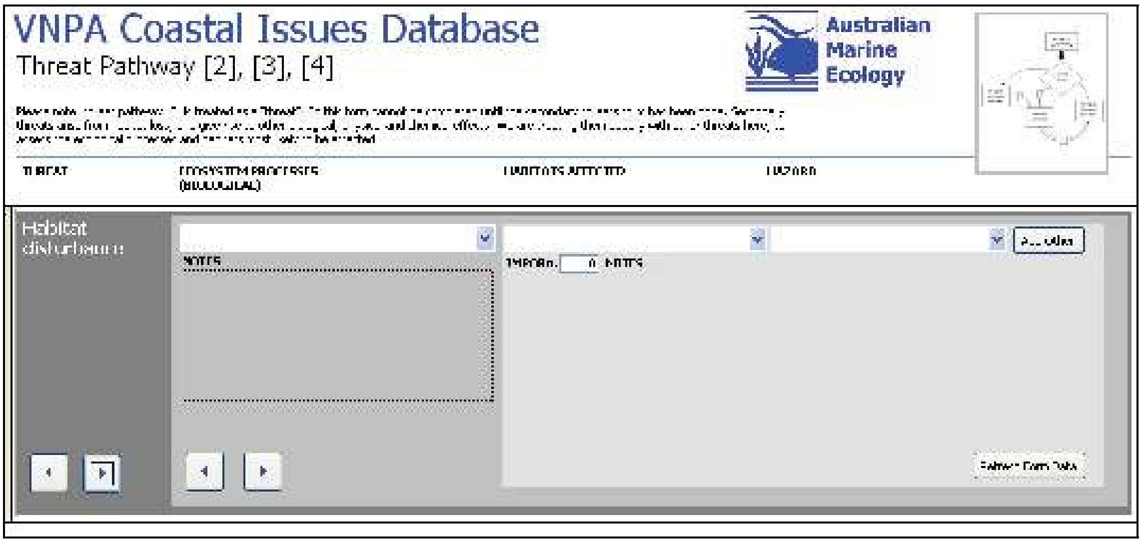


Figure 4.5. Data entry form used to link threats, ecosystem processes and habitats, then to identify overall 'hazards' caused.

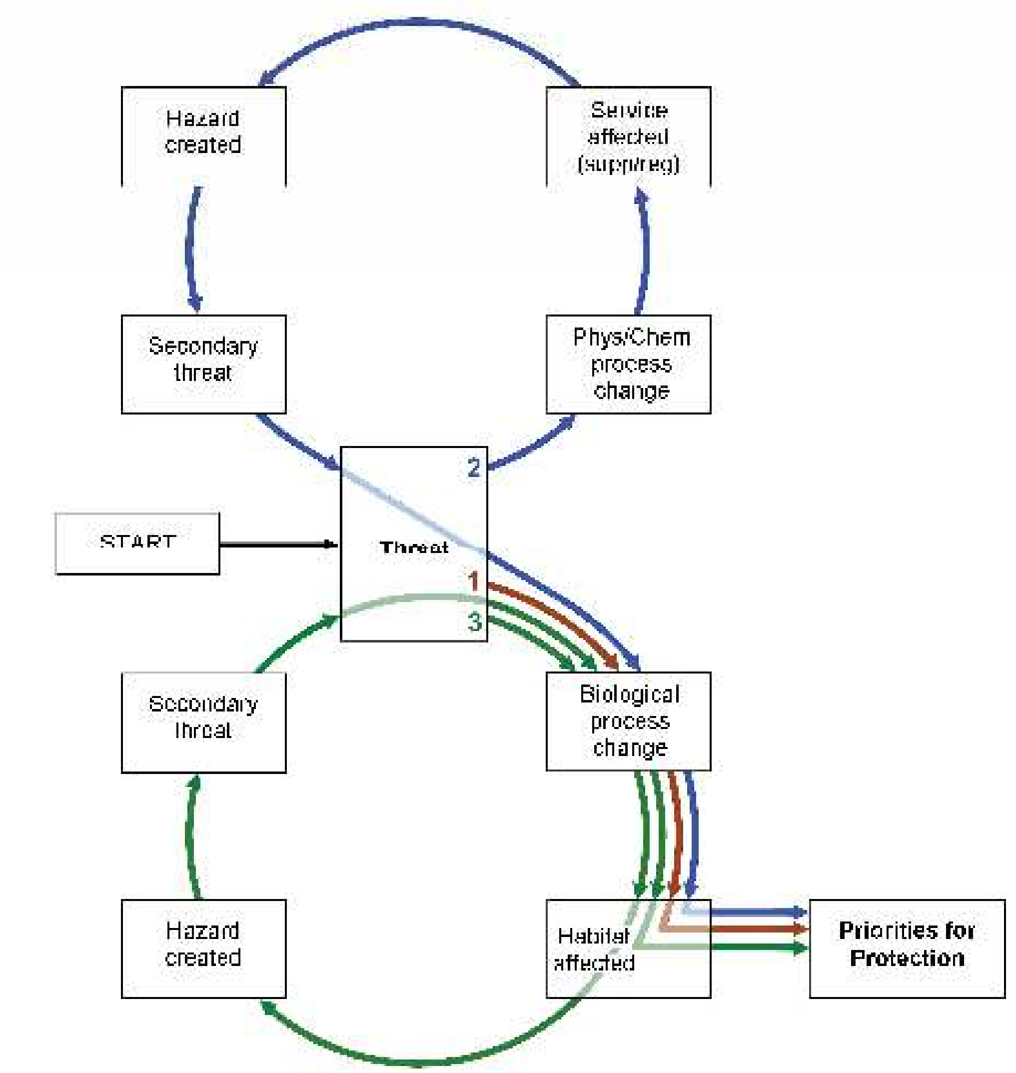


Figure 4.6. Flow diagram illustrating the process of entering data to link threats with effects on processes, habitats and services.

4.2.4 Priority conservation values of habitats

For creating tables of prioritisation, the ranking in Table 4.2 was used. This combines the results from the two analyses above by ordering, in descending order, based on the final score for the first line of defence habitats, then the score for habitats deemed important and vulnerable.

Table 4.2. Priority habitats (and habitat groups) based on conservation value.

Habitat
Saltmarsh
Mangrove
Seagrass
Grasses (coastal vegetation)
Heaths (coastal vegetation)
Woodland (coastal vegetation)
Dune (coastal vegetation)
Ruppia/estuarine grass
Scrub (coastal vegetation)
Moonah (coastal vegetation)
Beach
Intertidal reef
Mudflats
Sandflats
Sediment beds
Drift weed
Caulerpa
Channels
Pelagic fauna aggregations
Subtidal reef
Marine Vegetation Communities
Marine Vegetation Communities (Intertidal shallow)
Marine Non-veg Communities
Marine Non-veg Communities (Intertidal shallow)
Marine Sediment
Plankton and nekton

The scores are not presented as they were only assembled to provide a basic ranking for prioritisation. Comparison of scores would provide no estimate of relative importance, so to present them here would be misleading.

4.2.5 Priority Ecological Functions for Habitats of High Conservation Value

For each marine habitat, we listed functions that they performed in relation to the ecosystem processes identified throughout the analysis. This resulted in the list of key functions in Table 4.3.

Table 4.3. Ecological functions for key habitats identified as important and vulnerable, and contributing to critical ecosystem processes.

Habitat Function
Stabilize substrate and prevent coastal erosion
Act as nitrogen and phosphate sinks, reducing coastal water pollution
Provide a natural barrier to sea level rise and flood defence
Important nursery areas for commercial and other fish and invertebrates
Habitat for key declining marine coastal species
A source of nutrients for marine and terrestrial ecosystems through active and passive transport
A sink for pollution, including pesticides and heavy metals
Sheltered habitat for fish and invertebrates

4.3 Areas of High Conservation Value

4.3.1 Conservation importance of Areas

The criteria used for determining areas of high conservation importance were a subset of those used for identifying potential marine protected areas. The ANZECC Guidelines for Establishing the National Representative System of Marine Protected Areas (TFMPA 1998) include the criteria:

- Ecological importance
  - contributes to maintenance of essential ecological processes or life support systems;
  - contains habitat for rare or endangered species;
  - high species diversity;
  - contains components/habitat on which other species or systems are dependent – *e.g.* nursery areas, juvenile areas, feeding, breeding or rest areas, primary production areas; and
  - contained or isolated self-sustaining ecological unit;
- State, national or international importance – areas qualifying for listing under policies and agreements for biodiversity conservation;
- Uniqueness – unique species, populations, communities or ecosystems as well as unique or unusual geographic features;
- Productivity – populations or communities with high natural biological productivity;
- Vulnerability – the susceptibility or low resilience to natural processes;
- Biogeographic importance;
- Naturalness – the degree the area has been protected from human induced change.

For the purposes of this study, the criterion for State, National or International Importance was not used at the valuation phase as this information is lacking (see gap analysis, Chapter 6). For the purposes of this study, uniqueness and bio-geographic importance were excluded as being sufficiently captured within the other criteria, based on our present level of knowledge. Productivity was also considered redundant, with Ecological Importance having already been considered in detail through the database process.

Presence of habitat for rare or threatened species could be a very important measure if done at the community scale. For example, areas or habitats with a particularly large number of associated threatened species are likely to have higher conservation value. Unfortunately, there has been little historic effort to assess conservation status of marine species and so much missing knowledge that available information could not be adequately and usefully interpreted. Further, it is questionable whether threatened species alone are a reasonable basis for understanding habitat function. For example, the only threatened shorebirds in Victoria are few in number, yet many hundreds of thousands of shorebirds gather in the central Victorian bays and inlets. The ecological character of an area is equally often determined by habitat-dependent species, even if they are not listed threatened. In the Gippsland Lakes for example, the largest declines have been in freshwater species such as Purple Swamphen, which are far from endangered at the State level but their local scarcity indicates a catastrophic loss of freshwater.

However, whilst the mere presence of any given species is not a reason for assuming a particular area is a priority, the importance of threatened species management should not be underestimated. There is also a risk of over-emphasising the larger-scale strategic protection of habitat and ignoring the fact that species characterise healthy functioning environments. Critical processes at any given spatial scale depend on species and sometimes these species may occur only locally. It is acknowledged that this report is quantifying habitat value at relatively large scales.

Effort has been made to list areas of habitat that are generally critical for life phases of marine species and where these are rare and threatened, this is noted. However, this is provided for information and will be incomplete. This issue is also addressed in the gap analysis (Chapter 6).

The resultant criteria, and the scoring system used for estimating an area's conservation value, are detailed in Table 4.4.

Table 4.4: Criteria used for estimating levels of area conservation value.

Criteria		Database Measure
Ecological Importance	Degree of importance of a habitat for supporting essential ecological processes	Measured as High, Medium, Low.
Diversity	High species, community or taxonomic diversity	Measured on a scale of 0-0.5 in increments of 0.1. Only included if habitat was obviously diverse.
Unit	Contained or isolated ecological unit	Measured on a scale of 0-0.5 in increments of 0.1. Only included if habitat was obviously isolated.
Vulnerability	Degree of susceptibility of habitat to given threats, via changes to ecological processes.	Measured as High, Medium, Low.
Naturalness	Degree to which area has been protected from human-induced change.	A function of the likelihood of a threat occurring (based on knowledge about threatening processes existing in given regions) and an overall subjective assessment of the level of human interference in processes (High, Medium or Low).

Ecological importance and vulnerability were used to assess the conservation value of habitat types. Therefore, the areas of greatest conservation value are those that:

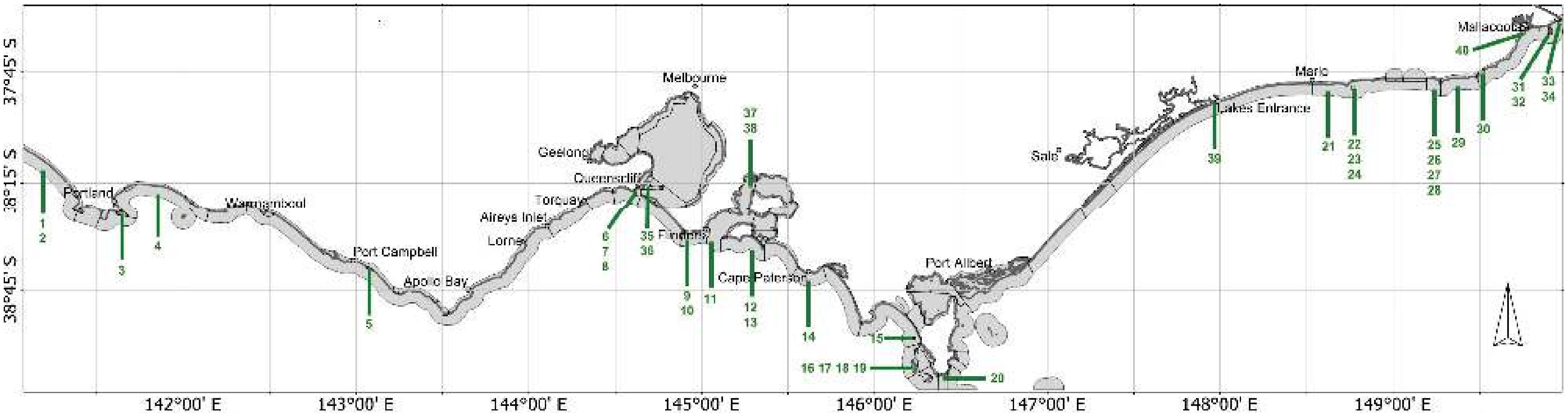
1. support a major extent of the habitats of highest conservation value; and
2. are considered relatively diverse, isolated and natural.

We assessed the habitats within each of the 90 Victorian coastal regions according to these criteria by combining the habitats of highest conservation value (Table 4.3) and estimates of their ecological uniqueness. The ranking of conservation value was converted into a scale from 0-1.0. Ecological uniqueness was defined as a habitat's degree of uniqueness and level of endemism in terms of species and communities; it was ranked from 0-0.5, so these results were doubled. These measures were then added together, summed for each region-habitat combination.

This gave each unique habitat within each region a score for conservation value. This score was used to rank the habitat-region combinations. The location and details of the forty with the highest scores are shown in Table 4.5 and Figure 4.7.

Table 4.5. Forty habitat areas of highest conservation value in Victoria. **Note**: these are not shown in any particular order as they all score highly and similarly in terms of species richness and ecological uniqueness. The bioregion to which a region belongs is indicated after the region's name: (OTW) Otway; (CVA) Central Victoria; (FLI) Flinders; (TWO) Twofold Shelf; and (VES) Victorian Bays and Estuaries.

Habitat Class	Subhabitat	Region
Coastal/Dune	Islands	Gabo Is (TWO)
		Norman, Glennie, Anser Islands (FLI)
		Shellback Is (FLI)
Exposed Littoral	Intertidal reef	Western Channel, Flinders (CVA)
Sheltered littoral (estuaries and wetlands)	Fauna feeding, breeding and resting area	Cape Grant, Lawrance Rocks (OTW)
		Lakes Entrance (TWO)
		Mallacoota Inlet (VES)
	Seagrass	Swan Bay (VES)
Sheltered subtidal (bays and estuaries)	Seagrass	Swan Bay (VES)
	Subtidal reef	Crawfish, Eagle Rocks (VES)
Subtidal to state limit	Deep reef	Beware Reef (TWO)
		Cape Howe (TWO)
		Discovery Bay (OTW)
		Norman, Glennie, Anser Islands (FLI)
		Point Hicks, Sensation Reef, Clinton (TWO)
		Port Phillip Heads (CVA)
		Roaring Meg to Southeast Pt (FLI)
		Schanck to West Head (CVA)
		Southern Phillip Is (CVA)
	Intermediate reef	Arches and Apostles (OTW)
		Norman, Glennie, Anser Islands (FLI)
		Point Hicks, Sensation Reef, Clinton (TWO)
	Pinnacle/Canyon	Beware Reef (TWO)
		Crawfish, Eagle Rocks (VES)
		Discovery Bay (OTW)
		Norman, Glennie, Anser Islands (FLI)
		Point Hicks, Sensation Reef, Clinton (TWO)
		Port Phillip Heads (CVA)
		Southern Phillip Is (CVA)
	Seagrass	Portland Bay (OTW)
	Subtidal reef	Beware Reef (TWO)
		Bunurong, Inverloch (CVA)
		Cape Howe (TWO)
		Croajingalong, Petrel to Lit Rame (TWO)
		Croajingolong, Marlo to Bemm (TWO)
		Gabo Is (TWO)
		Point Hicks, Sensation Reef, Clinton (TWO)
		Port Phillip Heads (CVA)
		Schanck to West Head (CVA)
		The Skerries (TWO)



Bioregion		Otway				Central Victoria					Flinders			Twofold Shelf							Victorian Bays and Estuaries			
Region		Discovery Bay	Cape Grant, Lawrance Rocks	Portland Bay	Arches and Apostles	Port Phillip Heads	Schanck to West Head	Western Channel, Flinders	Southern Phillip Is	Bunurong, Inverloch	Shellback Is	Norman, Glennie, Anser Islands	Roaring Meg to Southeast Pt	Croajingolong, Marlo to Bemm	Beware Reef	Point Hicks, Sensation Reef, Clinton	Croajingalong, Petrel to Lit Rame	The Skerries	Gabo Is	Cape Howe	Swan Bay	Crawfish, Eagle Rocks	Lakes Entrance	Mallacoota Inlet
Habitat Class	**Subhabitat**																							
Coastal/Dune	Islands										15	16							31					
Exposed Littoral	Intertidal reef							11																
Sheltered littoral (estuaries and wetlands)	Fauna feeding, breeding and resting area		3																				39	40
	Seagrass																				35			
Sheltered subtidal (estuaries and wetlands)	Seagrass																				36			
	Subtidal reef																					37		
Subtidal to state limit	Deep reef	1				6	9		12			17	20		22	25				33				
	Intermediate reef				5							18				26								
	Pinnacle/Canyon	2				7			13			19			23	27						38		
	Seagrass			4																				
	Subtidal reef					8	10			14				21	24	28	29	30	32	34				

Figure 4.7. Forty habitat areas of highest conservation value in Victoria. **Note**, these are not shown in any particular order as they all score highly and similarly in terms of species richness and ecological uniqueness.

4.4 Conservation Priorities

4.4.1 Linking Habitat Value and Threats

In the preceding sections we identified threat pathways that gave rise to effects on critical ecosystem services and processes. We also identified habitats that were important for ecosystem processes, vulnerable to threats and critical for building ecosystem resilience (the most important habitats). The prioritization of habitat for protection and management is a function of habitat conservation value and degree of threat. The habitats of greatest importance in terms of protection priority are those that are:

1. of high conservation value (Section 4.3); and
2. subject to active threatening processes (Section 3.3).

4.5 Areas of High Conservation Priority

4.5.1 Areas of Existing Threat

Some of the most important areas to focus efforts for habitat preservation therefore, are regions of Victoria where there are:

1. a major extent of the habitats of highest conservation value; and
2. already threats occurring as a result of threatening processes.

In our analysis, the 90 Victorian regions were ranked based on these criteria by combining the habitats of highest conservation value (Table 4.2) and the areas of existing threat (Table 3.3). The twenty locations with the highest resulting rank are listed in Table 4.6. Note, climate change threats were assessed separately as they affect all areas.

Table 4.6. Top twenty locations ranked for degree of threat and presence of most important and vulnerable habitats.

Region (Including climate change threats)	Region (Excluding climate change threats)	Rank
Northern Channels (VES)	Lakes Entrance (TWO)	1
Lakes Entrance (TWO)	Northern Geelong Arm (VES)	2
Anderson Inlet (VES)	Port Phillip Heads (CVA)	3
Shallow Inlet (VES)	Port Fairy (OTW)	4
Waterloo Bay (FLI)	Marengo to Aireys (CVA)	5
Port Phillip Heads (CVA)	Lillias to Wilson (VES)	6
Mallacoota Inlet (VES)	Torquary to Barwon (CVA)	7
Bass Coast - Griffith to Coal Pt (CVA)	Mallacoota Inlet (VES)	8
Croajingolong, Marlo to Bemm (TWO)	Warrnambool (OTW)	9
Croajingalong, Petrel to Lit Rame (TWO)	Croajingolong, Marlo to Bemm (TWO)	10
Black Reef coast (FLI)	Northern Channels (VES)	11
Swan Bay (VES)	Bunurong, Inverloch (CVA)	12
Point Hicks, Sensation Reef, Clinton (TWO)	Southern Phillip Is (CVA)	13
Port Fairy (OTW)	Anderson Inlet (VES)	14
Warrnambool (OTW)	North Arm (VES)	15
Northern Geelong Arm (VES)	Swan Bay (VES)	16
East Arm (VES)	Shallow Inlet (VES)	17
North Arm (VES)	Nepean to Schanck (CVA)	18
Nepean to Schanck (CVA)	Corio Bay (VES)	19
Southern Phillip Is (CVA)	Bass Coast - Griffith to Coal Pt (CVA)	20

4.5.2 Biodiversity Hotspots

The term biodiversity hotspot originates from work by Dr Norman Myers in the late 1980s, early 1990s. In a publication in Nature (Myers *et al*. 2000), hotspots of global biodiversity were strictly defined as areas that:

1. had 0.5 % or 1 500 species of vascular plants as endemics; and
2. had lost at least 70 % of their primary vegetation.

Biodiversity hotspots are defined as areas that are the most biologically rich and endangered. The use of endemism is important as it indicates a level of specialist ecological function, which is found nowhere else.

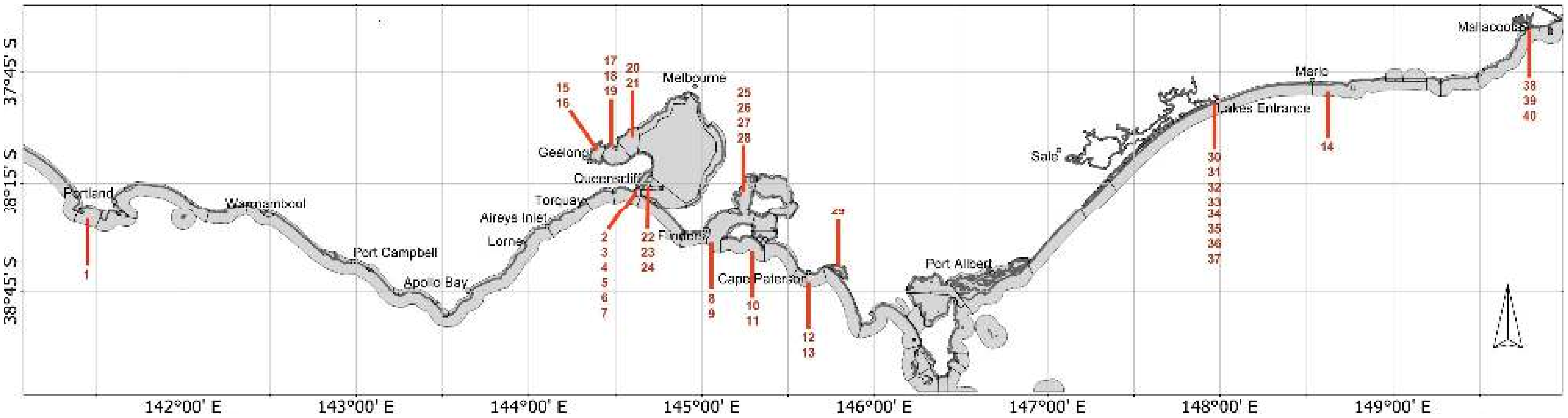
To apply this technique to the marine environment of Victoria is almost impossible, due to lack of information both about marine community composition, levels of endemism and historic threat (see gap analysis, Chapter 6). To simply use number of species as a measure of biodiversity would be inadequate as this only identifies areas of high species richness. Many critical habitats for primary and secondary production processes are species poor, very high biomass and may still, on a biogeographic level, be ‘hotspots’ in terms of endemism.

Therefore, there is no way to reliably quantify marine biodiversity hotspots within Victoria using available knowledge. Instead, we have identified some candidates by combining the habitats of highest conservation value (Table 4.2), the areas of existing threat (Table 3.3) and estimates of ecological uniqueness (Table 4.4). The ranking from the first two tables was converted into a scale from 0-1.0. Ecological uniqueness was ranked from 0-0.5, so these results were doubled. The three measures were then added together, summed for each unique region-habitat combination and ranked in descending order. Details and the location of the forty habitat-region combinations with the highest ranking are shown in Table 4.7 and Figure 4.8.

This list is inherently biased towards habitats that are known to be most threatened, based on our present knowledge of the existence of threatening processes. This almost certainly underestimates the threat to offshore habitats for which we have little or no knowledge about, in terms of the significance of impacts.

Table 4.7. Top 40 habitat areas subject to threatening processes that have substantial habitat that is vulnerable, important for ecological processes and considered to be an important ecological unit in terms of function, isolation or uniqueness. The bioregion to which a region belongs is indicated after the region's name: (OTW) Otway; (CVA) Central Victoria; (FLI) Flinders; (TWO) Twofold Shelf; and (VES) Victorian Bays and Estuaries.

Habitat Class	Subhabitat	Region
Coastal/Dune	Dune	Lakes Entrance (TWO)
	Grasses	Lakes Entrance (TWO)
		Port Phillip Heads (CVA)
	Heaths	Lakes Entrance (TWO)
		Port Phillip Heads (CVA)
Exposed Littoral	Dune	Lakes Entrance (TWO)
	Intertidal reef	Western Channel, Flinders (CVA)
Sheltered littoral (estuaries and wetlands)	Fauna feeding, breeding and resting area	Anderson Inlet (VES)
		Lakes Entrance (TWO)
		Mallacoota Inlet (VES)
	Ruppia/estuarine grass	Corio Bay (VES)
		Lakes Entrance (TWO)
		Lillias to Wilson (VES)
		Swan Bay (VES)
	Saltmarsh	Lillias to Wilson (VES)
		Mallacoota Inlet (VES)
		Northern Geelong Arm (VES)
	Sandflats	Mallacoota Inlet (VES)
	Seagrass	Lakes Entrance (TWO)
		North Arm (VES)
		Swan Bay (VES)
Sheltered subtidal (bays and estuaries)	Channels	North Arm (VES)
	Drift weed	Northern Geelong Arm (VES)
	Intertidal reef	Northern Geelong Arm (VES)
	Seagrass	Corio Bay (VES)
		Lakes Entrance (TWO)
		Lillias to Wilson (VES)
		North Arm (VES)
		Swan Bay (VES)
Subtidal to state limit	Deep reef	Port Phillip Heads (CVA)
		Southern Phillip Is (CVA)
	Pinnacle/Canyon	Port Phillip Heads (CVA)
		Southern Phillip Is (CVA)
	Seagrass	Bunurong, Inverloch (CVA)
		Port Phillip Heads (CVA)
	Sediment beds	Bridgewater Bay (OTW)
	Subtidal reef	Bunurong, Inverloch (CVA)
		Croajingolong, Marlo to Bemm (TWO)
		Port Phillip Heads (CVA)
		Western Channel, Flinders (CVA)



Bioregion		Otway	Central Victoria				Twofold Shelf	Victorian Bays and Estuaries							
Region		Bridgewater Bay	Port Phillip Heads	Western Channel Flinders	Southern Phillip Is	Bunurong Inverloch	Croajingolong, Marlo to Bemm	Corio Bay	Lillias to Wilson	Northern Geelong Arm	Swan Bay	North Arm	Anderson Inlet	Lakes Entrance	Mallacoota Inlet
Habitat Class	**Subhabitat**														
Coastal/Dune	Dune													30	
	Grasses		2											31	
	Heaths		3											32	
Exposed Littoral	Dune													33	
	Intertidal reef			8											
Sheltered littoral (estuaries and wetlands)	Fauna feeding, breeding and resting area												29	34	38
	Ruppia/estuarine grass							15	17		22			35	
	Saltmarsh								18			25			39
	Sandflats														40
	Seagrass										23	26		36	
Sheltered subtidal (bays and estuaries)	Channels											27			
	Drift weed									20					
	Intertidal reef									21					
	Seagrass							16	19		24	28		37	
Subtidal to state limit	Deep reef		4		10										
	Pinnacle/Canyon		5		11										
	Seagrass		6			12									
	Sediment beds	1													
	Subtidal reef		7	9		13	14								

Figure 4.8. Forty habitats and areas most subject to threatening processes that are vulnerable, important for ecological processes and considered to be an important ecological unit in terms of function, isolation or uniqueness. **Note**, these are not shown in any particular order.

5 Conservation Status and Gap Analysis

5.1 Policy and Marine Conservation Strategies in Victoria

Victoria's marine protected areas exist within a complex policy and regulatory framework. Below is an outline of relevant marine protected areas and marine conservation policy, strategies, and regulations which are applicable to Victoria.

5.1.1 National Representative System of Marine Protected Areas

In the early 1990s Australian governments identified a need to protect representative examples of the full range of marine ecosystems and habitats in marine protected areas. They agreed to establish a comprehensive, adequate and representative system of protected areas covering Australia's exclusive economic zone. The system aims to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels (DEWHA 2008).

The NRSMPA exists within a broader range of national and State and Territory mechanisms to achieve biodiversity conservation and sustainable management of Australia's marine waters. It is a national system of marine protected areas in Commonwealth, State and Territory waters that aims to contain a comprehensive, adequate and representative sample of Australia's marine ecosystems. Ultimately the goal is to protect marine areas that represent all major ecological regions and the communities of plants and animals they contain (Department of Environment, Water, Heritage and the Arts, 2008).

The establishment of the NRSMPA helps to implement international and national agreements and strategies. It helps to meet Australia's obligations as a signatory to the Convention on Biological Diversity, which requires all member nations to establish a system of protected areas and to develop guidelines for their selection, establishment and management. It also supports national commitments under the Inter-governmental Agreement on the Environment (1992). This Agreement made a commitment to the establishment of representative marine protected areas (DEWHA 2008).

The marine protected areas (MPAs) that are established under this system are multi-zoned, with three management zones:

- ***Strict nature reserve*** (IUCN category Ia): scientific reference site for research and monitoring. No oil and gas exploration and production, recreational or commercial fishing permitted. Permits required for research, education, recreation and tourism use (Australian Conservation Foundation and National Environmental Law Association, 2006).

- ***Habitat protection zone*** (IUCN category VI) which excludes commercial fishing but allows oil and gas exploration and production and recreational and charter fishing (Australian Conservation Foundation and National Environmental Law Association, 2006).
- ***Managed resource protected zone*** (IUCN category VI) which provides for oil and gas exploration and production, recreational and charter fishing and commercial fishing, such as abalone and rock lobster, but excludes commercial fishing using demersal trawl, Danish seine, auto longline, mesh netting, demersal longline and scallop dredges (Australian Conservation Foundation and National Environmental Law Association, 2006).

However implementation of the NRSMPA has been mixed. Each jurisdiction creates MPAs in its own way and the system has evolved with inconsistent processes and outcomes for marine protection, and different targets, timelines, consultation processes, zonings and levels and types of protection. The first Regional Marine Plan, for the South-east Exclusive Economic Zone, was released in 2004. The plan covers an area of two million square kilometers off Victoria, Tasmania, southern New South Wales and eastern South Australia. It aims to provide for development that improves our quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. A draft SE MPA Management plan is currently being developed and will be available for public comment in 2010 (Australian Conservation Foundation and National Environmental Law Association, 2006).

5.1.2 World Conservation Union Protected Area Management Categories

Australia has adopted the World Conservation Union's (IUCN) internationally recognised set of management categories to ensure consistent definition and management of marine protected areas. Commonwealth marine protected areas must assign the reserves, and any zones within them, to one of the seven IUCN Protected Area Management Categories, outlined in Table 5.1.

The numbering system for the IUCN system is different to that applied by the EPBC Act but the categories are essentially the same (Department of the Environment, Water, Heritage and the Arts 2010).

Table 5.1. IUCN Protected Area Management Categories.

IUCN Protected Area Management Categories			
	Type of area	**IUCN**	**Explanation**
1	Strict nature reserve	Ia	Managed primarily for scientific research or environmental monitoring.
2	Wilderness area	Ib	Protected and managed to preserve its unmodified condition.
3	National park	II	Protected and managed to preserve its natural condition.
4	Natural monument	III	Protected and managed to preserve its natural or cultural features
5	Habitat/species management area	IV	Managed primarily, including (if necessary) through active intervention, to ensure the maintenance of habitats or to meet the requirements of specific species
6	Protected Landscape/seascape	V	Managed to safeguard the integrity of the traditional interactions between people and nature.
7	Managed resource protected area	VI	Managed to ensure long-term protection and maintenance of biological diversity with a sustainable flow of natural products and services to meet community needs.

5.1.3 Victorian System of Marine Protected Areas

In Victoria, the current system of Marine National Parks and Sanctuaries was established based on the recommendations of the Environment Conservation Council (ECC) in its *Marine, Coastal and Estuarine Investigation Final Report* (2000), which built on the earlier work of the Land Conservation Council (LCC 1996). The ECC recommended that the parks and sanctuaries be established with the primary objective of protection of biodiversity, and that extractive and damaging activities not be allowed (ECC 2000). In 2002 the Victorian government established a system of 13 Marine National Parks and 11 Marine sanctuaries which currently protect 5.3 % of Victoria's marine environment. The locations of existing marine national parks, marine sanctuaries, and marine and coastal parks and reserves are illustrated in Figure 5.1. Victoria's current marine national parks and marine sanctuaries were identified and established based on the principles of comprehensiveness, adequacy and representativeness used in the NRSMPA. Wescott (2006) describes a Comprehensive, Adequate and Representative (CAR) system of MPAs as '*a system which protects a full range of habitats and communities in each region (comprehensive), with boundaries established for the MPA which ensure a sufficient size and are practical enough to minimise external negative influences (adequate) and which reflects within the boundaries the diversity of flora and fauna in the protected habitats and communities* *(representativeness)*' (p.910). This is discussed in more detail in the MPA Gap Analysis (Section 5.3).

Victoria's Marine National Parks and Sanctuaries are established under the *National Parks Act 1975*. Overall arrangements for Parks Victoria's management responsibilities are set out in a Management Agreement between the Minister for Environment and Climate Change, the Secretary to the Department of Sustainability and Environment and Parks Victoria. The Department of Primary Industries coordinates and delivers fisheries compliance services across Victorian waters. The Department of Sustainability and Environment is also a significant partner in the management of the Marine National Parks and Sanctuaries. Other legislation, management agencies and policies also support management of the system.

The following definitions apply to marine and coastal protected areas in Victoria:

Marine National Parks are 'highly protected areas which contribute to a system representing the range of marine environments in Victoria, and in which no fishing, extractive or damaging activities are allowed. There are no restrictions on access, and activities such as recreation, tourism, education and research are encouraged' (Environment Conservation Council 2000, p.42). They are established to provide the highest level of protection for biodiversity and to maintain representative samples of natural ecosystems in perpetuity. Marine National Parks must be sufficiently large to achieve their objectives.

Marine Sanctuaries 'are smaller highly protected areas designated for protection of their special natural values, in which no fishing, extractive or damaging activities are allowed. These areas also complement the larger marine national parks' (Environment Conservation Council 2000, p.43). Marine Sanctuaries have a range of values, including: typical or outstanding examples of habitat not otherwise represented in the system of marine protected areas; areas of special significance; and areas that provide important opportunities for recreation and education associated with the enjoyment and understanding of the natural environment. These sites, as for marine national parks, are given the highest level of protection.

Special Management Areas are areas designated (formally through legislation or through other management arrangements) for protection of their special natural values, in which fishing and other uses are generally allowed. Special management areas ensure that areas of special value are identified and that they are managed appropriately (Environment Conservation Council 2000, p.43). The ECC investigation recommended the establishment of 18 Special Management Areas however these were established legally but never implemented in a practical sense (see Appendix 4).

Marine and Coastal Parks and Reserves are multiple-use parks that existed prior to the establishment of a representative system of marine protected areas in 2002. These are areas of high environmental values being managed for a variety of uses including recreational and commercial fishing. Marine and coastal parks and reserves have very significant environmental values, and make a substantial contribution to the representative and comprehensive nature of the marine protected areas system (Parks Victoria 2003). However, there is little formal documentation pertaining to their objectives, purposes and levels of protection. It is therefore difficult to assess their adequacy in terms of protection levels and the values to be protected.

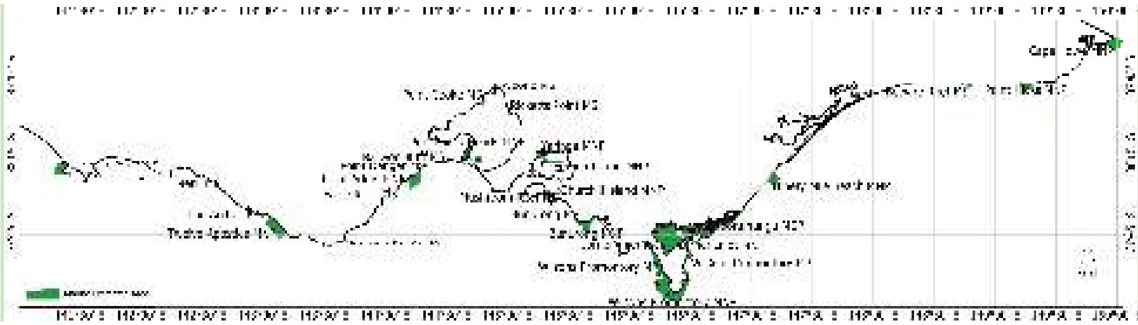


Figure 5.1. Existing Marine Protected Areas.

5.1.4 Marine Protected Areas Policy Framework in Victoria

The Department of the Environment, Water, Heritage and the Arts defines a marine protected area as '*an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, and managed through legal or other effective means'* (DEWHA 2010). Marine protected areas exist within a complex regulatory framework, involving policies and legislation at international, national and state levels. They can be managed by State, Territory or Commonwealth government agencies, or a combination of government agencies.

Australia's rights and responsibilities over its marine jurisdiction is established under the United Nations Convention on the Law of the Sea. State and Territory governments have primary responsibility for marine environments up to three nautical miles out from the territorial sea baseline unless otherwise determined by legislation. The Commonwealth usually manages oceans from the State or Territory limit to the limit of the Australian Exclusive Economic Zone (EEZ) 200 nautical miles out to sea. This means that the Commonwealth, States and Northern Territory governments exercise separate jurisdictions over the marine environment. Marine protected areas can be declared under Commonwealth or State legislation and each government uses its own policies and laws to establish and manage marine protected areas. Marine protected areas can also be managed through a combination of fisheries and parks management laws administered by separate government agencies (DEWHA 2010).

In Victoria, the Commonwealth and State government agencies responsible for marine protected areas are the Department of the Environment, Water, Heritage and the Arts, the Department of Sustainability and Environment, and Parks Victoria. Below is a list of existing marine protected areas policy applicable to Victoria.

Australia's Oceans Policy
Commonwealth Environment Protection and Biodiversity Conservation Act 1999
National Parks Act 1975
National Strategy for the Conservation of Australia's Biological Diversity (1996)
Australia's Biodiversity Conservation Strategy 2010-2020
Victoria's System of Marine National Parks and Marine Sanctuaries Management Strategy 2003–2010
World Heritage Areas
Wetlands of International Importance
Biosphere Reserves

5.1.5 Commonwealth and State Marine Conservation Policy Framework

In Victoria, many strategies and plans, such as the Victorian Coastal Strategy, the Biodiversity Strategy and the Victorian Aquaculture Strategy, address aspects of marine, coastal and estuarine management but inconsistencies and problems within and between them have weakened biodiversity conservation outcomes and sustainable resource use. Many environmental issues are managed through collaboration between jurisdictions and agencies, but catchment-coast-ocean management has been obstructed by narrow, sector-based management focused on the exploitation of marine resources within jurisdictional boundaries (Smyth *et al.* 2003).

The Victorian Department of Sustainability and Environment (DSE) is responsible for sustainable management of water resources, climate change, public coastal land, and ecosystems. Specific services are delivered by a number of statutory authorities, including the Environment Protection Authority (EPA), Sustainability Victoria, Parks Victoria, and five coastal Catchment Management Authorities (CMAs). There are also several bodies that provide advice to the Victorian Government, including the Victorian Environmental Assessment Council, the Victorian Catchment Management Council, the Victorian Coastal Council and the Commissioner for Environmental Sustainability (CES 2008).

Local governments are authorized by State legislation to provide works and services for land use planning and environment protection. This level of government has an immediate role in shaping the local environment (CES 2008).

National and state policy instruments aimed at marine conservation are currently not sufficiently coordinated, wasting resources and missing valuable and complementary policy opportunities. Below is a list of the key policies, strategies and legislation applicable to marine conservation in Victoria. Please refer to Appendix 3 for a more detailed outline of each document.

Offshore Constitutional Settlement
Fisheries Management Act 1991
Coastal Management Act 1995
Victorian Coastal Strategy (2008)
Securing Our Natural Future: A White Paper for Land and Biodiversity at a Time of Climate Change
Flora and Fauna Guarantee Act 1988
Victoria's Biodiversity Strategy (1997)
Fisheries Act 1995 (Vic)
Victorian Aquaculture Strategy (2008)
Planning and Environment Act 1987(Vic)
Wildlife Act 1975 (Vic)
Environmental Protection Act 1970 (Vic)
Environmental Effects Act 1978 (Vic)
State Planning Policy Framework and Victorian Planning Provisions
State Environment Protection Policies (SEPPs)
Water Act 1989 (VIC)
Action Statement: Introduction of exotic marine organisms into Victorian marine waters
Interim Victorian Protocol for Managing Exotic Marine Organism Incursions
Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria

5.2 Knowledge Gaps

5.2.1 Information Requirements for Conservation

As intimated in previous chapters, conservation assessment and management is heavily reliant on a variety of information types. Key information requirements are some level of:

- taxonomy – to understand what species exist and how to identify them;
- inventory – baseline to determine natural assets of species, communities and habitats, including abundance, distribution and areas of high diversity and endemism;
- basic biology, including habitat requirements, photosynthesis/feeding, reproduction and behaviour – to understand requirements of life and potential threatening processes;
- ecology, including processes such as community-environment relationships, production and trophic pathways, as well as habitat formers and shapers – to understand processes of conservation importance and consequences of threats, changes or impacts;
- environment – physico-chemical environment and variation from natural and human-induced processes, including levels of natural resource extraction, habitat

modification, pollution and pests – to understand existing and potential threats, placed in context with natural variations; and

- monitoring time series – to detect changes for management responses, including for prevention, improvement and rehabilitation.

5.2.2 Taxonomy

Much of Australia's marine biodiversity remains undescribed. For marine invertebrates in general, less than half the species have probably been described (Ponder *et al.* 2002). Probably less than a third of the sponges have been described and only a small proportion of existing sponge collections from Victoria has been sorted and identified (Hooper 2005). This is significant given approximately 523 species of the 1416 species described for Australia to date have been from the partially examined Victorian collections. New species of plants and animals are continuously being found as new sites are surveyed in Victoria, such as seaweed discoveries by Kraft (2000) and Edmunds *et al.* (2003) and echinoderms by O'Loughlin (2007).

Another key taxonomic issue is the paucity of taxonomic resources. There are presently few taxonomic experts in Australia, particularly relative to our relatively high endemic diversity of species. There are also few readily available and comprehensive identification guides to assist with ecological surveys and monitoring.

The consequences of these taxonomic issues are: that there are likely to be a considerable number of species of higher conservation concern which are presently unidentified; there are inadequate to assist ecologists with biodiversity surveys.

5.2.3 Inventory

Our present knowledge and understanding of Victorian marine natural values is relatively poor and very patchy in spatial coverage and quality. This is well depicted by the low coverage of habitat mapping along the coast, which is mostly confined to the marine protected areas (Figure 5.2b). There have been very few systematic and robust biodiversity and community surveys across the coast of Victoria. Three exceptions are surveys of: intertidal reef biodiversity (O'Hara, Museum Victoria unpublished data); sediment infauna biodiversity (Coleman *et al.* 1997, 2007); and habitat structures (Roob 2000 – and also unpublished observations by Roob and Currie). There have been a variety of other detailed biodiversity surveys, predominantly on subtidal reef, however most were spatially confined (*e.g.* Wilson *et al.* 1983; O'Hara 2000, Edmunds *et al.* 2000a, 200b). Apart from fished species, we presently know little of the abundance and distribution of even the most common marine species in Victoria. The intermediate and deep reefs remain largely unexplored and unsurveyed.

Most of the Victorian marine habitats have not been systematically mapped and surveyed and the associated communities and biodiversity are undescribed. Consequently, the conservation values and status is unknown for large areas of

Victoria's marine environment. This problem is presently being addressed through a statewide near-shore bathymetry mapping and ground-truthing program, which will facilitate the subsequent design and implementation of flora and fauna inventory surveys.

5.2.4 Biology and Ecology

We presently know very little about the basic biology and ecology of Victorian marine species, with the exception of fished or aquaculture species. For example, there is a paucity of information on which populations are unique or rare, the nature of habitats and areas critical for particular life phases, such as nursery habitats or larval recruitment and populations with very old individuals or other properties that are irreplaceable. We also know little about species requirements and ecophysiology that are important for conservation management. For example, we do not know what the light requirements are for seagrass, kelp and seaweed beds for their survival, let alone to sustain their biomass at a level adequate to support other species in the community.

Our understanding of ecosystem interactions is rudimentary, such that predictions of impacts or management responses can only be done for processes at a scale that negate ecological complexity, such as major habitat changes caused by marine pests or dredging. We do not understand key processes such important energy and matter (trophic) flows between species in the community, rates of primary and secondary production, nutrient cycling, competitive and predator/prey interactions. Such knowledge is important for determining and managing threatening processes. At present, we are unable to predict ecological implications of recent abalone population declines from virus outbreaks, fishery management changes or of species shifts with climate change.

5.2.5 Monitoring

The only state wide monitoring marine programs are associated with fished populations, seagrass habitats and marine protected area management. Some localised areas have more intensive monitoring, such as water quality monitoring in Port Phillip Bay and environmental monitoring associated with discharges and other marine developments. Key gaps in monitoring are difficult to establish until we have fully mapped habitats, have a better inventory. Known gaps include deeper ecosystems and open coast water quality.

5.2.6 Resourcing Recommendations

Increased resourcing for a better knowledge base is desperately required if the prospects for marine nature conservation is to be improved. This means much increased field investigations. The present level of investment in information for marine natural resource and conservation management is very low; in the order of low hundreds of thousands of dollars. This does not include expenditure on biology for fisheries management, but fisheries expenditure on ecology for ecosystem-based fisheries management is equally lacking.

Substantial improvements in the knowledge base can be gained with funding at levels that greatly enhance economies of scale and that are designed in a systematic, comparable and efficient manner. Levels of funding that provide good economies of scale (field data and information return per dollar spent) are in the order of high hundreds of thousands to low millions of dollars. Studies in the order of tens of thousands of dollars are generally limited in data returns by overhead costs. Very large projects in biological terms are in the order of millions of dollars. Such projects have advantages of relatively low overhead costs such as for vessels and staff, but their efficiency is limited by increased bureaucracy, with disproportionate funding on strategy and project management compared with actual fieldwork expenditure.

Examples of projects with high data returns and with lasting and varied usage include: the bays and inlets habitat mapping 1998-2001; long-term water quality and phytoplankton monitoring stations in Port Phillip Bay; long term subtidal reef program in selected marine protected areas; seagrass monitoring in Port Phillip Bay and Corner Inlet; and the recent lidar bathymetry mapping along most of the coastline.

An important resourcing consideration is long-term monitoring commitments, beyond the term of any particular Government. Understanding and managing natural resources requires at least sub-decadal to decades of monitoring. While this is generally assured for fisheries management, there would be benefits with longer-term commitments to other marine biological and water quality monitoring programs.

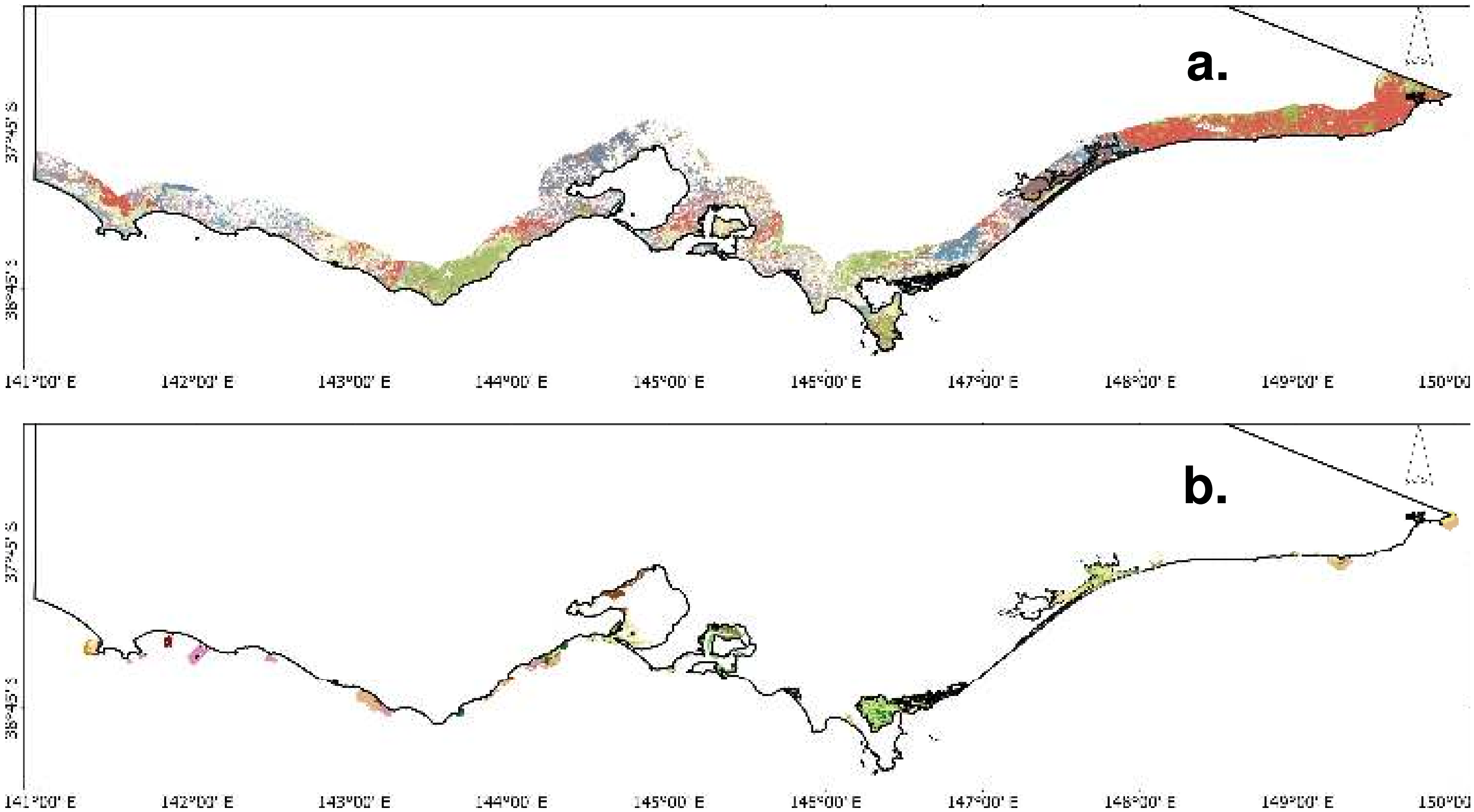


Figure 5.2. Spatial data coverage of habitat and community mapping for (a) coastal terrestrial and (b) marine environments.

5.3 Marine Protected Areas

5.3.1 National MPA System

Marine protected areas (MPAs) are used worldwide as a method to preserve areas of the marine environment from present and future threats. Use of the general term 'marine protected area' is adopted from Traill and Porter (2001) and refers to all forms of reserves, parks and sanctuaries in marine waters that provide a formal management framework for an area. The National Representative System of Marine Protected Areas (NRSMPA) was created by the Commonwealth Government to meet international and national agreements for protecting the marine environment (Convention on Biological Diversity, UNEP 1994; Intergovernmental Agreement on the Environment, Commonwealth of Australia 1992). The primary goal of the NRSMPA is to:

> "*establish and manage a comprehensive, adequate and representative system of MPAs to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels.*" (TFMPA 1998)

In addition to the primary goal, key characteristics of the NRSMPA are that the MPAs

- are identified and established primarily for conservation of biodiversity;
- have secure status which can only be revoked by a Parliamentary process;
- contributes to the representativeness, comprehensiveness or adequacy of the national system;
- highly protected areas (IUCN Categories I and II) are included in each bioregion; and
- the precautionary principle should apply – the absence of scientific certainty should not be a reason for postponing measures to establish MPAs to protect representative ecosystems (TFMPA 1998).

The NRSMPA guidelines provide a framework for identifying, prioritising and selecting marine protected areas. The identification and prioritisation criteria were used here for the gap analysis.

The NRSMPA criteria for the identification of candidate MPAs are:

- **comprehensiveness** – areas that add to the full range of ecosystems recognised at an appropriate scale within and across each bioregion;
- **representativeness** – marine areas that reasonably reflect the biotic diversity of the marine ecosystems from which they derive;
- **ecological importance** – areas that have a high contribution to:
    - maintenance of essential ecological processes;
    - high productivity;
    - habitat for rare or endangered species;
    - preservation of genetic diversity;
    - dependent habitat, including nursery, juvenile, feeding, breeding or resting areas;

    - functional, self-sustaining biological units;
- **international or national importance** – area listed or qualifies for listing under an international or national conservation agreement;
- **uniqueness** (this criterion is also met under ecological importance);
- **vulnerability** – communities and ecosystems vulnerable to natural processes (this criterion is difficult to apply with our present limited knowledge base);
- **biogeographic importance** (this criterion is also met under ecological importance); and
- **naturalness** (because of lack of long-term data, this criterion is generally only applied in terms of coarse degrees of modification).

In addition to comprehensiveness and representativeness, a third principle of the NRSMPA is that of **adequacy**: the NRSMPA will have the required level of reservation to ensure the ecological viability and integrity of populations, species and communities. Together, these principles are known as CAR and are applied at the level of each marine bioregion.

Comprehensiveness, adequacy and representativeness (CAR) are the most important considerations for the NRSMPA. Comprehensiveness and adequacy are applied at the scales of bioregions, ecosystems and habitats while representativeness is applied at smaller scales of communities and species (TFMPA 1999). By way of example, CAR analyses in Tasmania and South Australia involved spatially delineating the coast into bioregions into ecologically functional biophysical units, or biounits (Edyvane 1999; RPDC 2006). Biounits were delineated using biogeographical features, depth, wave and wind exposure and water system characteristics and ecosystems were defined as hard and soft substrata within each biounit. Following from this, MPA coverage was considered comprehensive if the MPAs encompassed all delineated ecosystems within the bioregion (RPDC 2006). Substratum types and habitats were mapped at a scale of 1:25 000, including different reef and vegetation classes (*e.g.* Barrett *et al.* 2001). These were used as biodiversity surrogates for community types and representativeness: MPA coverage was considered representative if the MPAs encompassed all habitats present within each biounit of the bioregion (Edyvane 1999; RPDC 2006).

The NSRMPA criteria used for this gap analysis is in accordance with the IUCN criteria for resilient networks:

- include the full range of biodiversity present in the biogeographic region;
- ensure ecologically significant areas are incorporated;
- maintain long-term protection;
- ensure ecological linkages; and
- ensure maximum contribution of individual MPAs to the network (IUCN WCPA 2008).

5.3.2 Regional Priorities for MPAs

The process of identifying candidate MPAs, prior to any selection of areas, is solely based on natural and conservation values of an area. The implementations of MPAs have advantages and disadvantages to different sectors of society and the selection of candidate areas involves a process of optimisation of conservation benefits versus implications for society such as shorter term economics. This optimisation is assisted and bounded by regional and ecosystem level priorities. Priorities used for the Bruny Bioregion in Tasmania (RPDC 2008) were:

Bioregional level

- ensure representation of all ecosystems and habitats consistent with the CAR principles;
- Ensure protection of flow on effects, such as at heads of estuaries, nursery areas and transport of biomass;
- protect linked systems, for example intertidal areas for migratory birds;
- protect ecosystems of conservation concern;
- ensure maintenance of near pristine ecosystems;
- provide for remediation of degraded ecosystems;

Ecosystem level

- ensure protection of specific habitats and communities of conservation concern;
- ensure maintenance of specific near-pristine habitats and communities;
- provide for remediation of degraded habitats and communities; and
- ensure the preservation of functional integrity of ecosystems.

These prioritisation aspects can be applied to Victoria, with the added aspect of existing MPAs.

5.3.3 The Victorian MPA System

The present system of Victorian MPAs is derived from the Environment Conservation Council's Marine, Coastal and Estuarine Investigation (2000). The ECC investigation cites the NRSMPA CAR principles and the identification criteria, as described above, however the implementation for identification and prioritisation were not explicitly reported (ECC 2000). The lack of habitat and biological information available for such an analysis at that time would have been highly limiting for such an analysis.

The ECC (2000) recommended:

- thirteen marine national parks of highly protected larger area to cover major habitats and communities within each bioregion;
- eleven marine sanctuaries of smaller highly protected areas to protect special values;
- eighteen special management areas which have special values which can be managed at a lower level of protection; and

- retention of remaining multiple use parks, such as marine conservation zones.

The Victorian Government implemented the marine national parks and marine sanctuaries and retained existing conservation zones, as recommended by the ECC. The special management areas were included in this process, but received no further attention following declaration and hence presently have no special management attributed to those areas. It is also noted that terrestrial Special Management Zones do not require a parliamentary process to be revoked and, as such, the ECC special management areas do not have long-term security or contribute to the NRSMPA.

5.3.4 MPA Gap Analysis – Methods

The existing system of MPAs in Victoria was assessed in accordance with the objectives of the NSRMPA, principally with respect to the CAR principles, and identification of any gaps with respect to areas of priority conservation value. The assessment of adequacy involved an examination of the area, boundaries and level of protection of each MPA with respect to the ecological objectives of the MPA, identified by the ECC (2000) and the respective MPA management plans, including those by Parks Victoria. Comprehensiveness was assessed by first establishing interim biounits and ecosystems for each of the Victorian bioregions using similar criteria to those used for the Bruny Bioregion in Tasmania (Appendix of RPDC 2006). The criteria for delineation of biounits were:

- ecologically functional structural units with recognisable natural boundaries at 10-100s km scale;
- depth – above or below 30 m;
- exposure – ocean swell exposure, wind exposure, aspect;
- water system – upwelling, Southern Ocean, Bass Strait, Tasman Sea;
- estuarine influence –size, enclosure, barriers, tides, salinity, suspended sediments, light climate, inputs/catchment.

For the purposes of communication in this report, delineated biounits are given interim names. Habitats are moderately well known and mapped within the biounits and MPAs of Victoria, providing information for at least a coarse assessment of representativeness and comprehensiveness of existing MPAs.

The adequacy of the existing MPAs was assessed by comparing the design in terms of boundary locations and levels of protection against the environmental values of the area. Key values of the existing areas are noted by ECC (2000) and some objectives and values are described by Parks Victoria, particularly in management plans. This information is tabulated in the appendices for each bioregion. The gap analysis also considers the IUCN protected area management categories, particularly in terms of recommendations. It is noted that the existing Victorian MPAs do not have any stated objectives with reference to the IUCN categories and that the IUCN categories do not explicitly include levels of protection (especially in terms of resource extraction - take or no-take).

The final component of the gap analysis involved the identification of areas suitable as MPAs and the priority of these areas using the prioritisation criteria listed above (as per RPDC 2008). Priority MPA areas were then compared with the actual MPA coverage for that bioregion to determine if there are any gaps particularly with respect to special or unique communities and species. The existing MPAs and the ECC recommended MPA areas were included in the analysis by default. Other areas were identified from the review of conservation values for each bioregion, as documented in the appendices. Tabulated results of the MPA gap analysis are provided in the appendices for each bioregion. A summary is provided below.

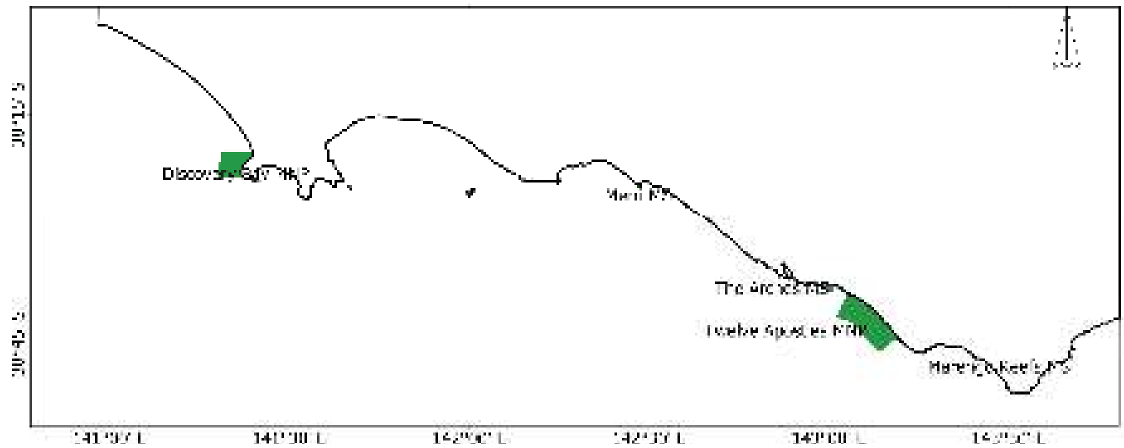


Figure 5.3. Otway Bioregion marine protected areas. Legend: (MNP) Marine National Park; and (MS) Marine Sanctuary.

5.3.5 MPA Gap Analysis – Otway Bioregion

Comprehensiveness, Adequacy and Representativeness

The Otway Bioregion can be divided into two biounits and contains four marine protected areas (Figure 5.3; Table 5.2).

In terms of habitats, the MPAs include intermediate and deep reefs, but intertidal and subtidal reefs are not well encompassed in the Discovery Bay MNP. In terms of vegetated sediments, the seagrass *Heterozostera* is present in both biounits in sparse patches. *Amphibolis* seagrass is present in the Shipwreck biounit, particularly in Dutton Bay. Seagrass is not encompassed within any of the Otway MPAs. The lack of coverage of shallow reef in the Discovery biounit and seagrass throughout the bioregion means the MPA system is not comprehensive (Table 5.3).

The listed values of the Discovery Bay MNP encompass intertidal to deep reef and sediment habitats (Table 5.4). Subsequent to the ECC recommendation, the Discovery Bay MNP has a 500 m section that separates it from the shore along Cape Duquesne and the western boundary was reduced. As a consequence, the area does not adequately encompass intertidal and subtidal reef habitats, or shore bird habitats adjoining dune and dune lake systems.

The Merri MS listed values include bird colonies, intertidal habitats and subtidal reef communities. The seaward boundary is relatively close to shore on continuous reef and, given boundary effects, is considered an inadequate area to protect subtidal reef biota (Table 5.4).

The Twelve Apostles MNP covers extensive areas of habitats at a high level of protection. The Arches MS is also likely to be adequate in encompassing specific habitat structures, however there is presently no survey data to properly assess the adequacy of this MPA.

The four MPAs encompass ecosystems of consolidated and unconsolidated substrata within all biounits and are therefore considered representative of the bioregion (Table 5.3).

Table 5.2. Otway Bioregion: provisional biounits, key ecological features and marine protected areas.

Biounit	Features	Marine Protected Area
Discovery biounit	Discovery Bay to Portland • Maximal exposure • Bonney upwelling	Discovery Bay MNP
Shipwreck biounit	Portland to Cape Otway • Maximal exposure • Southern Ocean	Merri MS The Arches MS Twelve Apostles MNP

Table 5.3. Otway Bioregion. Comprehensiveness and representativeness of marine protected areas in the Otway Bioregion. Legend: (◆) present in MPA; (⬩) minor presence in MPA; (✕) not present in MPA but present in biounit; and (☐) not known in biounit. Tan cells represent gaps in representation.

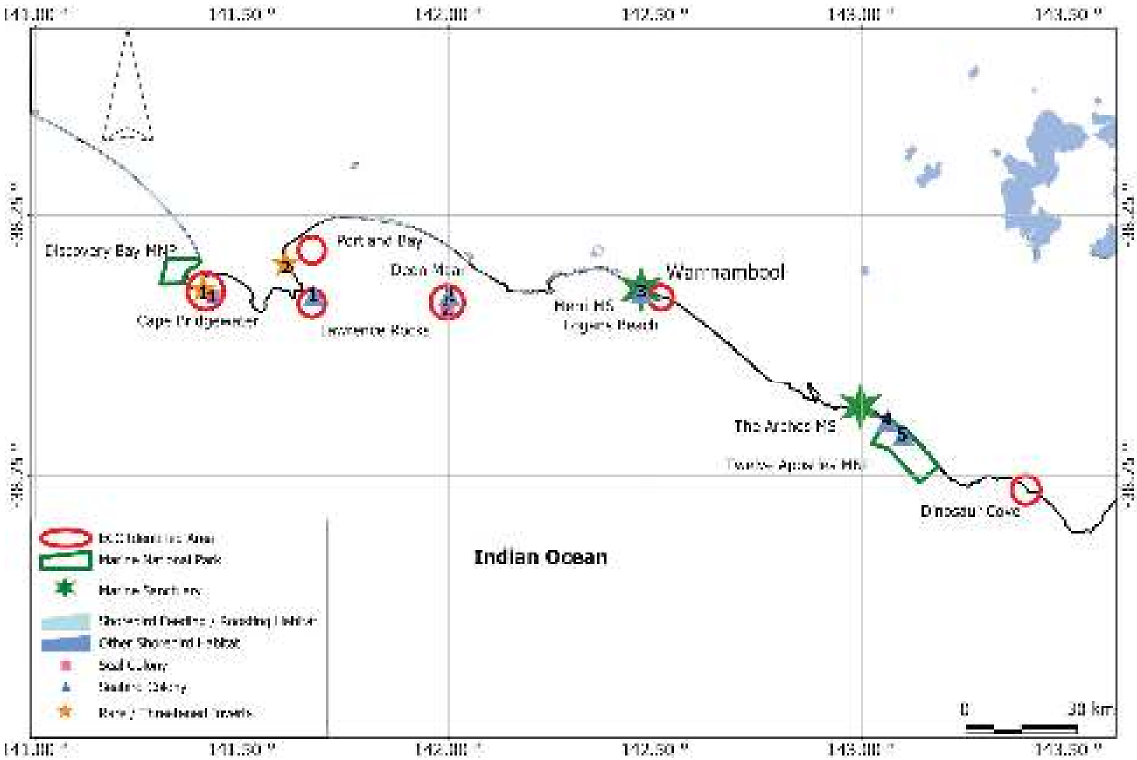
Ecosystem	**Habitat/ Community**	**Discovery Biounit**	**Shipwreck Biounit**		
		Discovery Bay MNP	Merri MS	The Arches MS	Twelve Apostles MNP
Intertidal Sediments	Bare mud				
	Bare sand	◆	◆	✕	◆
	Mangroves				
	Ruppia				
	Seagrass - intertidal				
Subtidal Bare Sediments	Beach – surf zone	⬩	✕	✕	◆
	Channels				
	Inshore sand	◆	◆	◆	◆
	Shelly sand				
	Gravel/pebble				
	Offshore sediment	◆	✕	✕	◆
Subtidal Vegetated Sediments	Seagrass - *Halophila*				
	Seagrass - *Heterozostera*	✕	✕	✕	✕
	Seagrass - *Amphibolis*		✕	✕	✕
	Seagrass - *Posidonia*				
	Caulerpa mats				
	Drift weed mats				
Biogenic	*Pyura* clump				
	Sponge clump				
Rocky Reef	Intertidal	✕	◆	✕	◆
	Subtidal patchy reef	⬩	⬩	✕	◆
	Subtidal reef	⬩	◆	✕	◆
	Intermediate reef	◆	✕	◆	◆
	Deep reef	◆	✕	◆	◆

Table 5.4. Otway Bioregion. Adequacy of marine protected areas in the Otway Bioregion.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
Discovery Bay MNP	**ECC** • Intertidal and subtidal rocky reefs. Calcarenite reefs with thick growths of sessile invertebrates (*e.g.* sponges, ascidians, bryozoans and gorgonians). • Balsaltic reefs covered by large kelps (*e.g. Ecklonia radiata*). • High intertidal and shallow subtidal invertebrate diversity. • Encompasses representative rock lobster and abalone populations and habitat. • Visitation by blue whale *Balaenoptera musculus* and white shark *Carcharodon carcharias*. • Adjoining dune and dune lake system. **PV Management Plan** • Deeper reefs support a variety of red and brown algae. Calcarenite reefs support a diverse range of ascidians, bryozoans and gorgonians. • Small areas of intertidal reef have a variety of invertebrates and algae.	• Good coverage of intermediate depth kelp and red algal habitat. • Good coverage of deep sessile invertebrate habitat. **Issues:** Some stated objectives and values not met by present boundaries and level of protection. • Intertidal and subtidal reef excluded from present MPA – objectives of the MPA are not being met and presents a CAR deficiency. • 500 m 'gap' between shore of Cape Duquesne and boundary greatly increases boundary effects into the park area. • Linkage to coastal ecosystems poor (White's Beach only).	• An additional area elsewhere in Discovery Biounit (*e.g.* Cape Nelson) which encompasses subtidal reef habitats and biota. Or • Extend boundary to shore of Cape Duquesne (*e.g.* as per ECC design). • Extend northern shore corner to north of Bridgewater Lakes to provide better linkage with beach and coastal systems and conservation values (*e.g.* as per ECC design).
Merri MS	**ECC** • Penguin colonies on Merri and Middle Islands. • Rocky overhangs and canyons support a variety of reef fish such as blue-throated wrasse, bastard trumpeters and magpie perch. • The seabed at the river mouth is a mixture of reef and sand with a diverse range of seaweeds and invertebrates. **PV Management Plan** • Protection of a sensitive intertidal community near Pickering Point by minimising recreational access.	• Encompasses islands, bird roosts and colonies and habitats. • Includes intertidal habitats. **Issues:** Some stated objectives and values not met by present boundaries and level of protection. • Subtidal area mostly only surf zone reef habitat. • Algal biodiversity, kelp beds and forests and associated fishes prevalent just inside the seaward boundary	• Extend seaward boundary another 200-300 m offshore to limit boundary effects and provide better assurance of adequacy.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	• Subtidal soft sediment communities. • Middle and Merri Island provide nesting sites for little penguins, black-faced cormorants and short-tailed shearwaters. • High diversity of algae including kelp forests on subtidal reefs. • Intertidal rock platforms provide habitat for invertebrates such as molluscs, anemones and crustaceans and a variety of algal species such as sea lettuce, Neptune's necklace and bull kelp.	and subject to strong boundary affects. • Subtidal surf zone inaccessible for monitoring and performance assessment – difficult to assess values.	
The Arches MS	**ECC** • Reef consists of limestone and arches and canyons that provide habitat for algae and invertebrates. • Upper surfaces of arches are covered with kelp and an understorey of red seaweeds. The undersides and canyon walls provide habitat for seastars, hydroids, sponges, bryozoans and other invertebrate's characteristic of deeper Bass Strait waters. • Giant kelp forests provide habitat for a suite of marine animals. **PV Management Plan** • Reef consists of formations such as sink holes, arches and caverns which provide complex habitat for a diverse range of seastars and sessile fauna including sponges, gorgonians, hydroids and especially bryozoans. • Limestone reefs are covered by a large variety of algae including giant kelps, red and green algae species.	• Encompasses unique reef habitat and communities. **Issues:** Unlikely but area remains unsurveyed. • No scientific surveys of species, communities an habitats present.	• Formal biodiversity and habitat mapping surveys required to assure adequacy of MPA.
Twelve Apostles MNP	**ECC** • Shorelines, rock stacks and islands provide seabird breeding colony sites. • High diversity of intertidal and shallow subtidal	• Comprehensive coverage of shore to deep reef and sediment habitats. • Large area of	

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	invertebrates on limestone. • Diverse marine life inhabiting underwater arches and canyons. **PV Management Plan** • Rock stacks and islands provide seabird breeding habitat (*e.g.* Mutton Bird Island supports a short-tailed shearwater breeding colony). • Isolated narrow intertidal reef supports a variety of echinoderms, molluscs, polychaetes and crustaceans. • Shallow reefs covered with a diverse range of red, brown, green and encrusting coralline algae. • Subtidal reefs provide habitat for invertebrates such as sponges, bryozoans, hydroids and a range of molluscs.	coverage reduces boundary effects and includes entire habitats. **Issues:** None – stated objectives and values encompassed by present boundaries and level of protection.	



Legend:

Seal Colony	
1	Cape Bridgewater • Australian fur seal *Arctocephalus pusillus*, haul out and occasional breeding colony; and • New Zealand fur seal *Arctocephalus forsteri* visitation site.
2	Deen Maar (Lady Julie Percy Island) Australian fur seal *Arctocephalus pusillus*, large breeding colony.
Seabird Colony	
1	Lawrence Rocks • Australasian gannet *Morus serrator*, largest Australian colony; and • Little penguin *Eudyptula minor*, colony.
2	Deen Maar (Lady Julia Percy Island) • Common-diving petrel *Pelecanoides urinatrix*, rookery; • White-bellied sea eagle *Haliaeetus leaucogaster*, breeding habitat; and • Fairy prion *Pachyptila turtur*, breeding habitat.
3	Middle Island (Merri Marine Sanctuary) • Little penguin *Eudyptula minor*, breeding colony; • Black-faced cormorant *Phalacrocorax fuscescens*, rookery; and • Short-tailed shearwater *Puffinus tenuirostris*, rookery.
4	Twelve Apostles Marine National Park • Short-tailed shearwater *Puffinus tenuirostris*, rookery.
5	Twelve Apostles Marine National Park • Little penguin *Eudyptula minor*, large breeding colony.
Rare / Threatened Invertebrates	
1	Ghost shrimp *Athanopsis australis* (Bridgewater Bay).
2	Snapping shrimp *Alpheus australosulcatus* (Dutton Way beach).

Figure 5.4. Otway Bioregion: features of conservation importance.

Conservation Priorities

Outside the existing MPAs, the ECC (2000) investigation identified six other areas worthy of designation as special management zones (Figure 5.3). Our review of the natural values did not reveal evidence for considering additional areas. Recent surveys of the bathymetry around Deen Maar Island identified unique deep reef habitat associated with this island, increasing its ecological importance in terms of uniqueness and as an ecological unit. Our review of general Victorian conservation priorities also identified Bridgewater Bay as an area of concern that is not presently within any MPA.

Recommendations

Recommendations arising from the CAR assessment are listed in Table 5.5. The recommendations of the ECC (2000) to implement special management zones remain valid, however it is recommended that some of these areas be given proper MPA status (*i.e.* an area that cannot be rescinded without an act of Parliament). Based on the conservation values, it is recommended that the protection status of Lawrence Rocks and Deen Maar Island be protected to a level at least equivalent to a Conservation Zone or IUCN Category IV – Habitat/Species Management Area (Table 5.5).

Table 5.5. Otway Bioregion. Recommendations arising from the MPA gap analysis.

Identified Area	Values of Concern	Recommendation
Discovery Bay MNP	• Comprehensiveness – intertidal and subtidal reef. • Linkage to shorebird and wetland habitats.	• Remove 500 m excision between MNP and Cape Duquesne. • Extend westward shore boundary.
Merri MS	• Adequacy - subtidal biota including algal biodiversity.	• Extend southern boundary 200-300 m seaward.
Dutton Bay	• Comprehensiveness - *Amphibolis* seagrass beds • Rare seaweed *Cystophora cymodocea*	• Marine Sanctuary – IUCN Category IV but with no-take.
Deen Maar Island (Lady Julia Percy Is) Offshore deep habitat	• Australian fur seal breeding • Seabird breeding • White shark • Island unit with diversity of seaweed habitats including bull kelp *Durvillaea*. • Offshore deep reef	• Marine Sanctuary or conservation zone – IUCN Category III Natural Monument. Some no-take area.
Bridgewater Bay	• Seal haulout • Sparse seagrass • Listed crustacean	• Conservation zone (with activities commensurate with protection of values of concern). IUCN Category IV Habitat/Species Management Area
Lawrence Rocks	• Bird breeding • Unique flora	• Conservation zone. IUCN Category IV Habitat/Species Management Area
Logans Beach	• Southern right whale calving and nursery area	• Special management zone. IUCN Category IV Habitat/Species Management Area.
Dinosaur Cove	• High reef biodiversity • Unique habitat	• Conservation zone or special management zone. IUCN Category V Protected Landscape, with allowances for scientific extraction.

Bay of Islands or Port Campbell	• Moderately exposed, mixed brown seaweed communities	• Special management zoning. IUCN Category V protected landscape/seascape.
Moonlight Head or Cape Otway	• Intertidal communities	• Special management zoning. IUCN Category IV Habitat/Species Management Area.

5.3.6 MPA Gap Analysis – Central Victoria Bioregion

Comprehensiveness, Adequacy and Representativeness

The Central Victoria Bioregion can be divided into five biounits and contains ten marine protected areas (Figure 5.5; Table 5.6).

The ten MPAs encompass ecosystems of consolidated and unconsolidated substrata within all biounits and are therefore considered representative of the bioregion (Table 5.7).

The MPAs within the Surfcoast, Canyon, Heads and Bunurong biounits generally encompass the range of habitats and communities present within each of those biounits (Table 5.7). This coverage was considered comprehensive, however it was noted that there was no MPA coverage of the moderately exposed Western Port entrance habitats, such as *Amphibolis* seagrass and shallow reef at Flinders or shallow reef at eastern Phillip Island. Such habitats and communities are represented in the Point Nepean section of the Port Phillip Heads MNP.

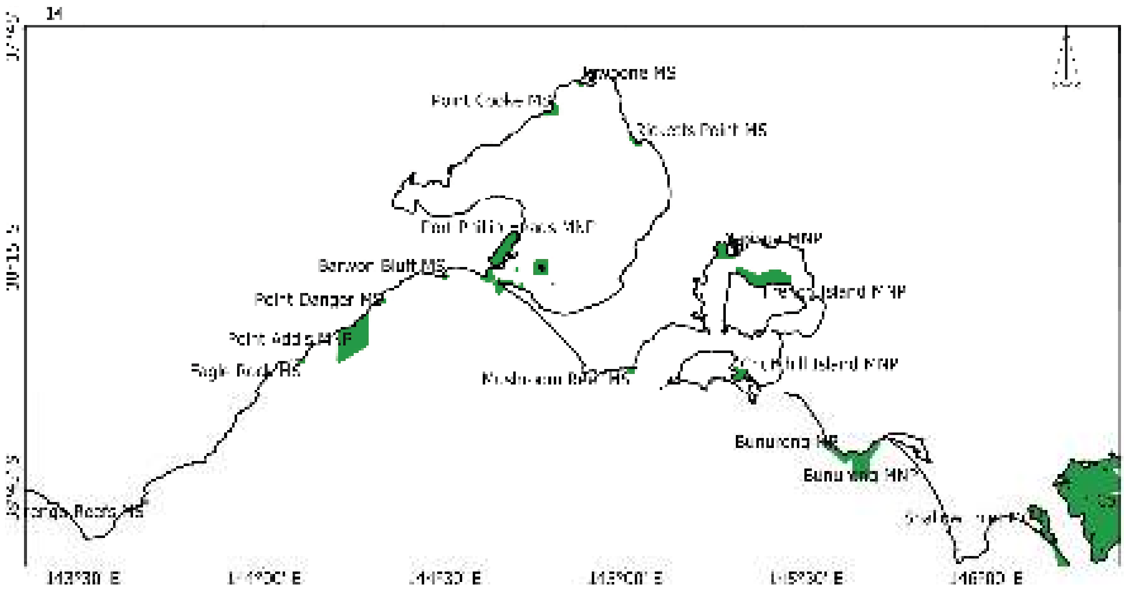


Figure 5.5. Central Victoria Bioregion marine protected areas. Legend: (MCP) Marine and Coastal Park; (MNP) Marine National Park; (MS) Marine Sanctuary.

Table 5.6. Central Victoria Bioregion: provisional biounits, key ecological features and marine protected areas.

Biounit	Features	Marine Protected Area
Surf Coast biounit	Cape Otway to Barwon Heads • High swell exposure • Moderate wind exposure • Bass Strait and Southern Ocean influence	Marengo MS Eagle Rock MS Point Addis MNP Point Danger MS
Mornington biounit	Barwon Heads to Coal Point including southern Phillip Island • Sub-maximal exposure • Bass Strait and bay water influences	Barwon Bluff MS Port Phillip Heads MNP Point Nepean (outside) Point Lonsdale (outside) Mushroom Reef MS
Canyon biounit	Port Phillip Heads Canyon • Canyon 20-100 m depth • Strong tidal currents • Bass Strait and bay water influences	Port Phillip Heads MNP Point Lonsdale Portsea Hole
Heads biounit	Port Phillip Heads and Western Port entrances • Moderate exposure • Strong tidal currents • Bass Strait and bay water influences	Port Phillip Heads MNP Point Nepean (inside) Point Lonsdale (inside) Popes Eye
Bunurong biounit	Coal Point to Sandy Point • High to moderate exposure • Bass Strait influence	Bunurong MNP Bunurong MCP

The MPAs in the Mornington biounit encompass near-shore habitats and communities but do not encompass deeper and offshore communities to any real extent. In particular, there are extensive intermediate depth reefs (15-25 m depth) offshore from Mornington Peninsula ocean beaches and Cape Schanck. These reefs include beds of *Ecklonia* kelp, thallose red algae and carpeting green *Caulerpa* algae, in addition to high abundances of ascidians and high diversity of sessile biota in crevices. Deep reefs are also not encompassed by MPAs in the Mornington biounit, with notable ecosystems present outside Port Phillip Heads, in the area between Cape Schanck and West Head and in the form of pinnacles south of Phillip Island. These habitats and communities are distinctively different to the Canyon biounit and should be represented within an MPA to provide comprehensiveness. Comprehensiveness would also be improved through the inclusion of offshore/deeper sediment habitats in the Mornington biounit (Table 5.7).

The listed values of the Merri MS are predominantly subtidal, however the boundary is such that only intertidal habitat is adequately encompassed (Table 5.8). The adequacy of the MPA would be greatly enhanced by expansion of the natural reef/sand boundaries, particularly to the north and south. Expansion of the seaward boundary to the east would also be required to provide some level of buffering of boundary effects.

The Eagle Rock MS encompasses the listed values, however the subtidal reef habitat within the boundary is patchy with continuous subtidal reef occurring outside the boundary. The adequacy of this area depends greatly on the level of the expectations or objectives for this area. This was also found to be the case for the Barwon Bluff MS. This area encompasses the objective values, namely *Durvillaea* bull kelp habitat, and could therefore be deemed adequate, but the boundaries encompass only a very small area with little buffering of edge effects. Mushroom Reef MS was largely established for its intertidal reef values, but also lists subtidal seaweed and fishes as key values. In this case, it would be more appropriate to remove subtidal features as core values or purposes for protection for this MPA. The subtidal area and nature of the boundaries are unlikely to afford any realistic protection to such values, with such values better protected by enhancing other areas (such as Point Nepean).

The Point Nepean section of the Port Phillip Heads MNP encompasses important *Amphibolis* seagrass and mixed brown algae habitats along the northern shore. The boundary is only 200 m from shore, encompassing approximately half the *Amphibolis* patches. Boundary effects are likely to greatly impinge on the effectiveness of this MPA. *Amphibolis* seagrass is not well encompassed within any highly protected MPA in Victoria. It is present in large areas of the Eastern Conservation Zone of the Bunurong Marine and Coastal Park. Adequacy and comprehensiveness would be greatly improved by extending the northern boundary to encompass the whole *Amphibolis* habitat in Nepean Bay. An alternative would be to extend the Bunurong MNP eastward into *Amphibolis* habitat.

The Point Addis MNP, Point Danger MS, as well as the Swan Bay, Popes Eye, Portsea Hole, Mud Islands and Point Lonsdale components of the Port Phillip Heads MNP were noted for encompassing key habitats of conservation concern in their entirety (Tables 6.6 and 6.7). This included reef habitats being bounded by sand, coverage of entire bays or headlands and coverage of larger areas to limit boundary effects inside the MPA.

The Point Lonsdale and Portsea Hole components of the Port Phillip Heads MNP do not encompass all habitat and community variations present in the Canyon biounit. Nevertheless, they have a relatively high degree of adequacy because they encompass complete patches and systems within the canyon seascape, including Lonsdale Wall, Lonsdale Reach sediments, Middle Reach shelf sediments and Catacombs Ridge.

The Bunurong MNP encompasses a relatively short length of coastline, however it encompasses the range of known of habitat types and high seaweed biodiversity. The nearshore area includes the previously established sanctuary zone and the size structure of some species indicates the sanctuary zone was effective for some species. This was not the case for abalone. The Bunurong Conservation Zones either side of the MNP contain high conservation values, including a listed holothurian species in the west and *Amphibolis* seagrass and cave/crevice biota in the east.

Table 5.7. Central Victoria Bioregion. Comprehensiveness and representativeness of marine protected areas. Legend: (◆) present in MPA; (⬩) minor presence in MPA; (×) not present in MPA but present in biounit; and (☐) not known in biounit. Tan cells represent gaps in representation.

Ecosystem	Habitat/ Community	Surfcoast				Mornington			Canyon	Heads	Bunurong	
		Marengo MS	Eagle Rock MS	Point Addis MNP	Point Danger MS	Barwon Bluff MS	Port Phillip Heads MNP	Mushroom Reef MS	Port Phillip Heads MNP	Port Phillip Heads MNP	Bunurong MNP	Bunurong MCP
Intertidal Sediments	Bare mud											
	Bare sand	×	×	◆	×	⬩	◆	⬩		◆	◆	◆
	Mangroves											
	Ruppia											
	Seagrass - intertidal											
Subtidal Bare Sediments	Beach – surf zone	×	×	◆	×	⬩	◆	×			×	◆
	Channels								◆	◆		
	Inshore sand	⬩	⬩	◆	◆	⬩	◆			◆	◆	◆
	Shelly sand											
	Gravel/pebble	×	×	◆	×				◆		◆	×
	Offshore sediment	×	×	×	◆	×	×	×			◆	×
Subtidal Vegetated Sediments	Seagrass - *Halophila*											
	Seagrass - *Heterozostera*									◆		
	Seagrass - *Amphibolis*	×	×	◆	×					◆	⬩	
	Seagrass - *Posidonia*											
	Caulerpa mats											
	Drift weed mats											
Biogenic	*Pyura* clump											
	Sponge clump								×			
Rocky Reef	Intertidal	◆	⬩	◆	◆	◆	◆	◆		◆	◆	◆
	Subtidal patchy reef	×	◆	◆	×	×	◆	×		⬩	◆	◆
	Subtidal reef	⬩	⬩	◆	⬩	⬩	◆	⬩		◆	◆	◆
	Intermediate reef	×	×	◆	×	×	⬩	×	◆		◆	×
	Deep reef	×	×	◆	×	×	×	×	◆		⬩	

Table 5.8. Central Victoria Bioregion. Adequacy of marine protected areas.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
Marengo Reefs MS	**ECC** • Subtidal reef habitat covered with bull kelp, other seaweeds and an abundance of soft corals, sponges and other marine invertebrates. **PV Management Plan** • Haul out for Australian fur seals. • Subtidal reef is dominated by canopies of bubble weed and other brown species which provide habitat for understorey algae (*e.g.* red and coralline algae) and invertebrates (*e.g.* abalone, rock lobster and sea urchins).	• Good coverage of intertidal habitat only. **Issues:** Stated objectives and values not met by present boundaries and level of protection. • Subtidal area a narrow fringe of only metres in extent. • Boundary effects mean no adequate protection. • Natural island boundaries not used to encompass ecological unit.	• Expand boundaries by at least 200 m to northeast, east and southwest to provide adequate buffer. Encompass sand edge to north and south to provide natural boundary.
Eagle Rock MS	**ECC** • High diversity of invertebrates on intertidal rock platforms. • Subtidal kelp forests, sponges and invertebrate assemblages, including seastars, crabs and sea anemones are found throughout this area. **PV Management Plan** • Represents the westernmost distribution limit of the crab *Amarinus paralacustris* and the snail *Belloliva leucozona.* • Common fish inhabiting the park include leatherjackets, toadfish and stingrays.	• Encompasses islands, and bird roosts – unique coastal structures. • Includes intertidal habitats and patchy subtidal habitat. • Patchy reef habitat may reduce boundary effects. **Issues:** Some stated objectives and values not met by present boundaries and level of protection. • Subtidal area patchy reef habitat – continuous reef habitat outside boundary.	• Revise objectives (reduce expectations). Or • Extend boundary eastward by 300-400 m to encompass continuous reef habitat.
Point Addis MNP	**ECC** • A mixture of low profile reef and soft sediments provide habitat for a variety of algae and invertebrates. • Ingoldsby reef with a diverse range of marine life including the leafy sea-dragon.	• Comprehensive coverage of shore to deep reef and sediment habitats. • Includes unique deep communities • Large area of coverage reduces boundary effects and	

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	• *Amphibolis* seagrass. **PV Management Plan** • Moderate intertidal invertebrate species richness echinoderms, molluscs, polychaetes. • Subtidal overhangs at Ingoldsby Reef dominated by ascidians, gorgonians, hydroids and sponges. • Lower reefs contain colonial ascidians, bryozoans, rock lobsters and abalone. • Vast sponge gardens are associated with moderately deep reefs. • Urchins, seapens and sponge-hydroid are scattered in some of the park's deepest waters	includes entire habitats. **Issues:** Stated objectives and values encompassed by present boundaries and level of protection, however: • Ingoldsby Reef not well buffered by western boundary.	
Point Danger MS	**ECC** • High invertebrate diversity of limestone intertidal reefs. • Around 20% of opisthobranchs recorded from this site have yet to be scientifically described. **PV Management Plan** • High diversity of sea slugs. • Westernmost distribution limits of the crab *Hexapus granuliferus* and snail *Tuberculiopsis septaplia* are thought to be in the vicinity of the park. • Common fish include blue-throated wrasse, leatherjackets, toadfish and stingrays.	• Complete intertidal coverage with subtidal and natural sand barrier buffer. **Issues:** Most stated objectives and values met by present boundaries and level of protection, however: • Fishes would not be well protected in this MPA	
Barwon Bluff MS	**ECC** • Sandstone and basalt reefs covered with thick assemblages of giant and bull kelp. **PV Management Plan** • Intertidal flora is dominated by Neptune's necklace that carpets some areas. • Intertidal invertebrates include many gastropods, tubeworms and	• Complete intertidal reef habitat unit. • Near complete bull kelp *Durvillaea* habitat unit. • Habitat for bull kelp *Durvillaea*. Bull kelp appears to be susceptible to environmental changes with extensive declines in	• Review boundary with respect to objectives and cost-benefits of extending it.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	crustaceans that inhabit basalt and sandstone habitats. • Moderately sheltered subtidal reef supports giant kelp forests and thick stands of bull kelp. • Subtidal fauna include, prominently black-lip abalone, sponges and sea-tulips.	NSW. • Habitat for string kelp *Macrocystis*. String kelp severely declined in abundance in lastdecade. **Issues:** Stated objectives and values weakly met by present boundaries and level of protection, however: • present boundary is at *Durvillaea* patch boundary and therefore no buffering of boundary effects	
Port Phillip Heads MNP **Point Lonsdale**	**PV Management Plan** • Intertidal reef platforms that contain the highest diversity of any calcarenite reef in Victoria. • Diverse and abundant algal assemblages on Lighthouse Reef. • Deep undercuts in Lonsdale Reef with algae communities more typical of deeper waters. • Diverse fish and invertebrate fauna, with extensive encrusting communities such as ascidians, bryozoans and sponges on Lonsdale Wall. • Calcarenite shore and reef platforms that are regionally significant shorebird foraging habitats.	• Complete intertidal coverage with substantial subtidal buffer. • Complete coverage of some deep reef systems – Lonsdale Wall and Catacombs Ridge. **Issues:** None: stated objectives and values met by present boundaries and level of protection.	
Port Phillip Heads MNP **Swan Bay**	**ECC** • Sites listed under the Ramsar Convention for their importance for migratory wading birds. • Sheltered seagrass meadows. **PV Management Plan** • Internationally significant shorebird habitat for	• Complete coverage of intertidal and subtidal habitats in Swan Bay. **Issues:** None: stated objectives and values met by present boundaries and level of	

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	resident and migratory species. • Key wintering site for the Orange-bellied parrot. • Extensive seagrass beds providing nursery fish habitat, with two rare species of seagrass. • Regionally significant, intertidal mudflats and extensive saltmarsh that support a diverse community of birds, fish and other fauna.	protection.	
Port Phillip Heads MNP **Popes Eye**	**PV Management Plan** • Natural sand shoal with man made structure on top that supports a rich benthic invertebrate community, including, encrusting algae, sponges and soft corals. • Australasian gannet nesting and roosting colony. • Diverse and abundant fish assemblages.	• Complete coverage of intertidal and subtidal reef habitats of Popes Eye Annulus. **Issues:** None: stated objectives and values met by present boundaries and level of protection.	
Port Phillip Heads MNP **Mud Islands**	**ECC** • Sites listed under the Ramsar Convention for their importance for migratory wading birds. • Distinctive bird dominated nutrient rich island ecosystem. **PV Management Plan** • Dense seagrass beds provide habitat for invertebrate assemblages and nursery areas for juvenile fish. • Internationally significant shorebird habitat for resident and migratory species. • Isolated salt marsh communities largely protected from pest species and human interference.	• Complete coverage of intertidal and surrounding subtidal sediment and seagrass habitats of Mud Islands. **Issues:** None: stated objectives and values met by present boundaries and level of protection.	
Port Phillip Heads MNP **Portsea Hole**	**PV Management Plan** • Remnant section of the Yarra River forming limestone structure descending to a sandy	• Complete coverage of intermediate reef habitat and deep sandy hole of Portsea	

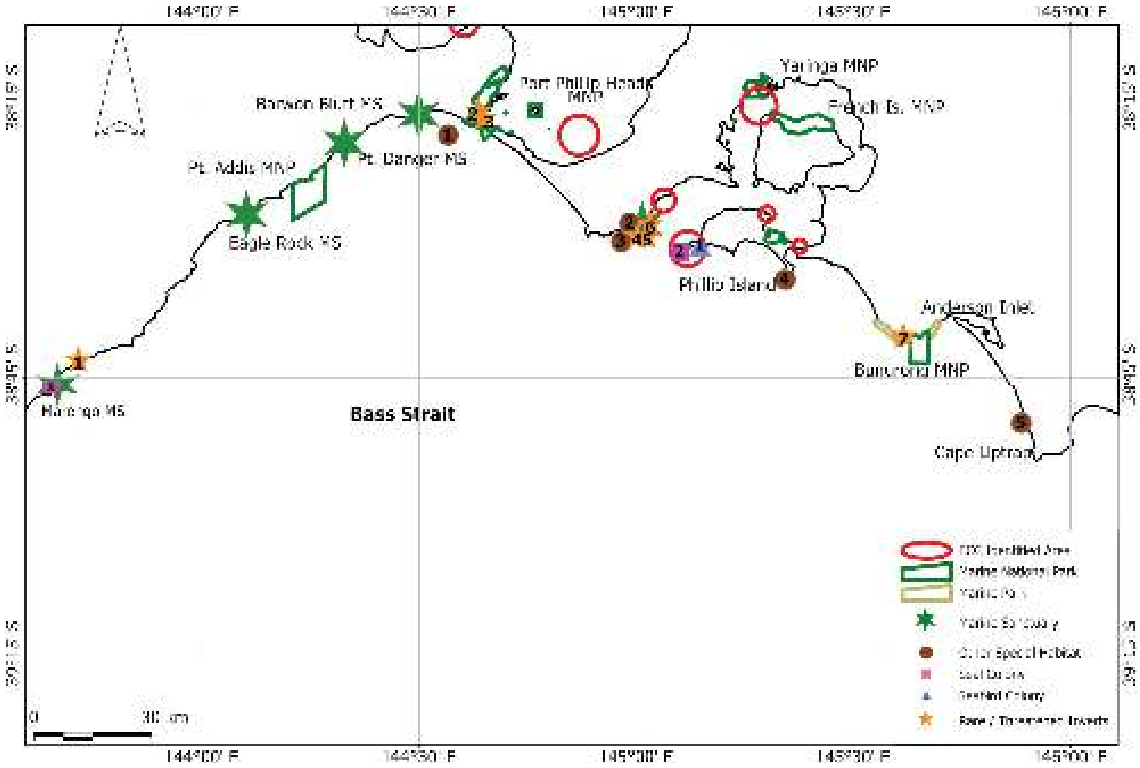
MPA	Documented Objectives and Values	Adequacy Assessment	Options
	base supports diverse marine flora and fauna communities. • Abundant and diverse fish assemblages and a rich benthic community of encrusting algae, sedentary organisms, sponges and soft corals.	Hole. **Issues:** None: stated objectives and values met by present boundaries and level of protection.	
Port Phillip Heads MNP **Point Nepean**	**ECC** • Intertidal rock platforms at Cheviot. • bottlenose dolphin populations. **PV Management Plan** • Intertidal reef platforms that contain a high invertebrate diversity similar to Point Lonsdale. • Shorebird foraging habitat along the sandy beaches and rock platforms.	• Complete coverage of intertidal reef systems. • Coverage of shallow and intermediate reefs and sandy beds on exposed coast. • Partial coverage of moderately exposed reef and *Amphibolis* habitats inside Heads – no other MNP or MS adequately encompasses *Amphibolis* habitat. **Issues:** Stated objectives and values generally met by present boundaries and level of protection, however: • *Amphibolis* seagrass an important value and protection of this habitat is poor because boundary halfway through habitat and only 200 m from shore.	• Extend boundary another 200-300 m offshore to fully encompass *Amphibolis* habitat; Or • Implement an MPA elsewhere (*e.g.* Flinders) that fully encompasses *Amphibolis* patches. • Extend Point Nepean boundaries to better encompass dolphin habitat/refuge areas.
Mushroom Reef MS	**ECC** • Intertidal basalt substratum provides habitat complexity containing subtidal pools and boulders which support highly diverse reef communities. **PV Management Plan** • Subtidal basalt reef forming gutters, ledges and boulders are dominated by canopies of	• Complete intertidal coverage with only minor subtidal buffer. **Issues:** Most stated objectives and values met by present boundaries and level of protection, however: • Fishes and most other subtidal biota not	• Remove any objectives pertaining to subtidal biota.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	Phyllospora comosa and *Ecklonia radiata*. Subtidal fauna includes rock lobster, ascidians, gorgonian fans, sponges and corals. • Sandy bottoms in sheltered intertidal pools support beds of *Amphibolis* seagrass. • Reef fish such as moonlighter's magpie perch and wrasses and cartilaginous fish such as Port Jackson and cat sharks are common in the sanctuary.	well protected in this MPA.	
Bunurong MNP	**ECC** • Extensive intertidal rock platforms that provide microhabitats for a high diversity of intertidal and shallow subtidal invertebrate fauna (e.g. brittle stars, sea-cucumbers, chitons). • Subtidal marine flora and fauna, including flora characterised by mixed assemblages of brown algae (*e.g. Acrocarpia paniculata*, *Seirococcus axillaris* and *Cystophora retorta*). • Seagrass beds of *Amphibolis antarctica*. • Eagles Nest provides habitat for breeding peregrine falcons and hooded plovers. **PV Management Plan** • Diverse marine flora and fauna – a total of 201 algal species, 87 fish species and 258 invertebrate have been identified within the park. • At least 21 species of algae, invertebrates and fish are thought to have there distributional limits in or near the park. • A population of the rare holothurian, Pentocnus bursatus. • Sandy beach environments	• Representative intertidal platforms but the extensive rock platforms are in adjacent conservation zones. • Rare seaweeds and high diversity seaweed assemblages. • Biogeographical limit for many species, including western blue groper and seaweeds. • Climax (old) population structures of some species within former Sanctuary Zone and now MNP. **Issues:** Most stated objectives and values met by present boundaries and level of protection, however: • Objectives of zoned areas unclear. • Listed holothurian *Pentocnus bursatus* in WCZ, not in MNP. • Deep reef habitat patchy and no appreciable deep reef sponge community – no contribution to	• Revise and differentiate management objectives of the no-take MNP from the adjacent conservation zones.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	provide important habitat for invertebrates such as amphipods, isopods, molluscs, polychaetes and crustaceans, and are also feeding grounds for many fish and seabird species. • Beach washed materials (i.e. wrack) provide a food source for scavenging marine birds and contribute to the detrital cycle on sandy beaches. • Intertidal reef platforms and rocky shores provide habitat for a diverse range of marine flora and fauna, such as Neptune's necklace and sea lettuce dominated communities in the mid intertidal and branching brown and red algae in the lower intertidal. • Intertidal reef platforms provide feeding and roosting habitat for a wide range of shorebirds. • Subtidal reefs provide habitat for fish, sessile invertebrates and sponges. • Subtidal soft sediments are dominated by a number of brown algae species and a variety of fish and invertebrates. • Patches of seagrass *Amphibolis antarctica* and *Heterozostera tasmanica* are found in sheltered coves within the park.	comprehensiveness and representativeness	
Bunurong MP (East and West Conservation Zones)	**PV Management Plans** • Objective – to protect species and communities of special biological interest and significant species. • Objective – protect hooded plovers and their habitat, particularly during breeding season. • Objective – review southern rock lobster, abalone and other fishing activities, if appropriate revise recreational and	• Extensive intertidal platforms. • Rare seaweeds and high diversity seaweed assemblages. • Extensive *Amphibolis* beds. • Listed holothurian *Pentocnus bursatus* in Western Conservation Zone. • Biogeographical limit for many species,	• Review and rationalise permitted activities with respect to Conservation Zone objectives.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	commercial restrictions. • Broad intertidal rock platforms and extensive subtidal reefs provide habitat for a range of marine flora and fauna.	including western blue groper and seaweeds. • Small areas of ledges, gutters and caverns with considerable sessile invertebrate community diversity. **Issues:** Most stated objectives and values met by present boundaries and level of protection, however: • activities, including harvesting, within the conservation zones should be periodically reviewed to ensure objectives are being met.	

As with all the Victorian Marine and Coastal Parks, there is little formal documentation pertaining to their objectives, purposes and levels of protection. Their management is not integrated with the management plans of adjacent Marine Sanctuaries and Marine National Parks and the formation of these newer areas appears to have supplanted some information regarding the conservation zones (particularly for Bunurong and Wilsons Promontory). Permitted activities are communicated in Parks Victoria Visitor Guides, but not in the Recreational Fishing Guide (2009-2010). It is difficult to assess the adequacy of the conservation zones in terms of protection levels and the values to be protected.



Legend:

Seal Colony	
1	Marengo Reef • Australian fur seal *Arctocephalus pusillus*, haul out colony and occasional breeding colony.
2	Seal Rocks (Phillip Island) • Australian fur seal *Arctocephalus pusillus*, breeding colony.
Seabird Colony	
1	Summerland Peninsula (Phillip Island) • Little penguin *Eudyptula minor*, breeding colony; • Kelp gull *Larus dominicanus,* only Victorian breeding site; and • Sooty oyster catcher *Haematopus fuliginosus,* breeding site.
Rare / Threatened Invertebrates	
1	Sea-cucumber *Apsolidium densum* (Skenes Creek).
2	Chiton *Bassethulia glypta* (Port Phillip Heads).
3	Listed Canyon Community (Port Phillip Heads)
4	Snapping shrimp *Alpheus australosulcatus* (North Head, Western Port).
5	Chiton *Bassethulia glypta* (North Head, Western Port).
6	Sea-cucumber *Apsolidium densum* (North Head, Western Port).
7	Sea-cucumber *Pentocnus bursatus* (Cape Paterson).
Other Special Habitat	
1	Graveyard deep reef
2	Flinders Pier
3	Cape Shank deep reef
4	The Pinnacle
5	Arch Rock

Figure 5.6. Central Victoria Bioregion: features of conservation importance.

Conservation Priorities

Outside the existing MPAs, the ECC (2000) investigation identified two other areas worthy of designation as special management zones: Honey Suckle Reef and Summerlands Peninsula, including Seal Rocks (Figure 5.5). Our review of the natural values supports these recommendations. There are other areas of high conservation value that should be considered further (Figure 5.5). These include deep reefs, with anecdotal evidence suggesting reefs in the region of Ships Graveyard at Point Lonsdale, Cape Schanck and the Pinnacles at Phillip Island have high biodiversity and unique values (but remain to be surveyed properly). The areas around Flinders was identified as important, including the *Amphibolis* seagrass beds, the sea dragon colonies (particularly around Finders Pier) and listed threatened species in the intertidal reef habitats.

Our review of general Victorian conservation priorities identified:

- Port Phillip Heads coastal, seagrass, subtidal reef, deep reef and canyon habitats;
- Flinders intertidal reef, subtidal reef and subtidal seagrass;
- Phillip Island deep reef/pinnacle habitat; and
- Bunurong seagrass and subtidal reef.

Recommendations

There were considerable issues identified with respect to the adequacy of existing marine protected areas and recommendations are listed in Table 5.9. The recommendations of the ECC (2000) to implement special management zones remain valid, however it is recommended that the Summerlands Peninsula be given proper MPA status (*i.e.* an area that cannot be rescinded without an act of Parliament). Based on the conservation values, it is recommended that the protection status of the sea dragon, *Amphibolis* seagrass beds and listed marine invertebrates in the Flinders region be protected within an area with a status equivalent to a Conservation Zone. Other notable gaps are deep reef habitats outside the Port Phillip Heads canyon (Table 5.9). Although knowledge is limited, the Phillip Island pinnacles are presently the greatest conservation priority with respect to deep reef habitat.

Table 5.9. Central Victoria Bioregion. Recommendations arising from the MPA gap analysis.

Identified Area	Values of Concern	Recommendation
Marengo MS	• Adequacy – subtidal reef.	• Expand boundaries to natural reef-sand boundaries.
Eagle Rock MS	• Adequacy – patchy subtidal habitat.	• Review objectives and potentially extend northeastern boundary to encompass continuous reef.
Barwon Heads MS	• Adequacy – bull kelp *Durvillaea* habitat	• Review objectives and potentially expand area to provide buffer for habitat protection.
Port Phillip Heads MNP Point Nepean	• Adequacy – Amphibolis seagrass. • Adequacy – dolphin refuge	• Extend northern Nepean Bay boundary to encompass seagrass habitat extent. • Potentially add conservation zone into Tricondera Bay as dolphin refuge.
Phillip Island Summerland Peninsula Seal Rocks	• Seal breeding colony • White shark area • Penguin colony • Muttonbird rookery • Macrocystis kelp habitat • High productivity	• Conservation Zone. IUCN Category IV Habitat/Species Management Area.
Mushroom Reef MS	• Objectives – subtidal reef	• Remove subtidal reef biota from objectives/expectations of protection.
Flinders/Honeysuckle/Merricks	• Listed species • *Amphibolis* seagrass • Sea dragon colonies	• Conservation zone or special management zoning. IUCN Category IV Habitat/Species Management Area.
Bunurong MCP Conservation Zones	• Listed species. • *Amphibolis* seagrass habitat • Crevice fauna	• Review and formalise objectives and permitted activities.
Cape Schanck or Phillip Island Pinnacles	• Comprehensiveness – deep reef and offshore sediment habitat • Sessile invertebrate diversity	• Conservation zone or special management zoning. IUCN Category IV Habitat/Species Management Area.

5.3.7 MPA Gap Analysis – Flinders Bioregion

Comprehensiveness, Adequacy and Representativeness

The Victorian component of the Flinders Bioregion can be divided into three biounits and contains four marine protected area zones (Figure 5.7; Table 5.10).

The MPAs encompass ecosystems of consolidated and unconsolidated substrata within inshore biounits but not the offshore biounit. This technically means the Victorian MPAs are not representative (Table 5.11). The offshore biounit is more prevalent in the Tasmanian sector of the Flinders Bioregion and improvements to representativeness and comprehensiveness for this biounit may be better met by Tasmanian contributions to the NRSMPA. Some Flinders Bioregion Offshore biounit habitat is contained within the Beagle Commonwealth Marine Reserve, which is a general purpose area with limits on demersal trawling, Danish seining and scallop dredging.

The four MPA zones comprehensively encompass all habitat types within the Wilsons Promontory biounits. Most community types are encompassed by the highly protected Marine National Park, with the exception of *Amphibolis* seagrass and mixed brown algal communities in moderately exposed areas (Table 5.11). The Marine National Park adequately encompasses the stated values and objectives for protection, including island units, much of the deep reef sessile invertebrate communities (excepting the Glennie Group and Brown Head) and large areas of shelf sediments.

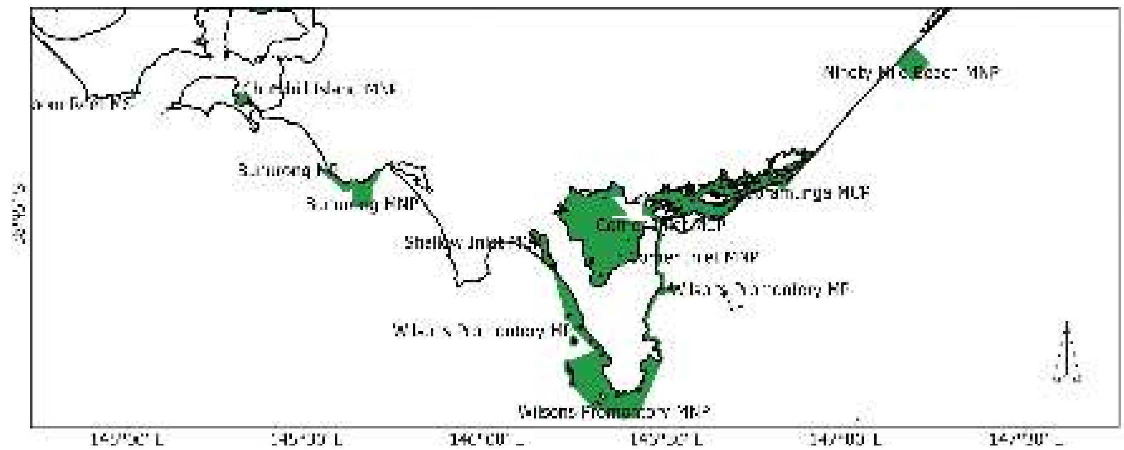


Figure 5.7. Flinders Bioregion marine protected areas. Legend: (MCP) Marine and Coastal Park; (MNP) Marine National Park; and (MS) Marine Sanctuary.

Table 5.10. Flinders Bioregion: provisional biounits, key ecological features and marine protected areas.

Biounit	Features	Marine Protected Area
Wilson Exposed biounit	Sandy Point to Cape Wellington • Isolated islands • High swell exposure • Maximal wind exposure • Bass Strait influences	Wilsons Promontory Marine Park Wilsons Promontory Marine Protection Zone (Tidal River) Wilsons Promontory Marine Reserve Wilsons Promontory MNP
Wilson Moderate biounit	Cape Wellington to McLoughlins Entrance • Moderate exposure • Bass Strait, Tasman Sea and Corner Inlet water influences	Wilsons Promontory Marine Reserve Wilsons Promontory Marine Protection Zone (Refuge Cove) Wilsons Promontory Marine Park
Flinders Offshore biounit	Seal Islands, Forty Foot Rocks • Isolated islands • High exposure • Deep sediment shelf • Bass Strait, Tasman Sea and Corner Inlet water influences	

Table 5.11. Flinders Bioregion. Comprehensiveness and representativeness of marine protected areas. Legend: (◆) present in MPA; (⬥) minor presence in MPA; (×) not present in MPA but present in biounit; and (☐) not known in biounit. Tan cells represent gaps in representation.

Ecosystem	Habitat/ Community	Wilson Exposed		Wilson Moderate	Flinders Offshore
		Wilsons Prom MR	Wilsons Prom MNP	Wilsons Prom MR	
Intertidal Sediments	Bare mud				
	Bare sand	◆	◆	◆	
	Mangroves				
	Ruppia				
	Seagrass - intertidal				
Subtidal Bare Sediments	Beach – surf zone	◆	◆	◆	
	Channels				
	Inshore sand	◆	◆	◆	
	Shelly sand	×	◆	◆	
	Gravel/pebble	×	×		
	Offshore sediment	×	◆		×
Subtidal Vegetated Sediments	Seagrass - *Halophila*				
	Seagrass - *Heterozostera*	×	◆	⬥	
	Seagrass - *Amphibolis*	◆	×		
	Seagrass - *Posidonia*		⬥		
	Caulerpa mats				
	Drift weed mats				
Biogenic	*Pyura* clump				
	Sponge clump				
Rocky Reef	Intertidal	◆	◆	◆	
	Subtidal patchy reef	◆	◆		
	Subtidal reef	◆	◆	◆	×
	Intermediate reef	×	◆	◆	×
	Deep reef	×	◆	◆	×

Table 5.12. Flinders Bioregion. Adequacy of marine protected areas.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
Wilsons Promontory MNP	**ECC** • Significant beds of seagrass species such as *Amphibolis antartica, Heterozostera tasmanica* and *Halophila ovalis* in sheltered bays. • Deep reefs with high diversity of epifauna especially sponges, stalked ascidians and sea whips. • Abundant reef fish such as butterfly and magpie perches, leatherjackets and morid cods. • Represents the distribution limit for a number of species (e.g. *Amphibolis antartica, Austrocochlea odontis* and *Cystophora spp*). • A number of islands are breeding habitat for Australian fur seals and many oceanic birds including the little penguin, short-tailed shearwater, fairy prion and Pacific gull. **PV Management Plans** • Intertidal rocky shore dominated by steep granite boulders, provides habitat for lichens, various brown algae, chitons and colonial ascidians. • High abundances of subtidal algae, especially within Refuge Cove. • Seagrass patches within sheltered coves including species such as *Amphibolis antarctica* and *Posidonia sp.* • Sixty-eight marine flora and fauna species are thought to have their distributional limits in and around the park. • Feeding and roosting areas for a number of threatened seabirds, including the	• Large protected area minimising boundary effects. • Coverage of some seagrass patches – excludes extensive Amphibolis to northwest. • Complete coverage of deep reef habitats (bounded by sand). • Includes island units of Cleft, Kanowna, Anser and Wattle Is. • Includes large sediment shelf areas. **Issues:** Most stated objectives and values met by present boundaries and level of protection, however: • inclusion of *Posidonia* and *Amphibolis* seagrass on eastern side of MNP is weak but encompassed in Marine Park.	

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	hooded plover, white-bellied sea-eagle and Caspian tern. • Australian fur seal breeding colonies are present in the park.		
Wilsons Promontory Marine Reserve	• Not explicitly stated	• Southern Norman Bay • Cape Wellington to Refuge Cove • Glennie Group • Protection level formerly: no recreational fishing. **Issues:** Level of protection unclear.	• Clarification of objectives and level of protection
Wilsons Promontory Protection Zones	• Not explicitly stated	• Tidal River • Refuge Cove to Sealers Cove. • Protection level formerly: only line fishing by recreational fishers. **Issues:** Level of protection unclear.	• Clarification of objectives and level of protection
Wilsons Promontory Marine Park	• Not explicitly stated	• Shallow Inlet to Pillar Point and Norman Island. • Sealers Cover to Entrance Point • Protection level formerly: recreational abalone and spearfishing not allowed on scuba, rock lobster limit of one per day. **Issues:** Present level of protection unclear (*e.g.* not stated in the Rec Fishing Guide).	• Clarification of objectives and level of protection

As mentioned previously, the Victorian Marine and Coastal Parks have little formal documentation pertaining to their objectives, purposes and levels of protection. The Wilsons Promontory Marine National Park overlayed the previous Marine Reserve zone, but not in its entirety. The present management plan refers to the remainder area as a marine park, however the previous Marine Reserve and Marine Park areas remain declared under the National Parks Act and the Marine Protection Zones are still applicable according to the Fisheries Act. The objectives, zoning and permitted activities in areas outside the MNP require formal clarification in the public domain to ensure adequacy (Table 5.12). This should also lead to a review of objectives and permitted activities to meet those objectives in the conservation zones adjacent to the MNP.

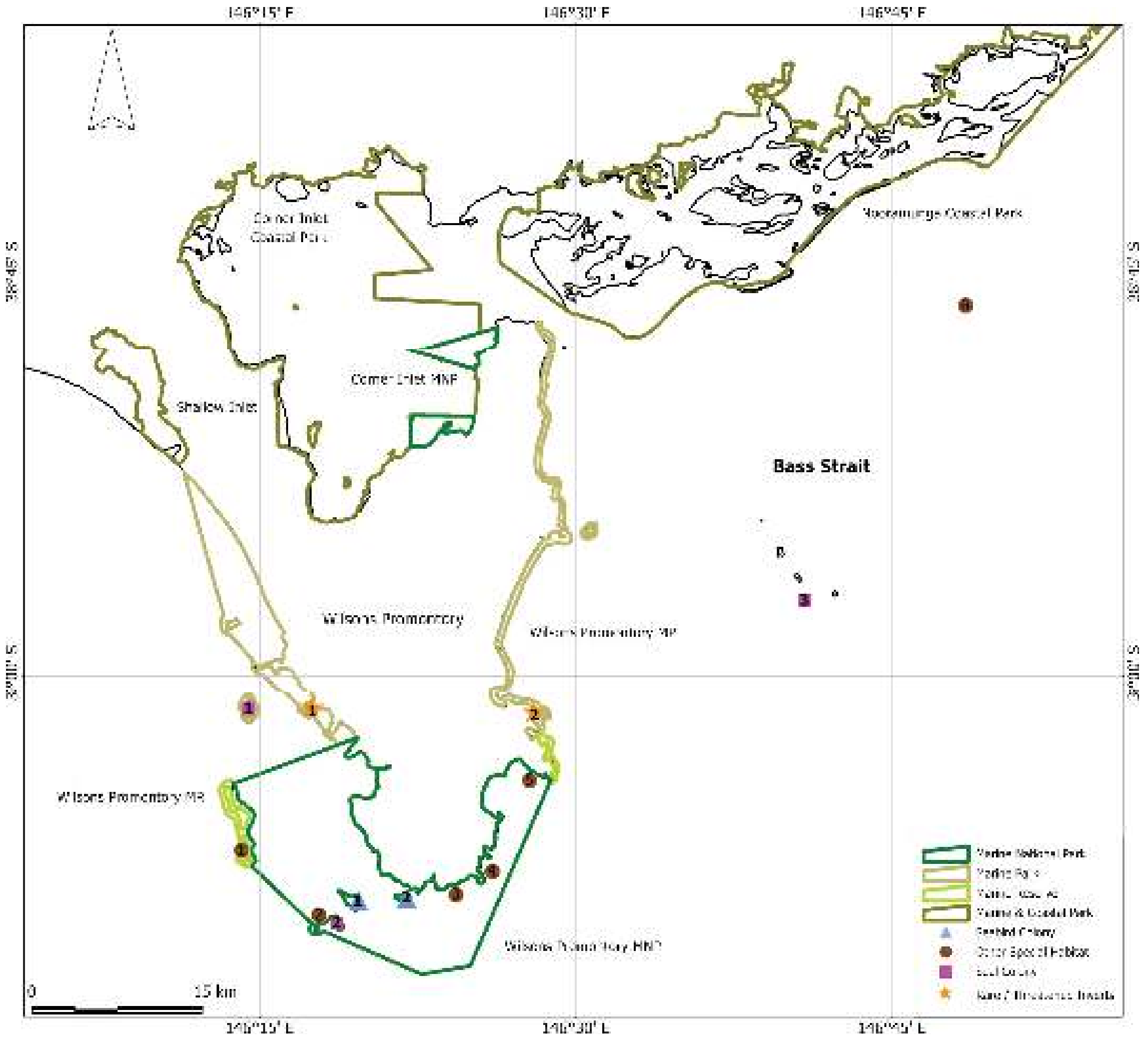


Figure 5.8. Flinders Bioregion: features of conservation importance. See next page for legend.

Figure 5.8 Legend:

Seal Colony	
1	Norman Island • Australian fur seal *Arctocephalus pusillus*, haul out colony.
2	Kanowna Island • Australian fur seal *Arctocephalus pusillus*, breeding colony; and • New Zealand fur seal *Arctocephalus forsteri,* small breeding colony.
3	Rag Island (Cliffy Group) • Australian fur seal *Arctocephalus pusillus*, breeding colony.
Seabird Colony	
1	Anser Island • Little penguin *Eudyptula minor*, short-tailed shearwater *Puffinus tenuirostris* and Pacific gull *Larus pacificus*, breeding habitat.
2	Wattle Island (Anser Group) • Little penguin *Eudyptula minor*, short-tailed shearwater *Puffinus tenuirostris* and Pacific gull *Larus pacificus*, breeding habitat.
Rare / Threatened Invertebrates	
1	Snapping shrimp *Alpheus australosulcatus* (Leonard Bay, Wilsons Promontory).
2	Snapping shrimp *Alpheus australosulcatus* (Horn Point, Wilsons Promontory).
Other Special Habitat	
1	Citadel reef.
2	Reef NW of Anderson Islets.
3	Fenwick Bight deep reef habitat.
4	South East Point deep reef.
5	North Waterloo Bay deep reef.
6	Primary residency region for juvenile white shark *Carcharodon carcharias.*

Conservation Priorities

Much of the identified conservation values in the Flinders Bioregion are encapsulated within either conservation zones or marine national park (Figure 5.7). Island habitats of relatively high value outside the marine national park include Norman Island, the Glennie Group and the Cliffy Group. Islands of high conservation are represented within the marine national park, being Kanowna Island, Cleft Rock and Answer Island (Figure 5.7). The area between eastern Wilsons Promontory, Corner Inlet and the Cliffy Group was recently identified as a primary residency area for juvenile white shark.

Our review of general, statewide conservation priorities did not identify areas within the Flinders Bioregion of having highest priority.

Recommendations

There were few issues identified with respect to the adequacy of existing marine protected areas, although it is recommended that the management objectives and permitted activities are clarified (Table 5.13).

Table 5.13. Flinders Bioregion. Recommendations arising from the MPA gap analysis.

Identified Area	Values of Concern	Recommendation
Wilsons Promontory MP, MR and MPZ	• Adequacy – protection status.	• Clarify status, objectives, values and permitted activities
Flinders Offshore	• CAR values for NRSMPA.	• Review need in conjunction with Tasmanian strategy.

5.3.8 MPA Gap Analysis – Twofold Shelf Bioregion

Comprehensiveness, Adequacy and Representativeness

The Twofold Shelf Bioregion can be divided into four biounits and contains four marine protected areas (Figure 5.9; Table 5.14).

The Beware Reef, Point Hicks and Cape Howe MPAs encompass ecosystems of consolidated and unconsolidated substrata within the Croajingolong and Mallacoota biounits (Table 5.15).

The Ninety Mile Beach MPA encompasses sandy habitat, but has not been surveyed. It is unknown whether this MPA also encompasses reef habitats, an important habitat in the region and a stated purpose of the MPA. Preliminary mapping in 2000 indicates the MPA is outside the predominant intermediate depth reef areas. If this is the case, the MPA would not be comprehensive for that biounit and the MPAs would not be representative for the bioregion.

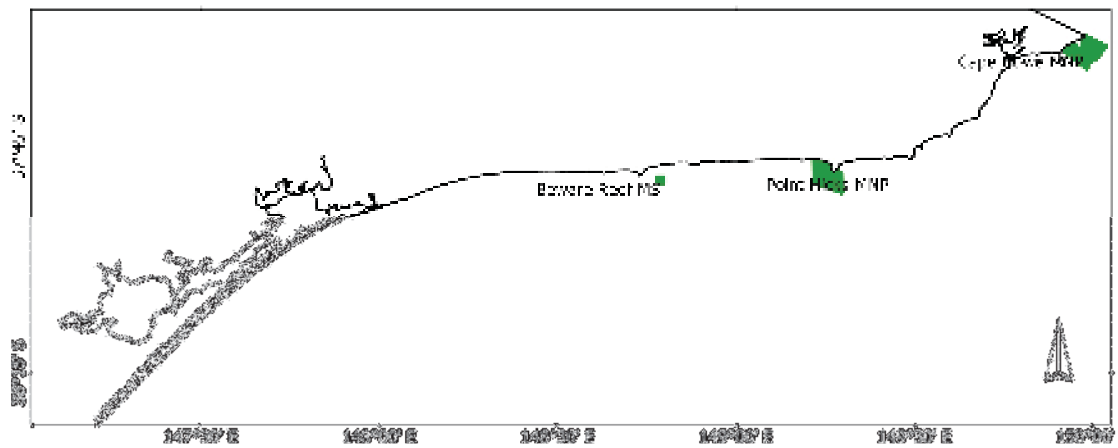


Figure 5.9. Twofold Shelf Bioregion marine protected areas. Legend: (MCP) Marine and Coastal Park; (MNP) Marine National Park; and (MS) Marine Sanctuary.

Table 5.14. Twofold Shelf Bioregion: provisional biounits, key ecological features and marine protected areas.

Biounit	Features	Marine Protected Area
Ninety Mile biounit	McLoughlins Entrance to Marlo • Isolated islands • High swell exposure • High wind exposure • Bass Strait throughflow, Tasman Sea	Ninety Mile Beach MNP
Croajingolong biounit	Marlo to Big Rame Head • High swell exposure • Maximal wind exposure • Deep sediment shelf • Canyon upwelling • Bass Strait throughflow, Tasman Sea, East Australia Current	Beware Reef MS Point Hicks MNP
Mallacoota biounit	Big Rame Head to Cape Howe • High swell exposure • Maximal wind exposure • Deep sediment shelf • Bass Strait throughflow, Tasman Sea, East Australia Current	Cape Howe MNP
Hogan biounit	Hogan Group • Isolated islands • High swell exposure • Maximal wind exposure • Deep sediment shelf • Bass Strait throughflow, Tasman Sea, East Australia Current	

Table 5.15. Twofold Shelf Bioregion. Comprehensiveness and representativeness of marine protected areas. Legend: (◆) present in MPA; (⬩) minor presence in MPA; (×) not present in MPA but present in biounit; and (☐) not known in biounit. Tan cells represent gaps in representation.

Ecosystem	Habitat/ Community	Ninety Mile	Croajingolong		Mallacoota	Hogan
		Ninety Mile MNP	Beware Reef MS	Point Hicks MNP	Cape Howe MNP	
Intertidal Sediments	Bare mud					
	Bare sand	◆	×	◆	×	
	Mangroves					
	Ruppia					
	Seagrass - intertidal					
Subtidal Bare Sediments	Beach – surf zone	◆	×	◆	◆	
	Channels					
	Inshore sand	◆	×	◆	◆	
	Shelly sand					
	Gravel/pebble					
	Offshore sediment	◆	×	◆	◆	×
Subtidal Vegetated Sediments	Seagrass - *Halophila*					
	Seagrass - *Heterozostera*					
	Seagrass - *Amphibolis*					
	Seagrass - *Posidonia*					
	Caulerpa mats					
	Drift weed mats					
Biogenic	*Pyura* clump					
	Sponge clump					
Rocky Reef	Intertidal		⬩	◆	⬩	
	Subtidal patchy reef		×	◆	⬩	
	Subtidal reef		◆	◆	◆	
	Intermediate reef	??	◆	◆	◆	??
	Deep reef		◆	◆	◆	??

Table 5.16. Twofold Shelf Bioregion. Adequacy of marine protected areas.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
Ninety Mile Beach MNP	**ECC** • Subtidal soft sediment habitat consisting of a mixture of fine and medium sand supports invertebrate assemblages such as clumps of ascidians (mainly *Pyura australis*). • *Coscinasterias muricata* a large endemic southern seastar that inhabits soft sediments occurs here in large numbers. • An unusual soft coral *Pseudogorgia godeffroyi* only found in this region in Victoria inhabits soft sediments in park. • Low profile reefs are dominated by invertebrates and have sparse floral communities. Invertebrates include sponges, ascidians, smaller bryozoans and hydroids. **PV Management Plan** • Objective – maintain high diversity of invertebrates found in and on the subtidal sand banks. • Sandy beach habitat within the park is potentially important foraging and breeding habitat for the endangered hooded plover. • Used by threatened shorebirds such as the pied-oyster catcher, crested tern, Caspian tern and sanderling. • The subtidal sand community along ninety mile beach has been found to be the most species-rich of its type in the world. • Subtidal sand invertebrate fauna is dominated by small animals such as crustaceans, polychaetes, molluscs and echinoderms.	• Biodiversity and habitat unsurveyed. • Rare crab in region, *Halicarcinus* sp nov. • *P. godeffroyi* not as restricted in distribution as implied. **Issues:** • no survey data to assess adequacy properly; • Unlikely to cover any reef based on published habitat maps. • Relatively small area if only for protection of sediment biota.	• Surveys of habitats and biodiversity required. • Extend/add area to encompass calcarenite reef habitat and biodiversity. • Extend/add area to encompass key shore bird breeding sites, particularly hooded plover (if inadequate).

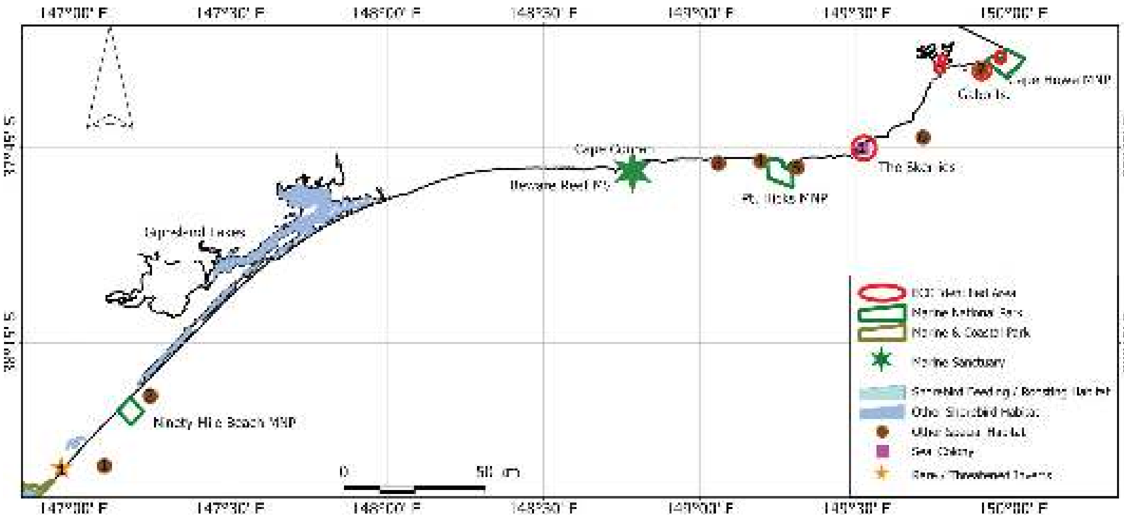
MPA	Documented Objectives and Values	Adequacy Assessment	Options
	• The area is thought to be a white shark nursery ground. • Subtidal calcarenite reef in the park supports invertebrate communities dominated by sponges and seasquirts.		
Beware Reef MS	**ECC** • Granite reefs support bull kelp forests and a diverse range of corals, sponges, anemones, gorgonians, zooanthids, crinoids and many reef fishes. **PV Management Plan** • Subtidal reef in the park is covered with a variety of brown algae including bull kelp and *Eckolonia radiata.* • An abundant and diverse range of invertebrates is present on subtidal reefs, including large finger sponges, stalked and colonial ascidians and sea urchins. • A variety of fish inhabit the subtidal reefs including butterfly perch that congregate in schools of over 1000 individuals. • The invertebrate fauna on intertidal reef is dominated by the Cunjevoi *Pyura stolonifera.*	• Island ecosystem unit • Probable eastern extent of eastern (and declining) bull kelp species/subspecies. **Issues:** None: area of high level of protection encompasses values..	
Point Hicks MNP	**ECC** • Very high total species richness of fauna in the intertidal and shallow subtidal zone. • Rocky subtidal reef forming large boulders and smaller rock clusters support marine flora and fauna including the kelps *Phyllospora comosa* and *Ecklonia radiata* and diverse colourful sessile invertebrates. **PV Management Plan** • Subtidal soft sediments are unvegetated, although	• High diversity of habitats and biota. • Intertidal to deep reef and sediment habitats • Unique/rare seaweed species. • Ecological units – Sensation Reef, Whale Back Rock, offshore reefs. • Upwelling area. **Issues:** None – stated values and objectives encompassed by boundaries and high	

<table>
<tr><th>MPA</th><th>Documented Objectives and Values</th><th>Adequacy Assessment</th><th>Options</th></tr>
<tr><td></td><td>a large number of Cerith molluscs have been observed in waters shallower than 46m.
• Subtidal reef is covered by canopy forming brown algae such as crayweed and common kelp.
• Diverse and colourful invertebrate assemblages inhabit the subtidal reefs in the park including sponges, bryozoans, corals, gorgonians and octocorals.
• There are high abundances of fish species and motile invertebrate fauna on the subtidal reefs in the park.</td><td>level of protection.</td><td></td></tr>
<tr><td>Cape Howe MNP</td><td>ECC
• Many species from warmer north Gippsland reach their southern limits in far east Gippsland in this area.
• High diversity of intertidal and shallow subtidal invertebrates.
• Subtidal soft sediments providing habitat for invertebrates such as polychaetes.

PV Management Plan
• High profile granite and low profile sandstone reef provides habitat for marine flora and fauna. Subtidal granite reef is dominated by bubble weed whereas deeper sandstone reef is covered by red algae.
• Intertidal rocky platforms are covered with algae species such as Neptune's necklace, sea lettuce and various red coralline algae.
• Bull kelp occurs on the intertidal fringes.
• High energy sandy beaches occur along the western section of the park's coastline, providing feeding grounds for a</td><td>• High diversity of habitats and biota.
• Subtidal reef to deep reef habitats.
• Intertidal to offshore sediments.

Issues:
None – stated values and objectives encompassed by boundaries and high level of protection.</td><td></td></tr>
</table>

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	number of shorebird species. • Soft sediment habitat provided by sandy beaches contains invertebrate fauna including bivalves and crustaceans.		



Legend:

■ Seal Colony	
1	The Skerries • Australian fur seal *Arctocephalus pusillus*, breeding colony.
★ **Rare / Threatened Invertebrates**	
1	Crab *Halicarcinus* sp (Woodside Beach).
● **Other Special Habitat**	
1	Primary residency region for juvenile great white shark *Carcharodon carcharias*.
2	Ninety Mile Beach low profile reef (sessile invertebrate habitat).
3	Bemm Reef.
4	Clinton Rocks.
5	Durvillaea Flats.
6	NZ Star Bank.
7	Gabo Island Harbour.

Figure 5.10. Twofold Shelf Bioregion: features of conservation importance.

The Victorian portion of the Hogan Group habitat is relatively small, with much of this biounit within Tasmanian waters. This biounit may be adequately represented by the Tasmanian Kent Group National Park, pending habitat mapping occurring in the Hogan Group. Some Hogan biounit habitat is contained within the Beagle Commonwealth Marine Reserve, which is a general purpose area with limits on demersal trawling, Danish seining and scallop dredging. As such, the lack of any MPA coverage of the Hogan biounit in Victorian waters is not considered to impact on the comprehensiveness or representativeness of MPAs in the Victorian section of the Twofold Shelf Bioregion.

In terms of adequacy, all the conservation values for establishing a Ninety Mile Beach MPA were from studies outside the existing MNP. There is a pressing need for surveys within the Ninety Mile Beach MNP to determine whether its boundaries contain its core conservation purposes. In particular, there is a need to survey whether the area encompasses low profile reefs, in addition to high invertebrate diversity sediments and shorebird breeding sites (including hooded plover). Should the MPA not include such values, there should be investigation of potential extension areas (to the northeast or southwest) or addition of a separate area along the Ninety Mile Beach coast.

The Beware Reef, Point Hicks and Cape Howe marine protected areas are considered adequate in that they generally fully encompass habitat patches and systems with a high level of protection (Table 5.16). A weakness of the Cape Howe MNP is that the subtidal reef is bounded by sand within the park in Victorian waters, but extends across the border into heavily fished New South Wales waters. There are likely to be considerable boundary effects along this border of the MNP. The Cape Howe MNP also excludes an area around Iron Prince that was included in the EEC recommendations. This area has persistently high richness and diversity of reef fishes, however, the existing area of the Cape Howe MNP is adequate in terms of meeting CAR values (Table 5.16).

Conservation Priorities

A conservation priority is to include an area or areas along Ninety Mile Beach that meet the CAR principals. There is presently no assurance that the existing Ninety Mile Beach MPA meets these, particularly in terms of encompassing intermediate depth, low profile reef habitat and a rare *Halicarcinus* crab species (Figure 5.10). This coast also encompasses a primary residency area for juvenile white shark.

Outside the existing MPAs, the ECC (2000) investigation identified the Skerries and Gabo Island of value as special management zones. The Gabo Island Harbour area satisfies the criteria conservation zone or marine sanctuary status (IUCN Category IV Habitat/Species Management Area). The existing Point Hicks and Cape Howe Marine National Parks encompass most of the highest priority communities and habitats in the eastern Twofold Shelf Bioregion, however gaps include:

- *Durvillaea* habitat;

- areas containing rare seaweeds and with unique community structure such as at Bemm Reef (probably influence by the upwelling events); and
- probable unique communities in the vicinity of New Zealand Star Banks, which are unsurveyed.

Our review of general Victorian conservation priorities identified:

- dune and coastal habitat of Ninety Mile Beach and Lakes Entrance region; and
- Croajingalong subtidal reef (upwelling area).

Recommendations

There were considerable issues identified with respect to the adequacy of Ninety Mile Beach MNP – habitat and biodiversity surveys in the region are required before these issues can be addressed (Table 5.17). The recommendations of the ECC (2000) to implement special management zones at the Skerries and Gabo Island Harbour remain valid.

The values within the Cape Howe and Point Hicks MNPs encompass highest priority values for eastern Twofold Shelf. Nevertheless, bull kelp *Durvillaea* beds and the variety of seaweed communities are identified as gaps. The deep habitats adjacent to New Zealand Star Banks, although unsurveyed, are likely to contain high conservation values.

Table 5.17. Twofold Shelf Bioregion. Recommendations arising from the MPA gap analysis.

Identified Area	Values of Concern	Recommendation
Ninety Mile Beach MNP	• Comprehensiveness, Adequacy and Representativeness – intermediate depth low profile reef.	• Survey of natural values of existing MNP, including presence of reef, sediment invertebrate diversity and shorebird breeding habitat. • Expand boundaries or add area to encompass core conservation purposes. • IUCN Category II National Park.
Cape Howe MNP	• Adequacy – state border.	• Review approaches for interstate cooperation.
Gabo Island - Harbour	• Comprehensiveness - urchin barren habitat • Fish biodiveristy • Little penguins	• Conservation Zone. IUCN Category IV Habitat/Species Management Area.
East Hicks (Durvillaea Flats)	• Comprehensiveness - *Durvillaea* bull kelp (vulnerable eastern form). • Red algae diversity	• Conservation Zone. IUCN Category IV Habitat/Species Management Area.
Rame Head, Skerries, Wingan Inlet	• Australian fur seal breeding colony (one of four in Vic). • Crested tern breeding. • White shark • Upwelling region	• Conservation Zone. IUCN Category IV Habitat/Species Management Area.
Bemm Reef	• Upwelling • High productivity. • Filter feeding assemblages. • Seaweed biodiversity – rare species	• Conservation Zone or special management zone. IUCN Category V Protected Seascape
New Zealand Star Bank	• Offshore deep habitats • Upwelling	• Survey of natural values and assessment of conservation priority. IUCN Category IV of V (if supported by survey).

5.3.9 MPA Gap Analysis – Victorian Bays and Inlets Bioregion

Comprehensiveness, Adequacy and Representativeness

The Victorian Bays and Inlets Bioregion can be divided into approximately six biounits and contains ten marine protected areas and four Ramsar wetlands (Table 5.18; Figures 5.4 and 5.6).

The ten MPAs encompass ecosystems of mostly unconsolidated substrata within all biounits (Table 5.19). The MPAs generally encompass hard substrata where present and could therefore be considered representative of the bioregion. A weakness is the Geelong Arm biounit, which is represented by patchy reef at Point Cook MS, at the eastern extent of the biounit. The reef habitat along the northern coast of the Geelong is one component that distinguishes this biounit from other inlet biounits, however much of this habitat has been transformed by introduced marine pests.

The Point Cooke MS does not encompass *Heterozostera* and *Halophila* seagrass beds, which are prevalent in the Geelong Arm (Table 5.19). It is debatable as to what biounit Swan Bay belongs and, as it shares affinities with Geelong Arm, the Swan Bay component of Port Phillip Heads MNP could arguably provide comprehensiveness for seagrass in that biounit. Two extensive habitats in the Geelong Arm are drift weed mats and *Pyura* clumps and are not presently encompassed in any MPA. *Pyrua* clump, sponge clump and channel habitats are not encompassed in any of the Port Phillip MPAs (Table 5.19).

The inclusion of channel habitat is lacking within the Western Port biounit MPAs (Table 5.19).

The Corner Inlet and Nooramunga MPAs cover almost the entire area, encompassing all habitat types. There are no MPAs in the King (Gippsland Lakes) biounit, however this whole area is effectively an MPA via the Ramsar status, which includes ecosystems to 6 m depth.

Some of the Minor Inlets habitats are encompassed in the Shallow Inlet Marine and Coastal Park, however intertidal and subtidal seagrass and *Ruppia* habitats are not comprehensively encompassed.

In terms of adequacy, the Point Cooke MS encompasses most of its declared values. The MS mostly overlays half of the Point Cooke Ramsar area and would benefit from inclusion of the northern Ramsar area along the shore to Skeleton Creek.

The Jawbone MS encompasses the core values of Mangrove, shorebird and previously protected intertidal communities. The stated values of seagrass and mudflat habitats are poorly represented within this area and should not be included as core conservation purposes of the MS. The offshore boundary is close to shore and unlikely to afford much protection for subtidal habitats (Table 5.20).

The Ricketts Point MS and Port Phillip Heads MNP (Mud Islands and Swan Bay) fully encompass habitats and natural boundaries, to a high level of protection. The offshore boundary of the Ricketts Point MS is close to the reef boundary and there are likely to be boundary effects extending over the subtidal habitats.

None of the three Western Port MPAs properly encompass deeper channel habitat and it is unknown whether the adequately encompass core channel conservation values of seapens *Virgularia mirabilis* and the 'fossil' shells species of *Neotrigonia margaritace*a, *Anadara tripezia* and *Magellania flavescens*. Surveys of the epibenthic biota within the channels are required to assess adequacy.

Saltmarsh and mangrove habitats are listed as key values for conservation in the French Island MPA (Table 5.20). The shoreward boundary traverses through the middle of the mangrove habitat and excludes saltmarsh habitat: neither of these habitats are adequately protected by the MNP. A key feature of the French Island MNP is the inclusion of Barrallier Rock, which is an important high tide roost for birds. This rock is on the boundary of the MNP and therefore not adequately protected.

Saltmarsh and *Amphibolis* seagrass habitats are listed as key values of the Churchill Island MNP but are not present within this area.

An important value of the Corner Inlet MNP is the protection of *Posidonia* seagrass meadows (Table 5.20). Such meadows are present in the northern MNP section, on Bennison Bank. The northern border of the MNP runs through the meadow and therefore does not encompass a whole *Posidonia* patch. This design means *Posidonia* within the protected area is also highly vulnerable to border effects, which could be minimised by extending the border northwards to Middle Channel (or further) and further west along Bennison Bank. Extension further to the west would greatly increase both adequacy and comprehensiveness as *Heterozostera* patches and the listed holothurian *Trochodota shepherdi* would also be included.

The comments above on the Victorian Marine and Coastal Parks also apply to the Corner Inlet and Nooramunga MCP and the Shallow Inlet MCP. Adequacy of these areas would be better assessed and enhanced through more formal documentation of the values to be protected and the corresponding management responses and permitted activities. Their management could be better integrated with the management plans of adjacent Marine National Parks. Permitted activities are communicated in Parks Victoria Visitor Guides, but not in the Recreational Fishing Guide (2009-2010).

Table 5.18. Victorian Bays and Inlets Bioregion: provisional biounits, key ecological features and marine protected areas.

Biounit	Features	Marine Protected Area
Geelong Arm biounit	Geelong Arm and Corio Bay • Weak tidal influence • Short fetch • Predominantly marine embayment • Nutrient inputs • Reefs	Point Cooke MS Port Phillip Heads MNP Swan Bay (? biounit) Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Wetland
Port Phillip biounit	Port Phillip Bay • Weak tidal influence • Long fetch • Predominantly marine embayment • Nutrient inputs and some river influences	Port Phillip Heads MNP Mud Islands Swan Bay (? biounit) Jawbone MS Ricketts Point MS Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Wetland
Western Port biounit	Western Port • Strong tidal influence • High tidal rise and fall • Short fetch • Channels • Predominantly marine embayment	Yaringa MNP French Island MNP Churchill Is MNP Western Port Ramsar Wetland
Nooramunga biounit	Corner Inlet and Nooramunga • Strong tidal influence • High tidal rise and fall • Short fetch • Channels • Predominantly marine embayment	Corner Inlet MNP South North Corner Inlet MCP Corner Inlet Ramsar Wetland
King	Lake Victoria, Lake King • Tidal influence • Short fetch • Marine to estuarine • Stratification (in lakes)	Gippsland Lakes Ramsar Wetland
Minor Inlets	Anderson Inlet, Shallow Inlet, Lake Tyers, Sydenham Inlet, Tamboon Inlet, Mallacoota Inlet	Shallow Inlet MCP

Table 5.19. Victorian Bays and Inlets Bioregion. Comprehensiveness and representativeness of marine protected areas. Legend: (◆) present in MPA; (⬩) minor presence in MPA; (×) not present in MPA but present in biounit; and (☐) not known in biounit. Tan cells represent gaps in representation.

Ecosystem	Habitat/ Community	Geelong Arm	Port Phillip			Western Port		
		Point Cooke MS	Port Phillip Heads MNP	Jawbone MS	Ricketts Point MS	Yaringa MNP	French Is MNP	Churchill Is MNP
Intertidal Sediments	Bare mud					⬩	◆	◆
	Bare sand	⬩	◆	×	◆			
	Mangroves			◆		◆	⬩	◆
	Ruppia							
	Seagrass - intertidal		◆	×	◆	◆	◆	◆
Subtidal Bare Sediments	Beach – surf zone							
	Channels		×	×	×	×	⬩	⬩
	Inshore sand	⬩	◆	◆	◆			
	Shelly sand							
	Gravel/pebble							
	Offshore sediment							
Subtidal Vegetated Sediments	Seagrass - *Halophila*	×	⬩					
	Seagrass - *Heterozostera*	×	◆	×	×	◆	◆	◆
	Seagrass - *Amphibolis*							
	Seagrass - *Posidonia*							
	Caulerpa mats	◆	⬩	×	⬩			
	Drift weed mats	×						
Biogenic	*Pyura* clump	×	×	×	×			
	Sponge clump		×	×	×			
Rocky Reef	Intertidal	◆	×	◆	◆			
	Subtidal patchy reef	◆	×	×	◆			
	Subtidal reef	◆	×	◆	◆			
	Intermediate reef							
	Deep reef							

Table 5.19 (continued).. Victorian Bays and Inlets Bioregion. Comprehensiveness and representativeness of marine protected areas. Legend: (◆) present in MPA; (⬥) minor presence in MPA; (✕) not present in MPA but present in biounit; and (☐) not known in biounit. Tan cells represent gaps in representation.

Ecosystem	**Habitat/ Community**	**Nooramunga**			**King**	**Minor Inlets**
		Corner Inlet MNP	Corner Inlet MCP	Nooramunga MCP		
Intertidal Sediments	Bare mud					
	Bare sand	◆	◆	◆		
	Mangroves	✕	◆	◆		
	Ruppia				✕	✕
	Seagrass - intertidal	⬥	◆	◆	✕	✕
Subtidal Bare Sediments	Beach – surf zone					
	Channels	◆	◆	◆	✕	◆
	Inshore sand	⬥	◆	◆	✕	◆
	Shelly sand					
	Silts				✕	
	Offshore sediment					
Subtidal Vegetated Sediments	Seagrass - *Halophila*	✕	◆	◆		
	Seagrass - *Heterozostera*	✕	◆	◆	✕	⬥
	Seagrass - *Amphibolis*					
	Seagrass - *Posidonia*	◆	◆	◆		
	Caulerpa mats					
	Drift weed mats					
Biogenic	*Pyura* clump	⬥	??	??		
	Sponge clump	⬥	??	??		
Rocky Reef	Intertidal					
	Subtidal patchy reef					
	Subtidal reef					
	Intermediate reef					
	Deep reef					

Table 5.20. Victorian Bays and Inlets Bioregion. Adequacy of marine protected areas.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
Point Cooke MS	**ECC** • Typical example of very shallow western shore of Port Phillip Bay with narrow beach of mud and sand. • Basalt reefs support a community of algae and marine fauna. • The adjacent Ramsar area and an area to 300 m offshore within the pre-existing marine reserve are listed on the Register of National Estate. **PV Management Plan** • The feeding and roosting habitat value of the intertidal areas will be protected for local and migratory seabirds. • Intertidal sandy beaches, habitat for meiofauna and feeding grounds for fish and seabirds. • Diverse and nutrient rich soft-sediments. • Pyura beds. • Seagrass patches on soft-sediment, intertidal and subtidal. • Intertidal rocky reef is frequently inundated with sand. • Subtidal reef with a canopy of kelp *Ecklonia radiata* and understorey of other brown, green and red algae. Supports a diverse range of invertebrates, including high abundance of common sea urchin *Heliocidaris erythrogramma* and blacked-lipped abalone *Haliotis rubra*. • Bottlenose dolphins frequent. • Feeding and roosting areas for shorebirds and seabirds. The MS encompasses part of a nationally significant	• Point Cooke not between Altona and Williamstown. **Issues:** Most stated objectives and values encompassed by present boundaries and level of protection, however, • Only encompasses half of Ramsar area – Skeleton Creek to Point Cooke.	• Encompass inshore Ramsar area along shore to Skeleton Creek.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	shorebird feeding area that extends between Altona and Williamstown. • The orange-bellied parrot has been recorded in the adjacent wetlands and Coastal Park and may use parts of the sanctuary.		
Jawbone MS	**ECC** • The site supports diverse habitats including rocky reef, seagrass, intertidal flats, saltmarsh and the largest area of mangroves in Port Phillip Bay. • The reef supports a relatively unmodified and diverse algal community with associated fauna. • Subtidal sediments support high species richness. • Basalt Platform is a roosting site for migratory waders. **PV Management Plan** • The intertidal reef, mudflat, mangrove, saltmarsh and seagrass communities will be protected as a scientific resource. • Unique remnant mangrove community amongst basalt boulders. • Feeding and roosting areas for migratory and local seabirds and shorebirds. • Seagrass beds that are a nursery for juvenile fish and habitat for invertebrates. • Intertidal reef and coastal habitats with a long history of protection from direct human disturbance.	• Isolated mangrove stand. • Important bird habitat. • Unique intertidal population structures through previous protected status. **Issues:** Most stated objectives and values met by present boundaries and level of protection, however • Seagrass and mudflat habitats insignificant this area.	
Ricketts Point MS	**ECC** • The sanctuary includes diverse habitats, including rocky intertidal and subtidal reefs, sandy beaches and subtidal soft sediments. • The offshore reefs have a high diversity of flora and	• Intertidal and shallow subtidal reef. • Intertidal seagrass. **Issues:** None: stated objectives and values encompassed by present boundaries and	

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	fauna. **PV Management Plan** • Intertidal reefs will be managed for education while maintaining the feeding and roosting habitat for seabirds and shore birds. • The seagrass will be maintained subject to natural ecological processes. • Diversity of habitats. • Widest intertidal reefs on the eastern shore of Port Phillip Bay and with a high diversity of Port Phillip Bay invertebrate fauna. • Subtidal reef which support a variety of biota, including diverse and abundant populations of bryozoans and rare hydroids. • Patches of seagrass. • Important feeding and roosting habitat for high numbers of seabirds and shorebirds.	level of protection	
Yaringa MNP	**ECC** • Saltmarsh, mangroves, sheltered intertidal mudflats and subtidal soft sediments channel habitats are represented within the park. • Relatively undisturbed saltmarsh and mangrove habitats • Mangroves and mudflats are important habitat for shorebirds. • The area is part of the Western Port Ramsar wetlands. • Adjacent coast, including Quail Island, supports a variety of habitats. Quail Island and nearby Chinaman Island are of state botanical and zoological significance. **PV Management Plan** • Mangrove and saltmarsh	• Includes seagrass beds as well. **Issues:** Most stated objectives and values encompassed by present boundaries and level of protection, however: • channel habitat minor and unlikely to support/protect significant populations of seapens *Virgularia mirabilis* and species of 'living fossil', *Neotrigonia margaritacea*, *Anadara trapezia* and *Magellania flavescens*.	• Revise objectives pertaining to protection of channel biota.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	communities will be maintained subject to natural ecological processes. • Floristically rich seagrass areas will be maintained subject to natural ecological processes. • Intertidal feeding and roosting habitat for migratory waders and shorebirds will be preserved and protected. • The saltmarsh community of Watson Inlet and Quail Island is of national significance as it is relatively floristically rich and undisturbed. This area cover one-third of the park. • Extensive areas of exceptionally wide mangrove and saltmarsh habitat of cover a third of the park. These areas are of state significance as they are the least disturbed areas of their type on the Western Port mainland. • Extensive *Zostera muelleri* and *Z. tasmanica* beds cover approximately a third of the park. • Seapens *Virgularia mirabilis* are abundant in the deep water channels of Western Port. • Three species of 'living fossil', the brooch shell *Neotrigonia margaritacea*, mud ark *Anadara trapezia* and brachiopod *Magellania flavescens* are abundant in Western Port but have a very restricted range globally. • Bottlenose dolphins may visit the parks and other large mammals may pass nearby. • Intertidal mudflats and seagrass in Yaringa MNP are a secondary foraging for migratory waders. These are of state		

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	significance.		
French Island MNP	**ECC** • Seagrass, mangroves, sheltered intertidal mudflats, sandy beach and subtidal soft sediments channel habitats are represented within the park. • The park includes one of the major areas of saltmarsh and mangrove habitat in Victoria. • The park contains relatively intact areas of seagrass that are nursery areas for commercially important fish species. • The park contains a high diversity of soft-sediment habitats in a well developed tidal channel system. • Intertidal flats are important foraging grounds for migratory waders. The area is part of the Western Port Ramsar wetlands. • Barrallier Island is an important high tide bird roosting site. **PV Management Plan** • Mangrove and saltmarsh communities will be maintained subject to natural ecological processes. • Floristically rich seagrass areas will be maintained subject to natural ecological processes • Intertidal feeding and roosting habitat for migratory waders and shorebirds will be preserved and protected. • One of the major mangrove and saltmarsh resources in Victoria. Mangroves grow up to 4 m tall. • Extensive *Zostera muelleri* and *Z. tasmanica* beds cover approximately	• Important bird habitat. • Encompasses relatively large areas of seagrass and mudflats. • Channels unsurveyed. **Issues:** Objectives and values not well covered present boundaries and level of protection (excepting seagrass and mudflats): • Barrellier Island on boundary and subject to boundary disturbance; • channel habitat not represented, particularly deep channels; • saltmarsh habitat not present within boundary; • boundary through middle of mangrove habitat – most mangrove habitat outside boundary.	• Enlarge northwestern corner to provide a buffer area around the high tide roost site of Barrellier Island – Preferably extend to Crawfish Rock to encompass that area of high conservation value (IUCN Category II National Park). • Extend southern boundary to encompass mangrove habitat and, if possible, saltmarsh habitat. • Survey location of key deep channel biota, including seapen and fossil shell biota. • Extend northern boundary, e.g. to Joe Island, to encompass deeper channel habitat – particularly if valued channel epibiota present.

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	a third of the park. Sparse patches of *Halophila australis* are present in the centre of the park.		
Churchill Island MNP	**ECC** • Seagrass, mangroves, rocky intertidal cobble and shingle, sheltered intertidal mudflats and subtidal soft sediments channel habitats are represented within the park. • The area includes important roosting and feeding habitats for migratory waders, particularly intertidal mudflats, which are a primary feeding area. • The area is part of the Western Port Ramsar wetlands. • The seagrasses *Zostera muelleri*, *Amphibolis antarctica* and *Heterozostera tasmanica* are present in the park. **PV Management Plan** • Mangrove and saltmarsh communities will be maintained subject to natural ecological processes. • Floristically rich seagrass areas will be maintained subject to natural ecological processes. • Intertidal feeding and roosting habitat for migratory waders and shorebirds will be preserved and protected. • Mangrove communities exist at North Point and Swan Corner. • Extensive *Zostera muelleri* and *Z. tasmanica* beds cover up to two thirds of the park. • Seapens *Virgularia mirabilis* are abundant in the deep water channels of Western Port. • Three species of ‘living	• Important bird habitat. • *Amphibolis* seagrass not present. • Channel habitats unsurveyed – values unknown. • Saltmarsh habitat not mapped within boundaries. **Issues:** Objectives and values not well covered present boundaries and level of protection (excepting seagrass and mudflats): • channel habitat not represented, particularly deep channels; • saltmarsh habitat not present within boundary.	• Survey channel biota and, if appropriate, revise objectives pertaining to protecting channel biota. • Remove objectives pertaining to saltmarsh habitat (or expand boundaries).

MPA	Documented Objectives and Values	Adequacy Assessment	Options
	fossil', the brooch shell *Neotrigonia margaritacea*, mud ark *Anadara trapezia* and brachiopod *Magellania flavescens* are abundant in Western Port but have a very restricted range globally. Brachiopods are found at high density (up to 250/m2) in the park. • Bottlenose dolphins may visit the parks and other large mammals may pass nearby. • Intertidal mudflats and seagrass in Churchill Island MNP are of national significance as primary feeding grounds for shorebirds and of state significance as a secondary feeding area.		
Corner Inlet MNP	**ECC** • Seagrass, mangroves, sheltered intertidal mudflats, sandy beach and subtidal soft sediment habitats are represented within the park. • Contains extensive seagrass beds, including the only extensive beds of *Posidonia australis* in Victoria. • Very high diversity of soft-sediment invertebrate fauna. • Part of a Ramsar site. Important over-wintering site for up to 50 % of Victoria's migratory waders and 21.5 % of Victoria's total wader population.	• *Posidonia* of moderate coverage in northern area. • Areas exclude adjacent *Heterozoster*a patches that support listed holothurian *Trochodota shepherdi*. • Important shorebird habitat. **Issues:** High level of protection for most stated values, however: • long northern boundary of northern zone through middle of *Posidonia* patch means extensive boundary effects and patch not adequately protected; • conservation values greatly enhanced in encompassed *Heterozostera* and *Trochodota* habitat; and • coverage of channel	• Expand boundary to Middle Channel to reduce boundary effects and increase adequacy for protecting the *Posidonia* patch on Bennison Bank (IUCN Category II National Park). • Increase coverage of Bennison Channel habitats. • Encompass *Heterozostera* in western section of Bennison Bank to increase habitat diversity and include listed holothurian (IUCN Category II National Park). • Incorporate highly protected area in Nooramunga, preferably including listed

MPA	Documented Objectives and Values	Adequacy Assessment	Options
		habitat is minimal. • Mangrove habitat not present within the MNP.	holothurian *Trochodota shepherdi* and brittlestars *Ophiocomina australis* and *Amphiura trisacantha*.(IUCN Category II National Park)
Corner Inlet and Nooramunga MCP	**PV Visitors Guide** • No aquaculture. • No flounder spearing. • No disturbance to plants and animals	• Important Ramsar site. • No clear management document for MCP. **Issues:** Level of protection and management to meet objective of protecting birds and other values not stated clearly in public documents.	• Review values, objectives and levels of protection to meet objectives. • Integrate with Ramsar site management and objectives (IUCN Category IV Habitat/Species Management Area)
Shallow Inlet MCP	**PV Visitors Guide** • Extensive sandflats exposed at low tide provide feeding habitat for a range of marine shorebirds. • Sandy beaches provide breeding habitat for pied oystercatchers and red capped plovers. • Seagrass meadows exist on subtidal soft sediment areas of Shallow Inlet.	• Complete coverage of inlet. • Important shorebird habitat. • No apparent or accessible management document. **Issues:** Level of protection and management to meet objective of protecting birds and other values not stated clearly in public documents.	• Provide clear documentation of objectives and levels of protection (IUCN Category IV Habitat/Species Management Area).

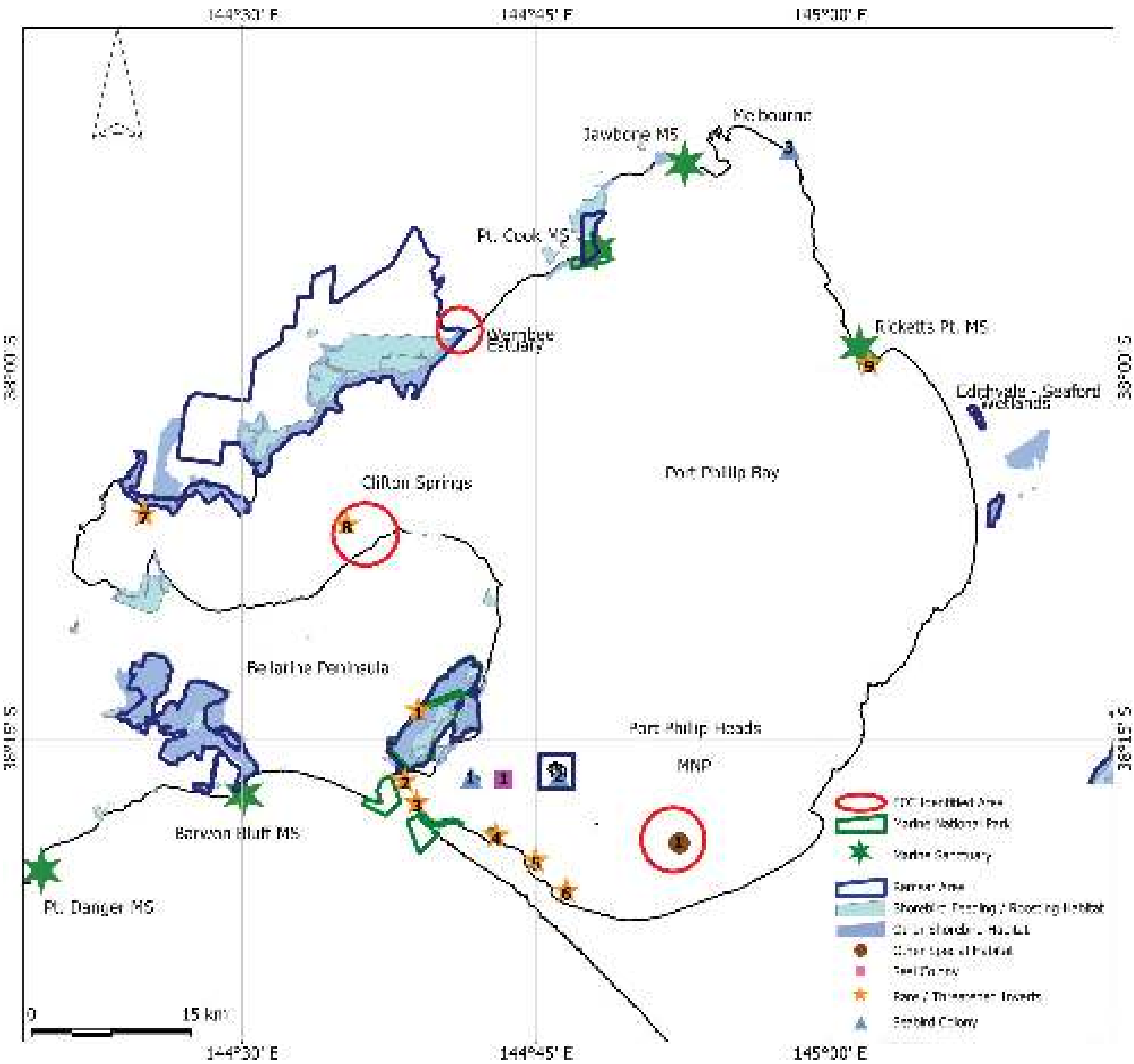
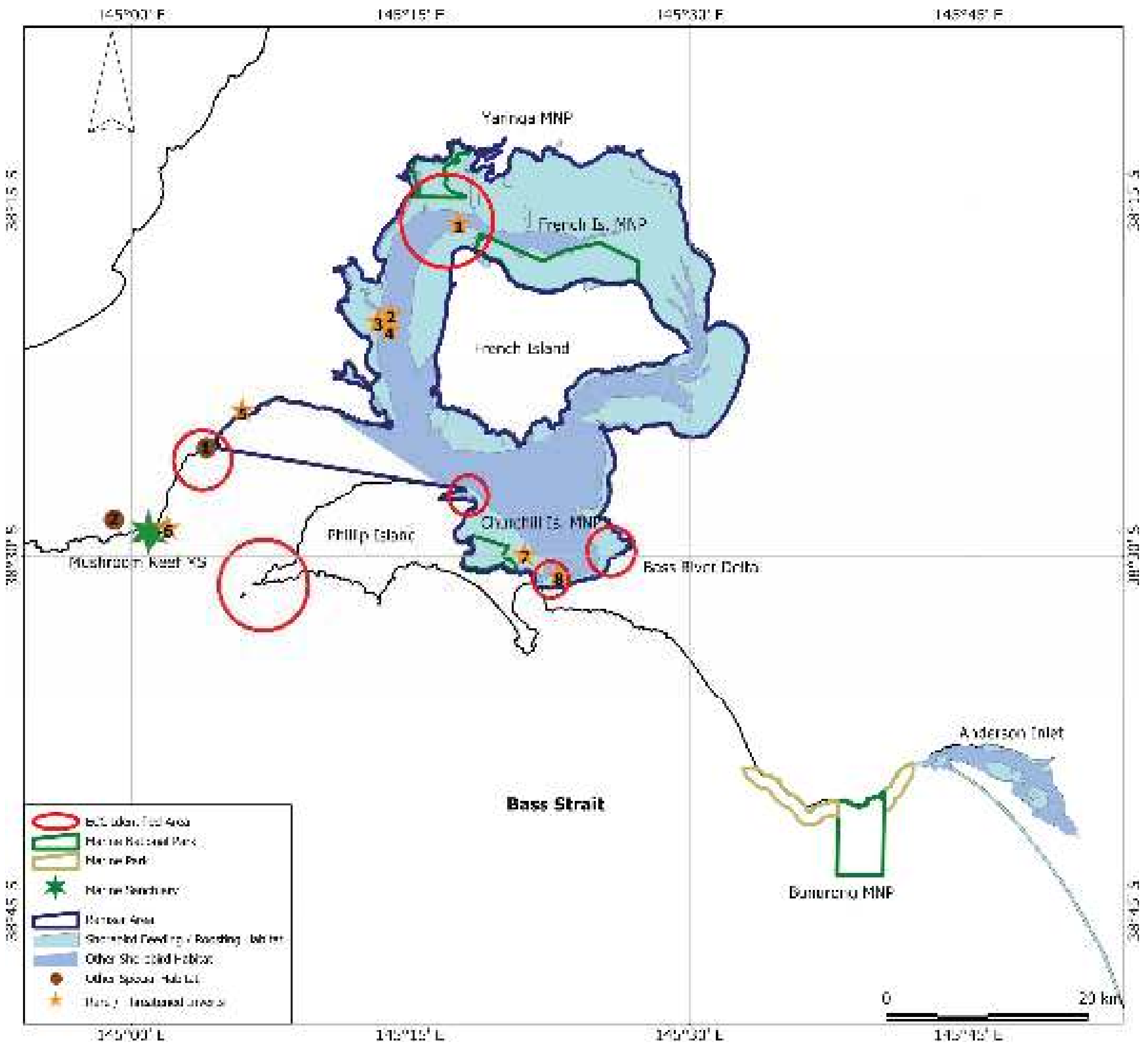


Figure 5.11. Victorian Bays and Inlets Bioregion – Port Phillip Bay: features of conservation importance. See over for legend.

Figure 5.11 Legend:

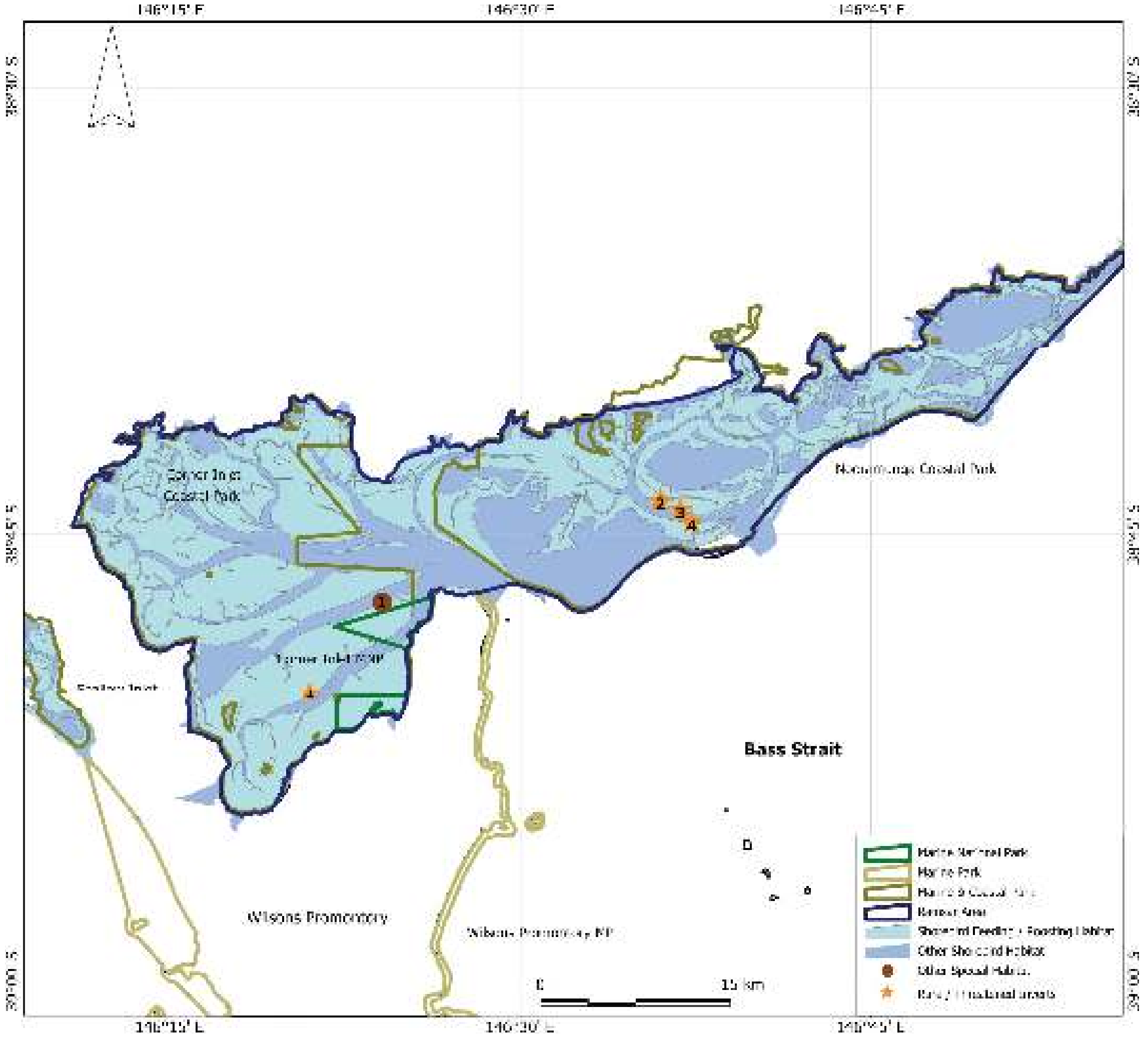
Seal Colony	
1	Chinaman's Hat • Australian fur seal *Arctocephalus pusillus*, haul out colony.
Seabird Colony	
1	Annulus (Pope's Eye) • Australasian gannet *Morus serrator*, nesting and roosting site.
2	Mud Island • Important breeding and feeding habitat for seabirds and migratory wading birds.
3	St Kilda • Little Penguin *Eudyptula minor,* breeding colony.
Rare / Threatened Invertebrates	
1	Ghost shrimp *Eucalliax tooradin* (Swan Bay).
2	Chiton *Bassethulia glypta* (Port Phillip Heads).
3	Listed Canyon Community (Port Phillip Heads)
4	Chiton *Bassethulia glypta* (Portsea).
5	Chiton *Bassethulia glypta* (Southern Port Phillip Bay).
6	Chiton *Bassethulia glypta* (Southern Port Phillip Bay).
7	Sea-cucumber *Thyone nigra* (Corio Arm, Port Phillip Bay).
8	Snapping shrimp *Athanopsis australis* (NE of Portarlington, Port Phillip Bay).
9	Snapping shrimp *Athanopsis australis* (Beaumaris, Port Phillip Bay).
Other Special Habitat	
1	Capel sound



Legend:

Rare / Threatened Invertebrates	
1	Hydroid *Ralpharia coccinea* (Crawfish Rock).
2	Ghost shrimp *Michelea microphylla* (Crib Point).
3	Ghost shrimp *Eucalliax tooradin* (Crib Point).
4	Ghost shrimp *Paraglypturus tooradin* (Crib Point).
5	Sea-cucumber *Apsolidium handrecki* (Merricks).
6	Snapping shrimp *Alpheus australosulcatus* (North Head, Western Port).
7	Marine opisthobranch *Platydoris galbana* (NE of Newhaven).
8	Marine opisthobranch *Rhodope* sp. (San Remo).
Other Special Habitat	
1	North Honeysuckle reef
2	Flinders Pier

Figure 5.12. Victorian Bays and Inlets Bioregion – Western Port: features of conservation importance.



Legend:

★ **Rare / Threatened Invertebrates**	
1	Sea cucumber *Trochodota shepherdi* (Corner Inlet).
2	Sea cucumber *Trochodota shepherdi* (NE Snake Island, Nooramunga).
3	Brittle star *Amphiura triscacantha* (South of Sunday Island, Nooramunga).
4	Brittle star *Ophiocomina australis* (NE Snake Island, Nooramunga).
● **Other Special Habitat**	
1	Corner Inlet *Posidonia* seagrass beds.

Figure 5.13. Victorian Bays and Inlets Bioregion – Corner Inlet: features of conservation importance.

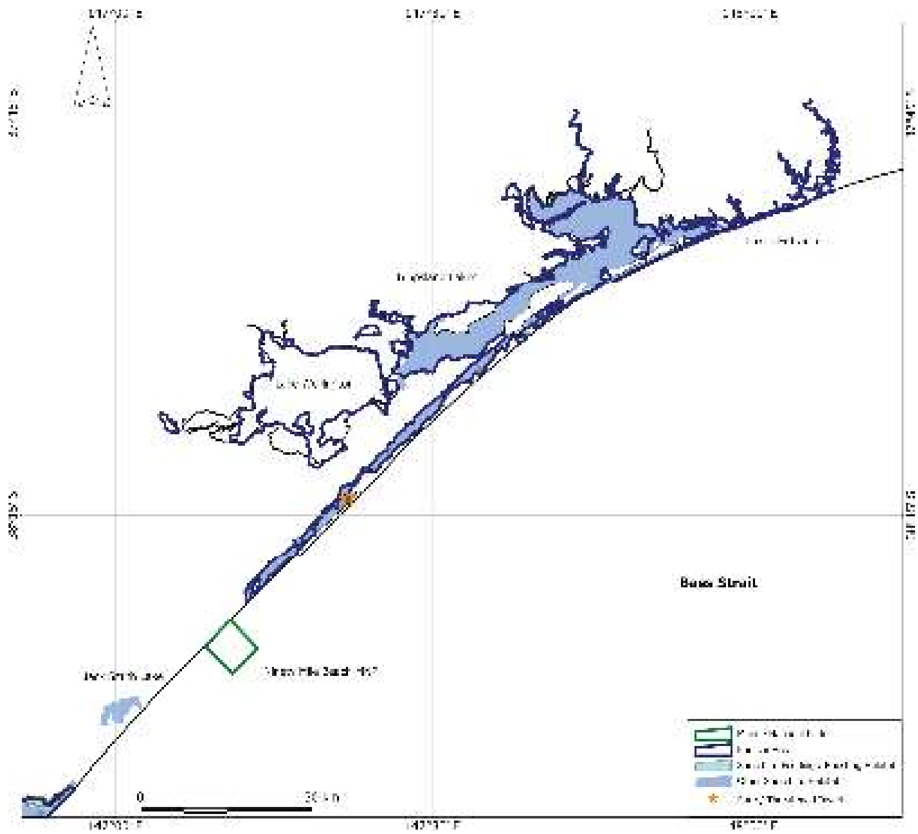


Figure 5.14. Gippsland Lakes: features of conservation importance.

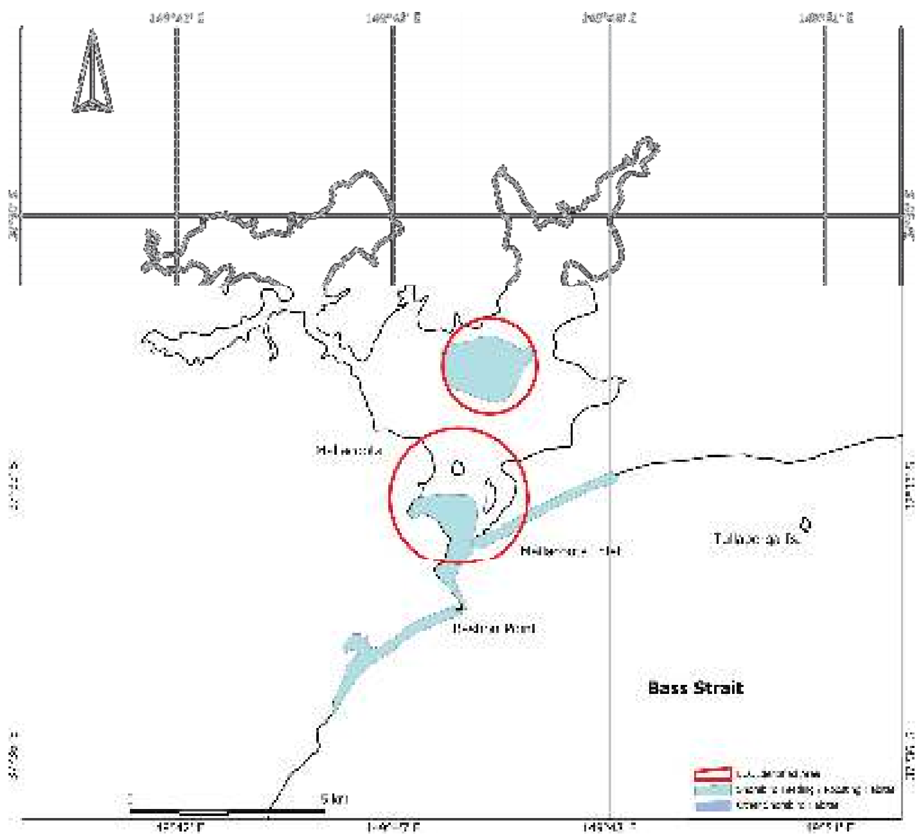


Figure 5.15. Mallacoota: features of conservation importance.

Conservation Priorities

Outside the existing MPAs, the ECC (2000) investigation identified nine other areas worthy of designation as special management zones (Figures 5.6 to 5.10). Our review of the natural values also identified other priority habitats of:

- North Arm of Western Port, supporting rare and listed ghost shrimp species; and
- Sediment channel communities of seapens *Virgularia mirabilis* and the 'fossil' shells species of *Neotrigonia margaritacea*, *Anadara tripezia* and *Magellania flavescens* – which are presently unmapped.

Our review of general Victorian conservation priorities identified most of these as being Bays and Inlets Bioregion habitats:

- *Ruppia*/estuarine grasses;
- saltmarsh;
- seagrass;
- drift algae; and
- bird feeding, breeding and resting areas.

Recommendations

There were considerable issues identified with respect to the adequacy of existing marine protected areas and recommendations are listed in Table 5.21.

The recommendations of the ECC (2000) to implement special management zones remain valid, however it is recommended that the Clifton Springs, Crawfish Rock, San Remo listed community and Mallacoota Inlet areas be given proper MPA status (*i.e.* an area that cannot be rescinded without an act of Parliament), equivalent to IUCN Category IV Habitat/Species Management Area. Notable gaps are the inclusion of drift algae, only present predominantly in northern Geelong Arm, and sediment channel epibiota in Western Port (Table 5.21).

It was noted that an MPA within Gippsland lakes (part or all thereof) would be required for representativeness and comprehensiveness and would be consistent in managing the Ramsar values of the area. The area is highly modified and some areas are considerably degraded and a IUCN Category V (Protected Seascape) may be an appropriate category of protection in this instance.

Table 5.21. Victorian Bays and Inlets Bioregion. Recommendations arising from the MPA gap analysis.

Identified Area	Values of Concern	Recommendation
Crawfish Rock	• Unique, vulnerable community. • High biodiversity of sessile invertebrates. • Listed hydroid species – area qualifies to nominated as a listed threatened community.	• Extend French Island MNP boundary westward to encompass Crawfish Rock and Barrellier Is and channel habitat. or • Create new Marine Sanctuary, IUCN Category II National Park
French Island MNP	• Adequacy – channel habitat • Adequacy – Barrellier Is bird roost • Adequacy – mangrove and saltmarsh habitats	• Survey channel biota and review adequacy and boundaries in conjunction with other MNPs in Western Port (e.g. extent boundary northward to Joe Island). • Extend boundary to encompass Barrellier Island. • Review boundaries and objectives with respect to these habitats.
Corner Inlet MNP	• Adequacy – *Posidonia* beds. • Comprehensiveness – *Heterozostera* beds • Listed species – holothurian *Trochodota shepherdi*. • Adequacy – channel habitat	• Expand northern boundary to Middle Channel to encompass whole *Posidonia* patch. • Expand western boundary of northern section to encompass *Heterozostera*, which is also listed holothurian habitat and more channel habitat.
San Remo	• Listed threatened marine community • High invertebrate diversity	• Marine Sanctuary or Conservation Zone. IUCN Category IV Habitat/Species Management Area.
Yaringa MNP	• Adequacy – channel habitat	• Survey channel biota and review adequacy and boundaries in conjunction with other MNPs in Western Port.
Churchill Island MNP	• Adequacy – channel habitat • Adequacy – saltmarsh habitats	• Survey channel biota and review adequacy and boundaries in conjunction with other MNPs in Western Port. • Remove saltmarsh as a conservation objective or move southern boundary.
Mallacoota Inlet	• Comprehensiveness – *Ruppia* and enclosed lagoon habitats. • Bird feeding and roosting.	• Conservation Zone or special management zone. IUCN Category IV Habitat/Species Management Area.
Clifton Springs	• Comprehensiveness - intertidal and subtidal seagrass beds. • High productivity	• Conservation Zone or special management zone. IUCN Category IV Habitat/Species Management Area.
Capel Sound	• *Virgularia* seapens. • Hard corals • Fish aggregations • Sheltered borwn seaweed community	• Conservation Zone or special management zone. IUCN Category IV Habitat/Species Management Area.

West Channels, Symmonds Channel or Pinnace Channel	• Sponge clump communities • Sandy channel communities	• Conservation Zone or special management zone. IUCN Category V Protected Seascape.
Rhyll Mud Banks and Observation Point	• Bird foraging and roosting	• Conservation Zone or special management zone. IUCN Category IV Habitat/Species Management Area.
Werribee River Estuary	• Estuary • Wetland • Bird feeding and roosting.	• Conservation Zone or special management zone. IUCN Category IV Habitat/Species Management Area.
Bass River Delta	• Bird foraging and roosting • Intertidal flats • algal beds • seagrass	• Conservation Zone or special management zone. IUCN Category IV Habitat/Species Management Area.
Corner Inlet MCP	• Adequacy	• Clarify status, objectives, values and permitted activities.
Shallow Inlet MCP	• Adequacy	• Clarify status, objectives, values and permitted activities.
Gippsland Lakes	• Comprehensiveness • Biodiversity – Ramsar wetland values	• Overlay an MPA over Ramsar wetland, as per Corner Inlet MCP. IUCN Category IV Habitat/Species Management Area.

5.4 Species and Communities of Conservation Concern

5.4.1 Listing of Species and Communities

The listing and protection of species and communities of conservation concern is provided by:

- Victorian Flora and Fauna Guarantee Act;
- Victorian Fisheries Act; and
- Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

The listings provide recognition of their conservation priority, various forms of legal protection and impetus for protective management measures to secure populations and habitats.

5.4.2 Gap Analysis - Listing of Species and Communities

Most threatened and migratory marine mammals and birds are explicitly protected under some form legislation, predominantly under the EPBC Act. Marine mammals, birds and reptiles are also generally protected under the Wildlife Act. The listing of all seahorses, pipefishes and seadragon members of Syngnathidae is encompassed by the EPBC Act and the Victorian Fisheries Act and this encompasses a large number of species under many types of habitats.

As mentioned in Section 2, Victoria has a high diversity of marine species, however, aside from the mammals, birds, reptiles and syngnathids, there are very few listings of threatened marine species. There are 14 marine invertebrates and three fully marine fishes listed (Table 5.22). This is likely to reflect a paucity of knowledge regarding the status of the vast majority of marine flora and fauna, rather than being an indication of security or naturalness in Victorian marine communities.

The process for the conservation assessment and nomination of marine species for listing is ad hoc. It is not a systematic part of core-government business, with only one commissioning for such work (O'Hara and Barmby 2000). Species listings have been limited to: species of interest to non-government nature conservation groups (primarily encompassing intertidal habitats); and museum records of selected taxa of only a few habitat types and poor spatial coverage (excepting infauna surveys).

There is clearly a large gap between the number and type of listed species and the potential occurrence of other threatened or endangered marine species in Victoria. Although there have been intensive biodiversity studies in particular areas, the lack of systematic and repeated studies throughout Victoria prevent determinations of rarity, vulnerability and population decline. In some instances, this gap in the listing of marine species has lead to adverse conservation determinations, where the lack of listing is used as evidence that species of conservation concern are not present for impact assessments.

There are two marine communities in Victoria listed as threatened under the FFG Act: the San Remo Marine Community; and the Port Phillip Bay Entrance Deep Canyon Marine Community. The only systematic community studies along the Victorian consist of sediment infauna, intertidal reef and subtidal reef habitats (*e.g.* Coleman *et al.* 2007; O'Hara 2000, Edmunds *et al.* 2007). The communities of Port Phillip Bay and Western Port have been more thoroughly studied (*e.g.* Cohen *et al.* 2000; Blake and Ball 2001; Ross 2000; May and Stephens 1996). These studies were by no means comprehensive and there is considerable potential for the discovery of additional communities of conservation concern.

5.4.3 Gap Analysis - Conservation, Action and Recovery Plans

Where species of conservation concern are listed, there is usually a subsequent requirement to develop and implement a recovery plan or action statement. The action statements of a selection of key marine listed species were reviewed in terms of securing the populations (Table 5.22).

There are presently no Action Statements for any of the listed marine invertebrates, although they have been drafted and presented for public comment. Any conservation measures are presently passive through recognition of their listed status and existence within marine protected areas (few MPA management plans recognise or manage for these species).

Of the listed items with Action Statements (Table 5.22), only those for the humpback whale and blue whale provide some form of targets and performance assessment of management success. None of the other Action Statements provide assurance, or indeed evidence, for improved conservation status of the species or community.

In summary, clear gaps in the conservation of listed species and communities are:

- the lack of plans/statements for most species; and
- for those with plans, lack of any outcomes based targets and assessments.

5.4.4 Recommendations

The identification and management of rare and/or threatened species would be greatly assisted by the collection of systematic data throughout Victoria, including habitats that have not been sampled before. Such programs require considerable field sampling and taxonomic support, but are required if biodiversity is to be better discovered, described and conserved.

In considering and managing human impacts on rare, vulnerable and threatened species the marine environment, the assessment should not be confined to just listed species. Assessments need to be cognisant that most species and communities of high conservation concern are not listed.

It is recommended that Action Statements are revised and implemented to provide progress on improvement of the conservation status of all listed items. At present, planned actions with tangible outcomes, implementation of any actions and developing a knowledge base for appropriate management is lacking.

Given that the number of presently listed marine species is likely to be under-representative of actually threatened species, and that comprehensive listings and associated actions are unlikely to occur in the near-term, it is recommended that risks to threatened species are managed in the interim through implementation of an adequate MPA network. As espoused by NRSMPA and IUCN, the principles of encompassing replicates of all habitat types as well as unique and special areas maximise the probability of conserving threatened species and communities. In addition, many marine benthic species are best managed through area protection methods rather than on a per-species management basis, as suggested by Ponder *et al.* (2002). Ponder *et al.* (2002) specifically recommend that marine invertebrate conservation focus on protecting and managing systems at a variety of scales, from assemblages and communities to ecosystems and bioregions. This approach is likely to be also valid for most benthic flora and fauna.

Table 5.22. Status of listed marine species and communities and identification of gaps.

Common Name	Scientific Name	Notes	Plan	Existing Protective Measures	Gaps/Key Threats
Stalked hydroid species	*Ralpharia coccinea*	Known only from Crawfish Rock, Western Port.	No (drafted)	None	• Status and biology poorly known. • Substantial changes to Crawfish Rock habitat. • Highly vulnerable.
Marine opisthobranch	*Platydoris galbana*	Endemic to south-eastern Australia. Habitat requirements are unknown.	No (drafted)	None	• Status and biology poorly known. • Threats from trampling and coastal development.
Marine opisthobranch	*Rhodope* sp.	Known only from San Remo, Western Port	No (drafted)	None	• Status and biology poorly known. • Threats from trampling and coastal development.
Chiton Species	*Bassethullia glypta*	Very rare and restricted distribution. Occurs on the southern shore of Port Phillip Bay, from Sorrento to Portsea and in Lonsdale Bight. Also at Mushroom Reef MS, Flinders.	No (drafted)	• Mushroom Reef MS - area probably too small to sustain population.	• Status and biology poorly known.
Sea-cucumber species	*Apsolidium densum*	Rare and restricted distribution. Endemic to Victoria, known from only three locations: Mushroom Reef MS, Honeysuckle Reef and Skenes Creek.	No (drafted)	• Mushroom Reef MS - area probably too small to sustain population.	• Status and biology poorly known. • Range recently extended.
Sea-cucumber species	*Apsolidium handrecki*	Found on rock shallow habitat. In Victoria, only known from Merricks, Western Port. Also known from one population in SA and one in WA.	No (drafted)	None	• Status and biology poorly known.

Common Name	Scientific Name	Notes	Plan	Existing Protective Measures	Gaps/Key Threats
Brittle Star Species	*Amphiura trisacantha*	In Victoria, known only from a single specimen from south of Sunday Island, Nooramunga. Possibly also North Arm, Western Port. Also known from SA and Tas.	No (drafted)	• Nooramunga and Corner Inlet Marine and Coastal Park.	• Status and biology poorly known. • Seagrass habitat highly variable – seagrass last surveyed in 1999.
Brittle Star Species	*Ophiocomina australis*	Rare and restricted distribution. In Victoria, known only from Sunday Island, Nooramunga. Also known from SA.	No (drafted)	• Nooramunga and Corner Inlet Marine and Coastal Park.	• Status and biology poorly known. • Seagrass habitat highly variable – seagrass last surveyed in 1999.
Sea-cucumber species	*Trochodota shepherdi*	Rare and restricted distribution In Victoria, known only from Sunday Island, Nooramunga. Also known from SA.	No (drafted)	• Nooramunga and Corner Inlet Marine and Coastal Park.	• Status and biology poorly known. • Seagrass habitat highly variable – seagrass habitat last surveyed in 1999. • Species last observed in 2001.
Sea-cucumber species	*Pentocnus bursatus*	In Victoria, only known from Cape Patterson. Also known from one location in SA and one in WA.	No (drafted)	• Bunurong Marine Park. • Parks Victorian monitoring of nearby reef habitats and condition.	• Status and biology poorly known.
Sea-cucumber species	*Thyone nigra*	Rare and restricted distribution. Found in shallow, near-shore benthic sediments in seagrass. In Victoria, only known from the north shore of Corio Bay. Also known from one population in SA and two in WA.	No (drafted)	None	• Status and biology poorly known. • Highly vulnerable to pollution. • Highly vulnerable to marine pests impacts.

Common Name	Scientific Name	Notes	Plan	Existing Protective Measures	Gaps/Key Threats
Southern Hooded Shrimp	*Athanopsis australis*	Rare and restricted distribution. Endemic to Victoria. Known from four specimens from Port Arlington, Point Wilson and Beaumaris and Bridgewater Bay.	No (drafted)	None	• Status and biology unknown. • Port Arlington population at risk from Bellarine Safe Harbour Project. • Subject to marine pest impacts.
Ghost shrimp	*Paraglypturus tooradin*	Rare and endemic to Victoria. Known from only two locations; Swan Bay and Crib Point, Western Port	No (drafted)	• Port Phillip Heads Marine National Park - Swan Bay	• Status and biology unknown.
Ghost shrimp	*Michelea microphylla*	Rare and endemic to Victoria. Known only from a single locality at Crib Point, Western Point	No (drafted)	None	• Status and biology unknown. • Extremely rare. • Subject to industrial disturbances and discharges.
Australian Grayling	*Prototroctes maraena*	Migratory species associated with coasts and rivers throughout coastal Victoria east of the Hopkins River	No (drafted)	• Important source populations identified. • Actions with targets identified.	• Causes of decline not known. • Water quality of Gippsland Lakes.
Southern Bluefin Tuna	*Thunnus maccoyii*	Globally depleted population (<15%). Slow growing and late maturing. Migratory species usually occurring on the seaward side of the continental shelf but recorded nearer shore. In Victorian waters, predominantly pre-adults up to 9 years old.	Yes	• Commercial bycatch limits • Recreational bag limits	None

Common Name	Scientific Name	Notes	Plan	Existing Protective Measures	Gaps/Key Threats
White Shark	*Carcharodon carcharias*	Wide ranging coastal shark frequently reported in Victoria.	Yes	• Protected under Fisheries Act. • Ban on targeted commercial shark gill netting in coastal waters. • Ban on use of mammal blood as berley. • Disincentives to land as longline bycatch.	• Few aggregation areas protected. • Apparent ongoing decline. • No targets, monitoring or performance assessment in Action Statement.
Grey Nurse Shark	*Carcharias taurus*	Only two records from Victoria but probably part natural of range.	Yes	• Ban on targeted commercial shark gill netting in coastal waters. • Disincentives to land as longline bycatch.	None
Leathery Turtle	*Dermochelys coriacea*	Uncommon but regularly encountered in rich coastal waters of Victoria. Has been recently seen off Port Phillip Heads. Range widely but most likely associated with strong upwellings and other oceanographic features.	Yes	• National turtle recovery plan. • Entanglement monitoring and codes of practice. • Reduction of marine litter.	• Entanglement and litter. • Oil spills and water quality. • No targets, monitoring or performance assessment in Action Statement.

Common Name	Scientific Name	Notes	Plan	Existing Protective Measures	Gaps/Key Threats
Humpback Whale	*Megaptera novaeangliae*	Winter migrant widespread and relatively abundant throughout Victoria during northward migration.	Yes	• Control of disturbances by air and boat. • Entanglement monitoring, responses and codes of practice. • Reduction of marine litter. • Seismic survey controls. • Reporting and monitoring of entanglement and deaths.	• Entanglement and litter. • Ship strike. • Oil spills and water quality. • Seismic exploration and noise.
Blue Whale	*Balaenoptera musculus*	Seasonally uncommon summer visitor that occurs often near the coast associated with the Bonney Coast Upwelling off Western Victoria but also seasonally as far east as Port Phillip Heads.	Yes	• Control of disturbances by air and boat. • Entanglement monitoring, responses and codes of practice. • Reduction of marine litter. • Seismic survey controls. • Reporting and monitoring of entanglement and deaths.	• Entanglement and litter. • Ship strike. • Oil spills and water quality. • Seismic exploration and noise.
Southern Right Whale	*Eubalaena australis*	Ranges seasonally (winter) throughout coastal Victoria, inhabiting shelf waters and breeding within the surf zone, most notably near Warrnambool.	Yes	• Control of disturbances by air and boat. • Entanglement monitoring, responses and codes of practice. • Reduction of marine litter. • Seismic survey controls.	• Entanglement and litter. • Ship strike. • Oil spills and water quality. • Seismic exploration and noise. • No targets, monitoring or performance assessment in Action Statement.

Common Name	Scientific Name	Notes	Plan	Existing Protective Measures	Gaps/Key Threats
Seahorses, pipefishes and seadragons	Family Syngnathidae	Includes common and rare species in all coastal benthic habitats. Some common species as threatened as the rare ones. All Hippocampus species are on the IUCN List of Threatened Species.	No	• Some species present within various MPAs. • Protection from collection.	• No monitoring or assessment. • Impacted by habitat changes and trawling.
San Remo Marine Community		Intertidal and subtidal marine community extremely species-rich in opisthobranch molluscs and bryozoans. Many rare species present. Site only 300 x 600 m.	Yes	• Monitoring of coastal works in region. • Awareness of presence of community.	• Monitoring suggested, but no clear targets or performance assessment in Action Statement.
Port Phillip Bay Entrance Deep Canyon Marine Community		Community dominated by sessile invertebrates, particularly sponges. Unique community structure and high diversity of bryozoans and hydroids. Encompasses 20-100 m depth range. Limited to only one place in Victoria.	No (only recently listed)	• Partially within Port Phillip Heads Marine National Park – Point Lonsdale. • Monitoring associated with channel deepening.	• Ongoing rock fall impacts from channel deepening – extent and frequency unknown. • Communities with large scale recent changes – coincident with deepening but causes unknown. • Biology poorly known.

6 Climate Change and Implications for Ecosystems

6.1 Physical and Environmental Predictions

Climate change will result in various physical changes such as temperature, sea level, ocean currents, ocean chemistry and solar radiation. These changes will have significant impacts on life in the marine environment.

Atmospheric and oceanic temperatures are predicted to increase by the year 2070 (Table 6.1; CSIRO 2007; Hobday *et al.* 2006), changing growth rates of plankton, photosynthetic and respiration rates of marine plants.

Sea level is expected to increase up to 0.59 m by 2070 (Bates *et al.* 2008), affecting low-lying coastal populations at intertidal areas, mangroves and wetlands.

There has been a strong warming trend occurring along the East Australian Current (Cai *et al.* 2005) which is predicted to strengthen further, increasing the amount of warm water flowing into east Victoria. El Niño events may become drier and La Niña events wetter by 2070, changing the dynamics of ocean currents in south-east Australia (CSIRO 2007).

There will be a decrease in pH of 0.2 units across the marine environment (Hobday *et al.* 2006), increasing the acidity of the ocean and in particular affecting organisms that produce calcified shells. The mixed layer depth in the ocean is a layer between the surface and a depth where the density is around the same as that at the surface. This mixed layer depth is predicted to reduce (become shallower), resulting in a decrease of nutrients from deeper waters (Hobday *et al.* 2006) and affecting the growth of phytoplankton, the primary producers in the marine environment.

Solar radiation is projected to increase 2-7 Wm^{-2} by 2070 (Hobday *et al.* 2006). This increase in solar radiation can have both positive and negative impacts on marine and coastal organisms. Photosynthetic efficiency in plants such as phytoplankton, seagrass, kelp and mangroves may be improved. However, harmful ultraviolet (UV) radiation would also increase, affecting phytoplankton (Jeffrey *et al.* 1996; Hogue *et al.* 2005; Litchman and Neale 2005), kelp (Graham 1996), intertidal animals (Cordi *et al.* 2001; Przeslawski *et al.* 2005), zooplankton (El-Sayed *et al.* 1996) and seagrass (Dawson and Dennison 1996). An increase of 0-1 ms^{-1} for sea surface winds are projected by 2070 (Hobday *et al.* 2006), which may affect plankton by increasing water column turbulence and influencing ocean currents and stratification of the mixed layer.

Annual rainfall in Victoria is projected to decrease around 6-11 % by 2070 (CSIRO 2007), which would directly influence salinity in coastal waters, impacting planktonic species, organisms in intertidal areas and mangrove plants. Coastal runoff would also be impacted, influencing stratification of the mixed layer and subsequently nutrient supply for phytoplankton, the primary producers. Storms and coastal flooding are expected to increase in severity and frequency by 2050 (IPCC 2007), increasing the probability for massive destruction of seagrass beds and mangroves.

Table 6.1. Climate change predictions of physical indicators for the years 2030, 2050 and 2070.

Climate Change Indicators	Year 2030	Year 2050	Year 2070
Atmospheric Temperature	Increase by 0.8 °C in Victoria (CSIRO 2007).		Increase by 1.4 - 2.7 °C in Victoria, depending on low or high emissions scenario (CSIRO 2007).
Sea Surface Temperature			Increase around 1 - 2 °C in Australian waters (Hobday *et al.* 2006).
Temperature at 500 m depth			Increase around 0.5 – 1 °C in Australian waters (Hobday *et al.* 2006).
Sea Level Rise		Impacts intensified by coastal development and population growth (IPCC 2007).	Global mean sea level rise of 0.18 m to 0.59 m, between late 20th century to the end of this century (Bates *et al.* 2008).
Sea Surface Currents			Decrease in strength of currents, between 0 – 1.2 ms^{-1} (Hobday *et al.* 2006).
Ocean Currents			Strong warming trend along East Australian Current (Cai *et al.* 2005). In south east Australia, El Niño events may become drier and La Niña events wetter (CSIRO 2007).
pH (ocean)			Decrease in pH of 0.2 units (Hobday *et al.* 2006).
Mixed Layer Depth (ocean)			Most areas greater stratification, shallowing of mixed layer by 1 m, reduced nutrient inputs from deep waters (Hobday *et al.* 2006).
Sea Surface Solar Radiation			Increase of 2 - 7 W m^{-2} (Hobday *et al.* 2006).
Sea Surface Winds			Increase of 0 – 1 ms^{-1} (Hobday *et al.* 2006).
Annual Rainfall	Decrease by 4 % in Victoria (CSIRO 2007).		Decrease by 6 – 11 % in Victoria, depending on low or high emissions scenario (CSIRO 2007).
Storms and Coastal Flooding		Increase in severity and frequency (IPCC 2007).	

6.2 Ecological Implications

6.2.1 Introduction

Much of the marine research done on the implications of climate change in previous years have focussed on the direct impacts of changing temperatures on shifts in abundance, distribution and timing (Harley *et al.* 2006). However, other impacts such as changes in ocean chemistry and ocean circulation are also important. Implications of climate change on particular species or communities do not occur in isolation in the marine realm, and can result in broad flow on affects due to the complex interactions of marine organisms. Potential climate affects on particular key habitats, communities and species from climate change predictions are detailed in the following sections.

6.2.2 Temperature

Ocean temperatures will increase, which may change the growth rates, abundance, distribution and timing for planktonic species in the marine environment (Hobday *et al.* 2006). Global mangrove distribution is constrained by 20 ºC winter sea isotherm (Hobday et al. *2006) so changes in atmospheric and ocean temperatures will impact the distributi*on of mangroves in Victoria. Higher temperatures also increase evaporation, thus increasing soil salinity, a major factor in the distribution of mangrove species. Declines of kelp forest in eastern Tasmania have been associated with warming temperatures (Edgar *et al.* 2005). Changing temperatures will also influence photosynthesis and respiration rates of marine seagrasses and macroalgae.

6.2.3 Sea Level Rise

An increase in sea level would have significant impacts on habitats with low profiles such as wet lands and mangroves (Hobday *et al.* 2006). Coastal and intertidal habitats may also be impacted by sea level rise. With an increase in sea levels, habitats moving shoreward may be constrained by anthropogenic-induced pressures such as coastal developments, resulting in the loss of habitats.

6.2.4 Currents

Changes in ocean circulation will have significant impacts on population dynamics because of its influence on larval transport and ocean productivity. The increasing strength of the warm East Australian Current (EAC; Cai *et al.* 2005) will likely affect marine species in eastern Victoria because of the increase in ocean temperatures. El Niño Southern Oscillation (ENSO) events also affect ocean currents such as the Leeuwin Current which is stronger during La Niña years and weaker during El Niño years (Feng *et al.* 2003). The changes in the Leeuwin Current, a major surface current, would affect marine species in western Victoria, via influences on the South Australia Current. El Niño events have been shown to lead to enhanced upwelling along the southern shores of Australia (Middleton *et al.* 2007).

6.2.5 Ocean Chemistry

Decrease in pH will alter ocean chemistry and affect marine carbon cycling and ocean-atmosphere carbon dioxide exchange. Changes in carbon dioxide concentrations have had a negative influence on growth rate and calcite productions of dominant marine calcifying phytoplankton (Engel *et al.* 2005; Hinga 2002; Riebesell *et al.* 2000). Shell deterioration in holoplanktonic molluscs because of increasing dissolution in more acidic conditions has been reported (Orr *et al.* 2005). If this occurs on a large scale, it will have irreversible and catastrophic consequences for both the terrestrial and marine environments, with incalculable human cost.

A higher concentration of dissolved carbon dioxide in the ocean will result from the increase in atmospheric carbon dioxide, helping to increase photosynthetic rates of various seagrass species (Invers *et al.* 2002). The growth of mangroves plants will also be stimulated by the increase in atmospheric carbon dioxide (Farnsworth *et al.* 1996).

6.2.6 Stratification

Stratification or the mixed layer depth refers to the vertical extension of the turbulently mixed surface layer in which most pelagic primary production occurs. Changes in the mixed layer depth caused by climate change have been found to affect the production, biomass and sinking export of phytoplankton (Diehl *et al.* 2002). In the North Atlantic, changes in the distribution and abundance of zooplankton have also been related to changes in stratification (Richardson and Schoeman 2004). Recent models have suggested that increased stratification caused by climate change will lead to a decline in primary and secondary productivity (Hobday *et al.* 2006).

6.2.7 Solar Radiation

Increased sea surface solar radiation will have both positive and negative effects on marine organisms. An increase in solar radiation will potentially increase photosynthetic efficiency in plants such as phytoplankton, seagrass and kelp. Minor increases in solar radiation increased net photosynthesis of mangrove seedlings, however with a higher increase there was a significant net decrease in photosynthesis of *Rhizophora apiculate* seedlings (Moorthy and Kathiresan 1997). Furthermore, an increase in solar radiation also indicates an increase in ultraviolet (UV) radiation. Various studies have shown harmful effects of UV radiation on phytoplankton (Jeffrey *et al.* 1996; Hogue *et al.* 2005; Litchman and Neale 2005), kelp (Graham 1996), intertidal animals (Cordi *et al.* 2001; Przeslawski *et al.* 2005), zooplankton (El-Sayed *et al.* 1996) and seagrass (Dawson and Dennison 1996).

6.2.8 Weather

Winds

Plankton can be directly affected by wind because of the production of water column turbulence that can physically kill sensitive plankton. Plankton can also be indirectly affected by winds interacting with surface ocean currents to enhance or suppress upwelling, influences on transport of plankton and also stratification in the surface layer affecting nutrient and light availability (Hobday *et al.* 2006). Wind has a variety of other effects on water movement via waves and currents, such as affecting upwellings, suspension of sediments and water clarity and sediment transport processes.

Rainfall
Salinity in coastal waters is directly influenced by rainfall and the associated river runoff. This will be affected by changes in the amount or timing of rainfall. Changes in salinity will impact planktonic species in the coastal waters, marine organisms in the intertidal habitats and mangroves (Hobday *et al.* 2006). Changes in rainfall patterns also influences the stratification of the water column and nutrient supply, which impacts primary production and nutrient cycling.

Storms
Storms can affect seagrass and marine macroalgae directly by uprooting or indirectly by increasing turbidity in the water column and reducing light. In severe cases, major or complete devastation of seagrass beds can occur (Preen *et al.* 1995). There has also been large scale destruction of mangroves by storms in northern Australia (Woodroffe and Grime 1999). With an increase in frequency and intensity of storms, the probability of massive destructions of seagrass beds and mangroves is expected to increase. Disturbance regimes in Australia may help to maintain diversity in southern Australia, however the shift from a ‘natural’ disturbance regime to one with more frequent or intense storms is likely to affect Victoria’s kelp forests and intertidal habitats unfavourably (Hobday *et al.* 2006).

6.3 Implications for Areas of High Conservation Value

Areas of greatest concern for climate change effects based on a major extent of the most vulnerable of important habitats are shown above in Table 4.6. Of the top ten areas with habitat considered most vulnerable to climate change, eight of these are also in the top 20 most at risk from existing threatening processes. Lakes Entrance, Port Phillip Heads and Mallacoota Inlet feature particularly highly. However, climate change effects could impact anywhere along Victoria’s coastline.

Some examples of modelled predictions include:

- inundation in the regions of the towns of Port Franklin, Port Welshpool and Port Albert (Corner Inlet) will increase in areal extent by 15-30 % by 2070 under a high wind speed change, high mean sea level rise scenario; and
- in the Gippsland Lakes, inundation resulting from sea level extremes will be greatest in existing swamp areas and in the vicinity of Lake Reeve. The total area of inundation within the model domain doubles from current climate values of around 25 km^2 to just over 50 km^2 under a 2030 high wind speed change, high mean sea level rise scenario.

6.4 Impacts and implications for Ecosystem Processes

The implications for ecosystem processes are profound. Assessing the relationship between threatening processes and threats (Table 6.2), climate change creates a wide range of second order effects, all of which further divide driving additional chains of effect. The combined effect of changes to biological processes can rapidly result in shifts to alternative stable states, such as has happened in the Gippsland Lakes. Elsewhere, there is already substantial evidence of significant changes in community composition, such as through invasion of pest species. This can come about through changes in water temperature and current patterns. In the case of ocean acidification, this would result in total ecosystem failure.

Table 6.2. Summary effects of climate change.

Threatening Process	1st order effects	2nd order effects
Climate change	Changed currents Changed nutrient regime Changed temperature regime Increased storm frequency Sea level rise Increased ocean temperature Increased El Nino frequency Ocean acidification	Species range shifts Pathogens Sedimentation Loss of primary productivity Loss of secondary productivity Changes to bio-genic habitat Change in community composition Eutrophication Coastal squeeze Habitat homogenisation Habitat fragmentation Reduction in ecosystem complexity e.g. food chain Coastal erosion **Leading to…** Ecosystem failure Shift to alternative stable state

In the short term (years), the immediate effects are likely to be reduced rainfall, changed currents and upwellings, which all leading to changes in nutrients and temperature. The changed currents and temperature also facilitate biogeographic shifts. In the Victorian context, these changes are possibly already evident, although they are not likely to be just from climate change:

- increased salinity of Port Phillip Bay through drought conditions;
- persistent declines of seagrass beds in southern Port Phillip Bay;
- almost complete loss of string kelp forests; and
- westward spread of long-spined sea urchin barrens.

In the medium term (years to decades), the major consequences are likely to be from sea level rise and increasing storm frequency. This will mostly affect coastal habitats but as discussed in section 4.2.2, some habitats vulnerable to existing threats are also first lines of defence against these climate-change related effects.

6.5 Building Biodiversity Resilience to Climate Change

We have identified three categories of threat from climate change (Table 6.3). The first two are physical threats and are most readily resisted. The second two are bio-physical and related to temperature changes. These are extremely difficult to resist but in many cases it may be possible to build resilience to allow ecosystem communities to adapt quick enough that critical processes are maintained. The final chemical threat, ocean acidification, is a tipping point and almost certainly irreversible so is not considered further here.

Table 6.3. Building resilience to the threats of climate change.

Threat	Type of change	Options for building resilience
Increased storm frequency Sea level rise	Physical	Relatively simple to achieve through protection and restoration of physical coastal features and processes.
Increased ocean temperature Increased El Nino frequency (and associated changed nutrient regime)	Bio-physical	Very difficult to control. May depend on restoring population structures and ecological complexity now, providing the ecosystem with the flexibility to adapt to rapid changes in the environment. May require considerable management intervention to maintain species and processes.
Ocean acidification	Chemical	None. Total ecosystem collapse. Irreversible.

6.5.1 Building Resilience to Physical Threats

The main difficulty is in allowing coastal processes to adapt. This requires land to be reclaimed to the sea and for the coastal zone to move inland. Although a controversial policy, defence against sea level rise is in many cases economically and physically impossible. Managed retreat, where saltmarsh and other habitat is encouraged, is another option that is being successfully used and may be relevant to some areas.

The primary ecosystem functions at risk in the near term are:

- stabilisation of coastal substrates to prevent coastal erosion; and
- provision of a physical defence to sea level rise and flood defence through absorption of wave energy and flood dispersal.

The habitats most likely to achieve this and that therefore require protection, management and restoration are

- saltmarsh;
- mangrove;
- seagrass;
- any coastal vegetation, including dune vegetation; and
- *Ruppia*, *Leplaena* and other estuarine grasses

If these habitats cannot be protected, there are likely to be significant feedback effects that will reduce resilience in other habitats as well these "first line of defence" habitats.

6.5.2 Building Resilience to Bio-Physical Threats

The consequence of ocean temperature change is to create entirely different ecological communities through a plethora of physical, chemical and biological changes. The chance to build resilience depends on both the rate of change and the ability of ecosystems to absorb the change through ecological adaptation.

At least for the higher taxa, adaptation is unlikely to occur fast enough at the species level as natural selection and evolution work on much slower time scales. Adaptation therefore has to be at the community level and this will be most likely in relatively natural habitats, with complex trophic interactions. In short, areas of high biodiversity value (in terms of structure, function and composition) will be potential sources of ecological resilience.

Where naturally important habitat and processes have been denuded through unsustainable resource exploitation, it may be necessary to restore ecosystem function and therefore restore flexibility to change and resilience. For example, loss of top predators through over-fishing can reduce selection pressure on prey, resulting in increased disease susceptibility or loss of control of habitat modifying species. Removing a particular species from a habitat also opens up ecological niches and enables monocultures of species (including marine pests) to gain foothold.

6.6 Implications for Existing Protection Methods

As discussed in *Section 6: Gap Analysis*, existing protection methods are currently failing to protect or restore ecosystem integrity. Because many of the problems are cumulative and occur outside protected areas, the rigorous consideration of environmental issues is necessary at every level of decision making. Unless policy can be made to create outcomes that are measurable and robust, any additional protection measures are likely to be moot.

7 Conclusions

7.1 Marine and Coastal Natural Values

7.1.1 Review Information

Since the third VNPA Nature Conservation Review in 2000, there has been a spate of statewide marine and coastal investigations. These investigations were largely to inform the implementation of a system marine protected areas, including for the Land Conservation Council (1996), Environment Conservation Council (2000) and the Department of Natural Resources and Environment (Ferns and Hough 2000, 2002). Over the last decade, systematic marine investigations included: an expansion of the marine protected area long term reef monitoring programs; near shore and offshore habitat mapping in selected areas selected areas; and surveys of intertidal reef communities across the State. The review also considered a plethora of reports and papers on selected locations or species, such as seagrass surveys of Corner Inlet and deep reef surveys of Port Phillip Heads.

Although there has been a considerable advancement in systematic, quantitative and comparable information on marine and coastal natural values in the last decade, the review identified considerable knowledge gaps. In terms of describing natural values, the review did not extend greatly on the descriptions provided by the Environment Conservation Council (2000). There remain large tracts of the Victorian marine environment that have not been scientifically surveyed, particularly intermediate and deep reef habitats and communities. For even well studied communities, such as seagrass beds and shallow reefs, we still lack knowledge of fundamental biological and ecological processes, such as biodiversity, growth age/mortality, habitat requirements, photosynthesis and production rates. These limitations make it difficult to identify aspects of conservation value, such as sites of particularly high production or communities with very old individuals that are not recoverable if impacted.

This review provided an assessment of natural values and conservation priorities according to the present knowledge status. While the findings provide an interim basis for conservation strategies and management, there is considerable scope for future improvement and redirection as fundamental knowledge gaps are filled.

7.1.2 Otway Bioregion

The Otway Bioregion is from southern South Australia to Apollo Bay. This region is a highly exposed coast with a predominance of coastal cliffs and extensive and complex deeper reef systems offshore. The seascapes include submerged volcano cones, drowned river channels, highly eroded underwater steps and reef faces and the islands of Lawrence Rocks and Deen Maar (Lady Julia Percy Island). Upwellings occur along the Bonney coast to Discovery Bay, Cape Bridgewater and Cape Nelson, which provide nutrient enrichment and increase productivity, making it an important area for seabirds, fur seals and whales. The reef habitats and communities are largely unexplored. They include extensive kelp and seaweed beds extending into deep waters, as well as sessile invertebrate (sponge garden) communities on complex inshore reefs and offshore deep reefs.

Both Lawrence Rocks and Deen Maar have important values for seabirds, seals and as island ecological units. Beds of bull kelp *Durvillaea potatorum* occur on patches of exposed, flat reef, with this species potentially being sensitive to changed oceanographic conditions from climate change. The seagrass *Amphibolis antarctica* forms significant beds in Dutton Bay, which supports a rare seaweed *Cystophora cymodocea*. Other rare and listed species include the blue whale *Balaenoptera musculus*, which feed in the Bonney upwelling region, ghost shrimp *Athanopsis australis* in Bridgewater Bay and snapping shrimp *Alpheus australosulcatus* in Dutton Bay. Rare plants are also present on Lawrence Rocks.

7.1.3 Central Victoria Bioregion

The Central Victoria Bioregion is between Apollo Bay and Waratah Bay. This region is moderate to sub-maximally exposed and consists of a series of coastal headlands and sandy beaches with extensive offshore reefs in places, but also extensive areas of sediment bed habitats. There are a variety of reef types and structures within the bioregion supporting a wide range of habitat and community types. A prominent and unique seascape feature is the 100 m deep canyon reef complex at Port Phillip Heads, which is subject to very strong currents and wave turbulence.

The canyon supports a unique sessile invertebrate community which is restricted to a small area and listed under the FFG Act. Unique deep sessile invertebrate and rhodolith (coralline plant) communities occur offshore from Point Addis and, although unsurveyed, other significant deep communities are likely to occur at Apollo Bay, Cape Schanck, Phillip Island (southeast pinnacle) and Cape Liptrap. Kelp bed habitats and communities dominate the shallow reefs. The seaweed assemblage of the Bunurong coast differs considerably in structure, having a high diversity of smaller species rather than a dominance of larger canopy formers typical of other Victorian shallow reefs. Other significant communities include: bull kelp *Durvillaea potatorum* beds in the Apollo Bay region and at Barwon Bluff; high diversity of opisthobranchs (sea slugs) at Point Danger; high fish diversity and abundance at Popes Eye; unique reef habitat at

Portsea Hole; and seagrass *Amphibolis antarctica* beds at Port Phillip Heads, Flinders and Bunurong. Kelp forests formed by string kelp *Macrocystis angustifolia* were once prevalent in the region, having dense surface canopies and distinctly different understorey and fish assemblages however this habitat type was diminished in 1998 and largely absent since 2000, although isolated *M. angustifolia* plants remain in some places.

Listed species include intertidal and shallow sea cucumbers *Apsolidium densum* (Skenes Creek and Flinders region) and *Pentocnus bursatus* (Cape Paterson) and the chiton *Bassethullia glypta* (Sorrento and Flinders). A significant seal colony is present on Seal Rocks, Phillip Island.

7.1.4 Flinders Bioregion

The Flinders Bioregion encompasses Wilsons Promontory in addition to islands of the promontory and northeastern Tasmania. This region is characterised by the steeply plunging granite rock of headlands and islands, separated by sandy beaches and extensive offshore sand beds. A range of environments are present, from sheltered habitats to the north on either side of the promontory, highly exposed reefs with high water clarity on the western side to more sheltered reefs influenced by sediment-laden water from Corner Inlet on the eastern side. Although the area of reef substratum is not extensive in this region, dropping steeply to sand, there is a diverse range of structures, from smoothly sloping bedrock, vertical walls, pinnacles, massive outcrops and ridges, large boulder fields and rubble beds. The shallow reefs supports a high biomass of kelp beds and, although seaweed diversity is generally lower than elsewhere, the fish diversity and biomass is relatively high. Much of the deeper habitats remain unsurveyed.

High value areas include the vertical reef communities of The Glennies, Citidel Is and Cleft Rock, as well as the deep sponge gardens and sea whip beds of Roaring Meg, Southeast Point, Fenwick Point and northern Waterloo Bay. Important seagrass habitat is present in Oberon Bay and Waterloo Bay, which includes small stands of *Posidonia australis*. A large seal colony is present on Kanowna Island and the northeastern region is a juvenile white shark *Carcharodon carcharias* aggregation area.

7.1.5 Twofold Shelf Bioregion

The Twofold Shelf Bioregion encompasses the Gippsland region from eastern Bass Strait to Cape Howe and southern New South Wales. The western coast, Ninety Mile Beach, consists of sandy beach and offshore sand beds, with some low profile reef offshore. The patches of low profile reefs have unique sessile invertebrate and seaweed communities.

Extensive sandy areas with patches of reef habitat occur along the East Gippsland and Croajingalong coasts. Reef environments are predominantly at Bemm River, Point Hicks, Big Rame Head and Cape Howe. Other significant seascapes are the island and pinnacle habitats of Beware Reef, Sensation Reef, New Zealand Star Banks, Tullaberga Island and Gabo Island. Upwellings occur in the region of the Bass Canyon, near Point Hicks, with nutrient enrichment occurring as far eastward as Gabo Island. Rare seaweeds and unique shallow reef communities, incorporating cool and warm temperate species, occur along the Croajingalong coast. Some shallow reef communities have exceptionally high densities of filter feeders, including crinoids *Cenolia trichoptera*, fan worms *Sabellastarte australis* and encrusting sponges, which may be associated with increased water column productivity from upwellings. The deep reef communities remain undescribed. Patches of the genetically distinct eastern bull kelp variety of *Durvillaea potatorum* occur at headlands along the coast with a western-most limit at Beware Reef. The range of this species has contracted substantially in New South Wales, possibly being impacted by increasing sea temperatures and associated reduced nutrient levels. A significant seal colony is present at Wingan Inlet.

7.1.6 Victorian Bays and Inlets

The Victorian Bays and Inlets consist of four major enclosed water bodies and numerous small inlets, the major ones being: Port Phillip Bay, Western Port, Corner Inlet/Nooramunga and Gippsland Lakes. The major inlets have very different environments and habitats.

Port Phillip Bay features the habitats: deep central muds; eastern sandy, *Pyura* bed and shallow reef habitat; and sheltered reef, seagrass, drift algae and estuarine habitats of Geelong Arm, Corio Bay and Swan Bay. Significant coastal habitats include wetlands and saltmarshes along Geelong Arm and in Swan Bay and Mud Islands which support important bird habitat. The areas of Swan Bay, Mud Islands and along the northern coast of Geelong Arm are listed as Ramsar Sites. The listed snapping shrimp *Athanopsis australis* occurs of Beaumaris and Port Arlington and the listed sea cucumber *Thyone nigra* occurs in Corio Bay.

Western Port is a highly tidal environment characterised by a network of sediment channels and intertidal mud flats. Significant tracts of mangroves and saltmarsh habitat occurs around the fringes of Western Port and remnant patches of intertidal and shallow subtidal seagrass occur on the mudflats. Western Port is an important bird feeding and roosting area and is a Ramsar wetland site. Significant marine communities include those of Crawfish Rock, San Remo and sediment channels. Crawfish Rock has a unique community of sessile invertebrates and seaweeds, which also supports the rare and listed hydroid *Ralpharia coccinea*. The listed San Remo invertebrate community has a high diversity of opisthobranchs, including the listed species *Platydoris galbana* and *Rhodope* sp. The sediment channels have significant populations of seapens *Virgularia mirabilis* and the ‘fossil’ molluscs *Neotrigonia margaritace*a, *Anadara tripezia* and *Magellania flavescens*. Western Port is listed as a Ramsar wetland. The rare and listed ghost shrimps *Michelea microphylla*, *Eucalliax tooradin* and *Paraglypturus tooradin* are only known from the North Arm sediment channel of Western Port.

Corner Inlet and Nooramunga has very large intertidal mudflat areas and substantial fringing mangrove stands. The intertidal and subtidal sediment banks also support stands of four species of seagrasses, including significant stands of *Posidonia australis* which is largely restricted to Corner Inlet in Victoria. Corner Inlet also has an extensive network of sediment channels. This inlet is listed as a Ramsar wetland, being a significant wetland for waterfowl. Although unmeasured, the extensive intertidal mudflats are likely to have high primary productivity from microalgae and high secondary productivity by infauna within the sediments. Listed species include the sea cucumber *Trochodota shepherdi* in seagrass beds of Nooramunga and Corner Inlet and the brittlestars *Amphiura trisacantha* and *Ophiocomina australis* in seagrass beds of Nooramunga.

Gippsland Lakes includes a system of estuarine lakes with considerable areas of seagrass, estuarine grass *Ruppia* and saltmarsh habitat. This region is listed as a Ramsar site. The environment in Gippsland Lakes has been highly modified through construction of the permanent opening to the sea at Lakes Entrance and changes to riparian vegetation and river flows.

The smaller Andersons Inlet, Shallow Inlet and Mallacoota Inlet are important wetland and water fowl sites.

7.2 Key Knowledge Gaps

As described in Section 5.2, there is a paucity of information for identifying marine conservation values and priorities (summarised in Table 7.1). Our inventory of marine natural values is limited to only very small areas of Victoria. The distribution of habitats is poorly known, let alone for species and communities. Fundamental natural history and biology of even common species is generally lacking, with the exception of commercially important species. We have little understanding of the ecological requirements of species and communities, including the vulnerability to threats. Long-term monitoring is presently restricted to a few commercial species and shallow reefs associated with marine protected areas.

The ability to measure and understand temporal stability, patterns and changes is presently limited to a few commercial species (such as rock lobster and abalone) and places (such as demersal fishes surveys of Port Phillip Bay) and shallow reefs associated with marine protected areas. We presently have little sentinel monitoring to detect changes in marine conservation status.

7.3 Conservation Status

7.3.1 Conservation Policies

Marine nature conservation is managed through a variety of State and Commonwealth policies, with an overview provided in Section 5. Principal strategies are through the direct management and mitigation of threats, marine protected areas and increased protection of particular species or communities.

7.3.2 Threats

There are a variety of threats that occur across the State, each having different implications for different communities and species. General threats have been listed and qualitatively ranked for a variety of state of the environment reviews and were replicated in this study (Section 3). Major threats include: water quality effects of eutrophication, dredging and catchment activities; fishing, including direct biomass removal and secondary ecosystem impacts; marine pests; coastal development and climate change. Of these, fishing is presently the most influential threat in marine habitats, with water quality changes in bays and inlets also being a major influence. Development and urbanisation is a major threat to intertidal and coastal environments. Marine pests and climate change have the potential to catastrophically impact marine and coastal values in the future.

To fully consider conservation status with respect to threats requires a detailed assessment of each threat level for each natural value or asset. This would require considerable effort as there are a large number of combinations of threats by natural values by locations. Such an analysis is presently limited by an incomplete inventory of natural values, little documentation or monitoring of threat levels and little understanding of ecological processes and how threatening processes work (*i.e.* the vulnerability and responses of natural assets to threats).

7.3.3 Marine Protected Areas

A comprehensive and representative system of marine protected areas was implemented for each Victorian bioregion in 2002. These areas included and supplemented previously protected areas in some of the bioregions, such as the Harold Holt marine reserves in Port Phillip Heads, the Bunurong marine sanctuary and various marine and coastal parks. These areas encompassed many of the natural values described by the ECC (2000).

The existing marine protected areas were reviewed in terms of their comprehensiveness, adequacy and representativeness (CAR), as well as any implications from the review of natural values and conservation priorities (Section 5.3). Some general issues identified from this gap analysis were:

- existing management plans for marine national parks and marine sanctuaries do not explicitly state conservation values being protected by the area (*i.e.*

the conservation objectives of the MPAs) – these objectives are more explicit within the ECC (2000) recommendations;

- there are generally no management plans and publicly stated conservation objectives for older marine protected areas, including marine and coastal parks;
- many natural values identified by the ECC (2000) were proposed to be protected within special management zones, which do not qualify as marine protected area status, and no additional protective measures are applied to these areas;
- there were considerable discrepancies with the location of the boundaries and the stated or presumed conservation objectives – for example the Ninety Mile Beach Marine National Park did not include low profile reef habitat even though it was clearly an important natural value of that bioregion; and
- the boundaries of most of the marine sanctuaries were poorly placed or the area too small to provide adequacy of protection.

There is considerable scope for greatly improving the conservation status of marine natural values through adjustments of existing marine protected areas. This includes revision of objectives such that conservation objectives are explicit and management expectations and actions can be directly targeted to the objectives. There are also many cases where the boundaries are adjacent to, but exclude habitats intended to be protected by the MPA.

There are many areas identified by both the ECC (2000) and this review that fulfill the criteria for MPA designation and management, but do not necessarily need to be in no-take zones such as marine national parks or marine sanctuaries. Although the ECC recommended such areas be designated special management zones, there is little security in such a designation as they can be overturned without a parliamentary process. The present special management zones also have not resulted in any increased protection. Consequently, different approaches need to be considered, such as some other form of marine and coastal park designation, for these areas that qualify as marine protected areas.

This conservation review and gap analysis identified important knowledge gaps, with the habitats and biodiversity of considerable areas being unknown to science. It would be prudent to expedite surveys in such areas prior to any changes or additions to the MPA. This would ensure comprehensiveness and representativeness, as well as the inclusion of unique or special communities.

7.3.4 Threatened Species and Communities

The threatened large and charismatic marine and coastal fauna, including whales, birds and reptiles, are well covered by listings under the FFG and EPBC Acts. Other groups such as seaweeds and invertebrates are poorly represented, with only one hydroid, three molluscs, two brittle stars, five sea cucumbers and three shrimps listed.

The present small number of listed species belies the actual conservation status of marine species in Victoria. This is largely through lack of information. Biodiversity surveys have largely been restricted to a few areas and habitats in Victoria and, as such, we have a poor inventory of species and their distributions. As reviewed by Ponder *et al.* (2002), less than half the marine invertebrates in Australia have been formally described and our taxonomic capacity to improve this situation is diminishing. New species of seaweeds are frequently discovered as new areas are surveyed and it is estimated there are potentially thousands of sponge species awaiting description within the Museum of Victoria. On this basis, there are likely to be many marine species that deserve listing and management as threatened species.

There are presently two listed marine communities; the San Remo opisthobranch community; and the Port Phillip Heads canyon sponge community. As with species, the listing of communities is highly limited by the available information, with marine communities only surveyed in a small proportion of Victorian marine waters. It is probable there are other threatened marine communities.

A review of the conservation measures for listed species and communities indicated that some had a high degree of protection and control of threats, such as for whales, and some species were protected by default within marine protected areas. Most fully marine species have received little to no direct management action, with Action Statements only being in draft form.

7.4 Conservation Priorities

Conservation priorities were analysed from a spatial perspective to determine areas that are adversely threatened with respect to the ecological and conservation values of those areas. A key element of the analysis design was to implement a systematic and repeatable method to reduce subjective biases. The analysis was at a coarse resolution of habitats, in accordance with the presently available scientific and anecdotal information available to support the analysis.

The Victorian coast was divided into arbitrary biogeographic units within each bioregion. These biounits comprised areas with obviously different ecosystem properties, for example southern Phillip Island, Wonthaggi coast, Bunurong coast and Venus Bay coast. They are not based on a rigorous assessment of biological and geophysical data. The presences of habitat types were determined for each of the 90 biounits, along with the presence of threatening processes. The conservation values of each habitat type were assigned using ecological importance criteria (such as those used for identifying candidate MPAs and for impact assessments) and values of habitats in terms of providing ecosystem services. Threats were also determined for each habitat type, taking into different processes for different habitat types, including an iterative assessment of secondary threats (knock-on effects).

A database algorithm was used to combine the information for each area (habitats within biounits), iterate through secondary threats and rank the areas in terms of conservation priority. The analysis was considered an interim analysis until more comprehensive information is available. As with any model, the results are subject to change with better quality input data.

In addition to the statewide, habitat conservation priorities analysis, the gap analysis also identified priorities in terms of representative, comprehensive and unique or special known values. The gap analysis was highly limited by our paucity of knowledge of marine natural values below low tide in Victoria.

The top 20 priority areas for conservation action, identified from both the priority habitats analysis and the gap analyses, are presented in Figure 7.1. The key values of these areas are summarised in Table 7.2. These areas include ecological units or sites of uniqueness or ecological significance, such as Deen Maar Island, Port Phillip heads canyon, Crawfish Rock, Phillip Island Pinnacles and Gabo Island. Some areas were prioritised because of threat levels, particularly estuaries and wetlands such as Anderson Inlet and Gippsland Lakes. Other areas are important in terms of representativeness and comprehensiveness, such as the reefs and sediment beds of Ninety Mile Beach (Figure 7.1).

7.5 Recommendations

7.5.1 Gap Analyses

A primary limitation in the marine and coastal conservation assessments was the lack of comprehensive and appropriate information. Suggestions for improving our knowledge base are listed in Table 7.1.

7.5.2 Conservation Priorities

Specific recommendations were provided with the detailed gap analysis. These included recommendations for improving the efficacy of existing marine protected areas and conservation of rare and threatened species and communities. Recommendations associated with the top 20 priority areas are summarised in Table 7.2.

7.5.3 Strategies for Improved Conservation Outcomes

As mentioned in the recommendations above, there is considerable scope for improving conservation outcomes within the existing policy framework. There are presently two existing policies that are generally not implemented but have the potential for substantial conservation improvements. One is the use of adaptive environmental management where the natural value is monitored, management decisions are implemented to improve the situation, changes to the natural value are measured, the efficacy of the management actions are assessed and adapted and the improvements on the natural value assessed again (this is often termed an adaptive management cycle). Key principles of this management approach are outcomes based assessment and continual improvement. This approach is enshrined within the Biodiversity Strategy of the FFG Act and in the international environmental management standard ISO 14000. Despite being considered best practice and often quoted in management plans, there are few instances of it being applied properly in Victoria. Two examples of its effective and transparent application are for the fisheries management of abalone and rock lobster fisheries. Examples of poor application are the succession of dredging projects, where turbidity may be monitored, but biological outcomes are invariably neglected to be monitored in a manner that supports responsive or preventative management actions. This is also a problem for some Action Statements for listed species and communities. Increased encouragement or enforcement of outcomes-based monitoring and assessment has several advantages for conservation:

- natural values and entities of importance (species, communities, ecosystem processes and environmental quality) and managed directly and decisions are based on observation rather than assumption;
- the monitoring process increases information levels and understanding of natural states and processes;
- examples of disturbance or improvement activities are documented to assist with predictions of future impacts or improvements from human activity.

A second existing policy that is worthy of increased application is that of ecosystem-based management. Ecosystem based management requires consideration of not only direct relationships between threats (such as fishing) and species responses, but implications on ecosystem processes and secondary, knock-on effects as well. This is presently a commonwealth government requirement for export fisheries, but is a concept of equal merit for application to other natural resource and environmental management. While Victorian export fisheries, such as for southern rock lobster, giant crab and abalone, recognise the requirement for ecosystem-based fishery management (EBFM), there is presently no rigorous evaluation of ecosystem effects. As stated in the gap analysis, there is a paucity of knowledge to do this so the first step would be targeted studies on key ecosystem processes, something which is not presently occurring. Ecosystem-based management has merit for all forms of natural resource management; however it requires integrated information flow and management responses between different agencies and organisations. The introduction of ecosystem-based limits, discussed below, solves some of this difficulty.

A problem with understanding the ecosystem implications of management decisions is that ecosystems have emergent properties that are difficult to learn from small research projects on isolated parts. The strategies of Walters and Holling (1990) are ‘learning while doing' and established the best-practice concept of 'adaptive management'. The principles of Holling and Walters adaptive management are to implement ecosystem-scale experiments as part of the resource management processes. This involves designating large areas (whole ecosystem units, > 10s km) and managing them quite differently, including extremes of perturbations (within sustainable levels) for potentially decades, to measure and determine ecosystem responses and properties. Ecosystem properties and processes can also be learned from 'natural experiments' such as responses during drought years, as well as from human perturbations, such as dredging turbidity plumes or marine pest incursions. There is presently little impetus or capacity to capitalise on such opportunities.

A relatively new conservation strategy is to place absolute limits on changes to important ecosystem components or processes. An example is the protection of marine benthic vegetation in Western Australia, where limits are placed on the cumulative loss of marine plant habitats – reflecting their value for habitat provision for other species and for benthic primary production (*e.g.* WAEPA 2004). Thresholds range from none in highly impacted areas, 10 % in development areas to 1 % in high protection areas. There are other ecosystem components/processes that could be similarly protected. Examples include: primary carbon production rates (linked to light climate); denitrification efficiencies in sediments; and abundances of functional species, such as large adult rock lobsters for controlling sea urchin abundances. This approach has advantages of: directly protecting important ecological processes; providing impetus for adequate quality of information for management and impact prediction; and providing a common element of ecosystem-based management between jurisdictions.

Lastly, another new conservation strategy is that of resilience building. This concept is based on the fact that properly functioning communities can often resist, buffer or recover from changes caused by increased environmental pressures, at lower disturbance levels. For example, climate change is likely to cause a westward expansion of the long-spined sea urchin *Centrostephanus rodgersii*, which often causes large habitat changes from kelp canopies to sea urchin barrens. Such changes may be prevented or mitigated through increased density and predation by large adult rock lobsters, which are presently fished down to very low densities. Resilience building involves the restoration of important ecosystem components or processes, such as large predators. It also involves maintaining redundancy in communities, including biodiversity such that multiple species are present to fulfil ecological roles and there are multiple sources of recruitment. The reduction of human disturbance levels also provides greater capacity for communities to respond and potentially buffer against other disturbances. For example, fished populations are presently maintained at very low proportions of virgin biomass to maximise the annual production and yield. Increased resilience for some fished populations and ecosystems may be provided by maintaining higher standing stocks. There is presently considerable uncertainty of the best means of building resilience and this is best addressed from a variety of perspectives:

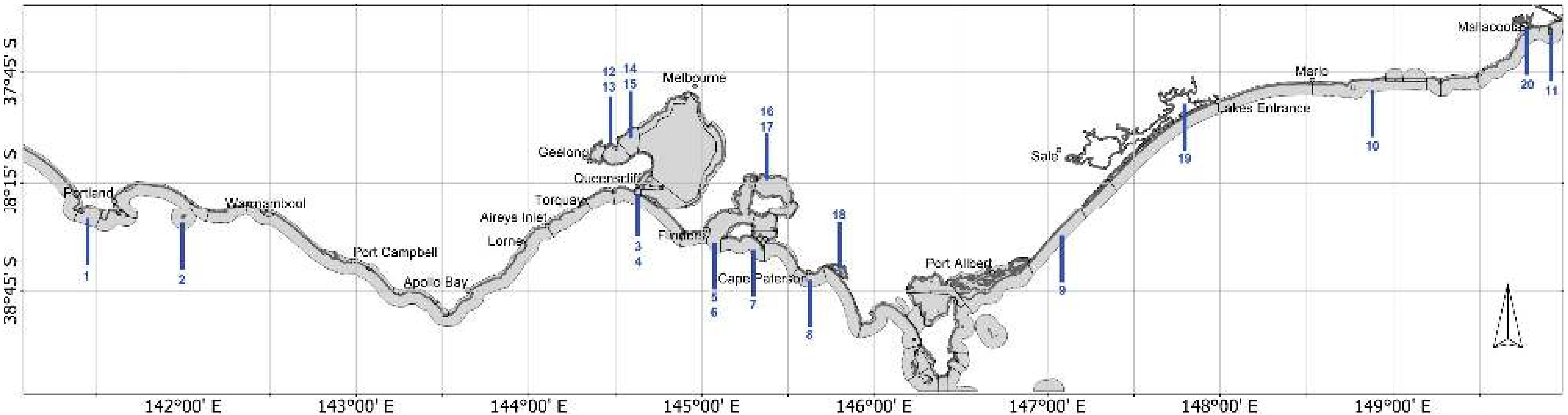
- restoring communities and ecosystems known to be degraded (for example most reefs are missing large predators);
- providing a buffer above minimum sustainable limits;
- reducing controllable perturbations to increase capacity for response to uncontrollable or unforeseen disturbances;
- provide redundancy of functional components or species and areas; and
- have a representative and comprehensive system of highly protected marine areas, including areas with minimal human disturbance to maximise the potential for rebuilding of fully functional systems and areas that act as biogeographical buffers.

In all of the existing and new strategies for conservation management, there are some generic needs:

- improved inventory of natural values and knowledge of biological and ecological processes;
- monitoring of conservation status, including levels of both threats and biological components;
- controlling and reducing threats and perturbations;
- restoration and improvement of communities and ecosystems.

Table 7.1. Key knowledge gaps and potential approaches for addressing them.

Knowledge Gap	Rationale	Recommendation
Lack of taxonomic and distributional information for marine species below the low tide mark, including levels of local and regional endemism and rarity.	Species distribution and abundance information is the basis for all biodiversity management. If this is lacking, value and significance cannot be properly assigned, and long-term monitoring is not possible.	More and better biodiversity surveys, sampling a wider array of habitats, including those outside threatened areas. Standardisation of methods across projects to provide complimentary data. Requires increased field survey effort and increased taxonomic resources.
Lack of strategic information on marine-dependent species, including the ecological values of species, such as old-age populations, recruitment source communities and keystone species.	To identify areas of conservation value based on population, community and ecological values. Taking the focus off just threatened species, given the poor listing effort and putting it onto highly valued and functional parts of the ecosystem.	Workshops, review and collation of knowledge about ecosystem processes. Identification of critical knowledge gaps and streamlining of research efforts into an integrated plan for Victoria.
Paucity of available information on ecosystem linkages and processes, particularly subtidal	Understanding processes is essential for assessing value and significance, for identifying functional 'hotspots' and for predicting consequences of change and responses to threats. Without this, environmental assessment is substantially constrained.	Workshops, review and collation of knowledge about ecosystem processes. Identification of critical knowledge gaps and streamlining of research efforts into an integrated plan for Victoria.
Only small proportion of marine habitats mapped. Lack of any consistent approach to community description and mapping.	Leads to poor recognition of local ecology significance (*e.g.* in impact assessment). Inhibits all stages of biodiversity management and planning of surveys and monitoring.	Hierarchical system of community characterization based on physical and biological parameters. Initial coarse resolution surveys, then adapted and augmented to finer resolution over time. Complete coverage of fine-resolution bathymetry mapping. Development of predictive models to fill gaps until all areas have been surveyed.
Inadequate listing process for marine threatened species and communities.	Understanding the degree of isolation and vulnerability of particular communities and species is critical to biodiversity management.	More systematic and rapid listing of species and, in particular, communities in the marine environment. Requires increased biodiversity survey effort and increased taxonomic resources.
Paucity of long-term monitoring and time-series information – limited to a few community types and sentinel stations.	Benchmarking and changes over time are required to detect declines or deterioration of populations and communities and to understand and manage threatening processes.	Review, standardisation and integration of many existing programs where possible – data sharing between organisations. Development and implementation of strategic, long-term sentinel monitoring across the state to provide fundamental information for management needs.



Habitat Class			Coastal/Dune			Exposed Littoral		Sheltered littoral (estuaries and wetlands)					Sheltered subtidal (bays and estuaries)				Subtidal to state limit				
Subhabitat			Dune	Grasses	Heaths	Dune	Intertidal reef	Fauna feeding, breeding and resting area	*Ruppia/* estuarine grass	Salt marsh	Sand flats	Seagrass	Channels	Drift weed	Intertidal reef	Seagrass	Deep reef	Pinnacle/ Canyon	Seagrass	Sediment beds	Subtidal reef
Bioregion		Identified Area																			
Otway	1	Bridgewater Bay					■												■	■	■
	2	Deen Maar Island		■	■		■	■													■
Central Victorian	3	PPH - Point Nepean																	■		
	4	PPH - Point Nepean															■	■			
	5	Western Channel Flinders					■												■		■
	6	Summerland & Seal Rock	■	■	■	■	■	■													■
	7	Phillip Is Pinnacles															■	■		■	
	8	Bunurong MCP																	■		■
Twofold	9	Ninety Mile Beach															■			■	
	10	Bemm Reef																			■
	11	Gabo Island		■	■		■	■													■
Victorian Bays and Inlets	12	Clifton Springs										■									
	13	Pt Lillias to Pt Wilson							■	■						■					
	14	Pt Wilson to Kirk Point								■											
	15	Wedge Pt												■							
	16	French, Yaringa, Churchill						■		■			■			■					
	17	Crawfish Rock											■				■	■			
	18	Anderson Inlet						■	■	■	■										
	19	Gippsland Lakes	■	■	■	■		■	■			■									
	20	Mallacoota Inlet						■	■	■	■										

Figure 7.1. Top 20 priority areas for conservation action in Victoria, identified as areas of high conservation priority and as gaps in the existing system of MPAs in Victoria; or assessed as priorities using subjective rationale. **Note**: these are shown in geographic order, not in order of priority.

Table 7.2. Top 20 priority areas for conservation action in Victoria. Blue (☐) areas were identified as areas of high conservation priority and as gaps in the existing system of MPAs in Victoria; Yellow (☐) areas were identified as gaps in the existing system of MPAs and assessed as priorities using subjective rationale. **Note**: these are shown in geographic order, not in order of priority.

	Bioregion	Region	Identified area	Habitat class	Habitat	Values	Recommendation
1	Otway	Bridgewater Bay	Bridgewater Bay	• Subtidal to state limit	• Sediment beds	• Seal haulout • Sparse seagrass • Listed crustacean	Conservation zone (with activities commensurate with protection of values of concern).
2		Deen Maar Island (Lady Julia Percy Island)	Deen Maar Island	• Coastal Vegetation • Exposed Littoral, • Subtidal to state limit	• Fauna feeding, breeding and resting area • Intertidal reef • Subtidal reef	• Seal breeding colony • White shark area • Seabird rookery • Macrocystis kelp habitat • High productivity	Marine Sanctuary or conservation zone.
3	Central Victorian	Port Phillip Heads	Port Phillip Heads MNP Point Nepean	• Subtidal to state limit	• Seagrass	• *Amphibolis* seagrass • Dolphin refuge	Extend northern Nepean Bay boundary to encompass seagrass habitat extent. Potentially add conservation zone into Tricondera Bay as dolphin refuge.
4		Port Phillip Heads	Port Phillip Heads MNP Point Nepean	Subtidal to state limit	• Deep Reef • Canyon	• Listed habitat • High diversity sessile invertebrate community	Reduce or remove excision between Point Lonsdale and Point Nepean MPAs to include deep reef habitat.
5		Western Channel, Flinders	Flinders/ Honeysuckle/ Merricks	• Exposed Littoral, • Subtidal to state limit	• Intertidal reef • Subtidal reef	• Listed species • *Amphibolis* seagrass • Sea dragon colonies	Conservation zone or special management zoning
6		Western Channel, Phillip Island	Summerland Peninsula and Seal Rocks	• Coastal Vegetation • Exposed Littoral, • Subtidal to state limit	• Fauna feeding, breeding and resting area • Intertidal reef • Subtidal reef	• Seal breeding colony • White shark area • Penguin colony • Muttonbird rookery • Macrocystis kelp habitat • High productivity	Marine Sanctuary or conservation zone.

Table 7.2. (continued). Top 20 priority areas for conservation action in Victoria. Blue (☐) areas were identified as areas of high conservation priority and as gaps in the existing system of MPAs in Victoria; Yellow (☐) areas were identified as gaps in the existing system of MPAs and assessed as priorities using subjective rationale. **Note**: these are shown in geographic order, not in order of priority.

	Bioregion	Region	Identified area	Habitat class	Habitat	Values	Recommendation
7	Central Victorian (continued)	Southern Phillip Is	Cape Schanck or Phillip Island Pinnacles	• Subtidal to state limit	• Pinnacle/Canyon • Deep Reef	• Deep reef and offshore sediment habitat • Sessile invertebrate diversity	Conservation zone or special management zoning
8		Bunurong, Inverloch	Bunurong MCP Conservation Zones	• Subtidal to state limit	• Seagrass	• Listed species • *Amphibolis* seagrass habitat • Crevice fauna	Review and formalize objectives and permitted activities within the conservation zones.
9	Twofold	Ninety Mile Beach	Ninety Mile Beach MNP	• Subtidal to state limit	• Intermediate depth reef • Sediment beds	• Intermediate depth low profile reef • High diversity infaunal community • White shark area	Survey of natural values of existing MNP, including presence of reef, sediment invertebrate diversity and shorebird breeding habitat. Expand boundaries or add area to encompass core conservation purposes.
10		Croajingolong, Marlo to Bemm	Bemm Reef	• Subtidal to state limit	• Subtidal reef	• Upwelling • High productivity. • Filter feeding assemblages. • Seaweed biodiversity – rare species	Conservation Zone or special management zone.
11		Gabo Island	Gabo Island	• Coastal Vegetation • Exposed Littoral, • Subtidal to state limit	• Fauna feeding, breeding and resting area • Subtidal reef	• Penguin colony • Seabird rookery • High diversity invertebrate community • High fish diversity • Listed species	Marine Sanctuary or conservation zone. Review and formalize objectives and permitted activities within the special management zone.

Table 7.2. (continued). Top 20 priority areas for conservation action in Victoria. Blue (☐) areas were identified as areas of high conservation priority and as gaps in the existing system of MPAs in Victoria; Yellow (☐) areas were identified as gaps in the existing system of MPAs and assessed as priorities using subjective rationale. **Note**: these are shown in geographic order, not in order of priority.

	Bioregion	Region	Identified area	Habitat class	Habitat	Values	Recommendation
12	Victorian Bays and Inlets	Lillias to Wilson	Clifton Springs	• Sheltered subtidal (bays and estuaries)	• Seagrass	• Intertidal and subtidal seagrass beds • High productivity	Conservation Zone or special management zone.
13		Lillias to Wilson	Point Lillias to Point Wilson	• Sheltered subtidal (bays, estuaries and wetlands)	• Seagrass • Saltmarsh	• Ruppia/estuarine grass • *Halophila* seagrass • Saltmarsh	Conservation Zone or special management zone.
14		Northern Geelong Arm	Point Wilson to Kirk Point	• Sheltered littoral (bays, estuaries and wetlands)	• Saltmarsh	• Saltmarsh	Conservation Zone or special management zone.
15		Northern Geelong Arm	Wedge Point, offshore	• Sheltered subtidal (bays, estuaries and wetlands)	• Drift algae	• Unique community	Conservation Zone or special management zone.
16		North Arm, Western Port	• French Island MNP • Yaringa MNP • Churchill Island MNP	• Sheltered subtidal (bays, estuaries and wetlands)	• Channels, • Seagrass • Mangrove and saltmarsh habitats	• Channel habitat • Barrellier Is bird roost • Mangrove and saltmarsh habitats	Survey channel biota and review adequacy and boundaries in conjunction with other MNPs in Western Port. Review boundaries and objectives with respect to these habitats e.g.: • Extend French Island MNP boundary northward to Joe Island. • Extend French Island MNP boundary to encompass Barrellier Island. • Move southern boundary, Churchill Island.
17		North Arm, Western Port	Crawfish Rock	• Sheltered subtidal (bays, estuaries and wetlands)	• Pinnacle/Canyon • Deep Reef • Channels	• Unique community • High invertebrate diversity • Listed species	Marine Sanctuary or conservation zone.

Table 7.2. (continued). Top 20 priority areas for conservation action in Victoria. Blue (☐) areas were identified as areas of high conservation priority and as gaps in the existing system of MPAs in Victoria; Yellow (☐) areas were identified as gaps in the existing system of MPAs and assessed as priorities using subjective rationale. **Note**: these are shown in geographic order, not in order of priority.

	Bioregion	Region	Identified area	Habitat class	Habitat	Values	Recommendation
18	Victorian Bays and Inlets (continued)	Lakes Entrance	Gippsland Lakes	• Sheltered littoral (bays, estuaries and wetlands), • Coastal/Dune, • Exposed littoral	• Seagrass • Fauna feeding, breeding and resting area • Ruppia/estuarine grass • Grasses • Heaths • Dune	• Biodiversity – Ramsar wetland values	Overlay MCP over Ramsar wetland, as per Corner Inlet MCP
19		Anderson Inlet	Anderson Inlet	• Sheltered littoral (estuaries and wetlands)	• Sandflats, • Fauna feeding, breeding and resting area, • Saltmarsh	• *Ruppia* and enclosed lagoon habitats • Bird feeding and roosting.	Conservation Zone or special management zone.
20		Mallacoota Inlet	Mallacoota Inlet	• Sheltered littoral (estuaries and wetlands)	• Sandflats, • Fauna feeding, breeding and resting area, • Saltmarsh	• *Ruppia* and enclosed lagoon habitats • Bird feeding and roosting.	Conservation Zone or special management zone.

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