2. Marine & Coastal Ecosystems

Guide to chapter 2

This chapter focuses on marine and coastal environments in recognition of their tight ecological links and the need for integrated management. The area of focus is waters under the jurisdiction of the Victorian government, which extend 5.5 kilometres seaward from the high water mark, and land within 500 metres of the shoreline. Some issues relevant to the coast are covered in chapters 3 and 4 on terrestrial and freshwater ecosystems.

Section 2.1 describes the high natural, social and economic values of Victoria's marine and coastal ecosystems and the major habitat types. Section 2.2 outlines the status of biodiversity and protected areas, and the condition of bays, inlets and estuaries. Major threats to marine and coastal nature – particularly climate change, coastal development, invasive species and fishing – are described in section 2.3. Section 2.4 is a summary of a gap analysis of Victoria's marine protected areas, which identifies bioregional priorities for new and expanded marine national parks and sanctuaries. Similarly, for coastal subregions, section 2.5 summarises an analysis of values, threats and priorities for upgrading the national park and conservation system. Finally, in sections 2.6 and 2.7, policy gaps and high priority reforms are identified in three major areas: improving knowledge, creating a comprehensive, adequate and representative national park and conservation system, and integrating and strengthening management of marine and coastal environments.

Topics covered

2.1 Values

2.2 State of marine and coastal ecosystems

- Biodiversity
- National park and conservation system
- Bays, inlets and estuaries

2.3 Major threats

- Climate change
- Dysfunction of biological interactions
- Habitat loss and degradation
- Over-exploitation

2.4 Marine bioregional values and priorities

2.5 Coastal bioregional values and priorities

2.6 Conservation gaps and priorities

- Knowledge gaps
- National park and conservation system
- Bays, inlets and estuaries
- Marine and coastal management
- Governance structures and processes
- Fishing

2.7 Future directions

2.8 Sources

2.1 Values

The wild beauty of Victoria's southern edge draws millions of visitors each year – to stroll on beaches and peer into rock pools, to watch seabirds riding coastal breezes and shorebirds probing sand and mud for prey to fuel up for their flight to the northern hemisphere, to surf and paddle, to explore underwater reefs and sponge gardens. The multiple attractions reflect the great diversity of habitats – sandy and muddy flats, estuaries, saltmarshes, cliffs, rocky reefs, seagrass meadows, kelp forests, among the many – inhabited by a multitude of life forms, many unique to Victoria.

Although less celebrated than tropical reefs, Australia's southern waters host many more unique species, and have the world's greatest diversity of red and brown seaweeds, sea mosses, crabs, shrimps and sea squirts.[1]

Victoria's coastline winds and wriggles for more than 2000 kilometres – about 1900 kilometres along the mainland and 600 kilometres around islands.[2] The terrestrial coastal ribbon (to 500 metres inland) covers about 1100 square kilometres and state waters (to 5.5 kilometres seaward) cover almost 7000 square kilometres, in combination close to 4% of Victoria's land-sea surface area.

Because of the many physical, climatic and biological factors overlapping where land and waterways merge into ocean, coastal habitats are inherently dynamic. Twenty thousand years ago, as the last ice age was drawing to a close, Bass Strait did not exist, Port Phillip Bay was part of the Yarra River floodplain and the sea level was about 100 metres lower. The shoreline has been fairly stable for about 6000 years.

The natural dynamism of these environments is both intensified and undermined by human activity: the rate of change has accelerated but coastal resilience has been compromised, reducing the capacity of natural systems to adapt to change. Victoria's marine and coastal environments are straining under the pressure of unsustainable human development, biological dysfunction due to species introductions, over-exploitation and climate change. Much of what lures people to the coast is at risk.

2.1.1 Biodiversity

Our southern marine communities are as distinctively Australian as our terrestrial marsupials and other flora and fauna.

Environment Conservation Council, 2000[3]

The biological richness and uniqueness of Victoria's marine environments derive from 80 million years of geological isolation restricting gene flow from other geographical regions, a lack of mass extinction events, and regional variability in geology, topography, oceanography and climate fashioning multiple habitats over a relatively small area. [4] Several currents and oceanic influences intersect in Victorian waters – the warm East Australian Current, the temperate South Australia Current, and northern Bass Strait and cold subantarctic surface waters. They place Victoria at the confluence of three marine biogeographic provinces, reflected in the mix of species shared with western, eastern and southern areas.[5]

The coarsest measure of Victorian diversity is at the bioregional level, each bioregion 'a cluster of interacting ecosystems that are repeated in similar form throughout' sharing similarities in physical and biological features.[6] Under a national classification scheme, there are six marine bioregions around Victoria: five in state waters (out to 5.5 kilometres) – four along the open coast and one grouping bays and inlets – and one outside state jurisdiction (Central Bass Strait).[7] Although Victoria's state waters account for less than 0.1% of Australia's exclusive economic zone, 8% of bioregions are represented there, a reflection of its habitat diversity. In this report, the five state bioregions have been further divided into 20 biounits to represent finer scale regional diversity, based on work by Australian Marine Ecology (see section 2.4).[8]

Victoria's coast also has high habitat diversity featuring parts of six terrestrial bioregions and 10 subregions, based on a national classification scheme.[9] At a finer scale, the coast (the area within 500 metres of

the shoreline) features 95 vegetation types, known as ecological vegetation classes, almost one-third of Victoria's total (at the bioregional level) (Box 2.1). They include scrubs, shrublands, heathlands, forests, woodlands, grasslands, lagoons, wetlands and marshes. Thirty-four vegetation classes (more than 10% of Victoria's total) are unique to the coast. The wetlands, sandflats and mudflats merging with beaches, sand dunes, cliffs and shore platforms on Victoria's coastline provide many different habitats for plants and animals, including strongholds for shorebirds. Some of the three dozen migratory shorebird species that spend part of the year in Victoria and travel thousands of kilometres to the northern hemisphere to breed undertake 'the longest known journeys in the natural world'.[10]

Australia's southern waters, particularly in the southeast, are more species-rich than most other temperate seas worldwide and host many more unique species than the more celebrated Great Barrier Reef. The level of endemicity (uniqueness) in many marine groups is close to 90%.[11] Victoria's marine diversity is particularly high in:[12]

- seaweeds (large marine algae),
- marine sediment infauna (animals living in soft sediments on the sea bottom, usually in tubes or burrows),
- hydroids (plant-like animals related to jellyfish, sea anemones and corals, usually living in colonies attached to rocks or plants),
- sea mosses (bryozoans – small colonial animals), and
- sponges (animals that lack true tissues and organs, with bodies full of pores and channels).

Southern Australia has the highest level of seaweed endemism (62%) of any region globally, as well as the highest species richness, with more than 1150 species.[13] The exceptional endemism of southern seaweeds is due to long stability and isolation of the Australian continent – 30 million years from Antarctica and 80 million years from other land masses – because seaweeds rarely disperse across ocean basins. It is also due to the extent and diversity of rocky habitats in southern Australia (seaweeds need something firm to attach to). Seaweeds have additional high value because, along with seagrasses, they are the main primary producers in marine waters – 'in some areas producing far more plant material than the richest agricultural land' – and they serve as food, habitat and predator protection for many animals.[14]

Sponge diversity and endemism is also exceptional, with Victorian waters hosting 523 of Australia's 1416 described species.[15] Port Phillip Heads Marine National Park has at least 115 sponges endemic to the park,[16] and the bay is rich in many other species as well: a combination of seagrass meadows, sponge gardens, wetlands, sandflats, mudflats and subtidal and intertidal reefs provide habitats for about 300 fish species and hundreds of species of molluscs, crustaceans, seaweeds, bristle worms and cnidarians.[17]

One vertebrate marine mammal is endemic to southern Australian waters, the Burrunan dolphin, described as a species in 2011 and known primarily from Port Phillip Bay and Gippsland Lakes.[18] It is endangered (according to the Victorian government's advisory list), although not formally listed.

Much marine and coastal biodiversity has become rarer due to human impacts (section 2.2.1): more than 180 species on the state government's advisory lists are considered threatened (Table 2.3, Table 2.4) as are about two-thirds of coastal ecological vegetation classes (Table 2.5). Two marine ecological communities and three coastal communities are formally listed as threatened. But the conservation status of most biodiversity, particularly in the marine environment and particularly marine invertebrates, is unknown.

2.1.2 Social and economic values

[The] value of Victoria's non-commercial coastal ecosystem services ($8.4 billion per year) is similar to the value of commercial coastal activities ($9.8 billion per year). … The results demonstrate the need for decision makers to consider the tradeoffs between the benefits of healthy functioning ecosystems and those associated with expanding use and development.

WorleyParsons, 2013[19]

The coast is extremely popular with Victorians. A 2012 survey found that 84% had made at least one trip to the coast in the previous year, and the average was 23 trips.[20] The most common activities were walking or hiking (63% spent time doing this), swimming (52%) and nature-based activities/appreciation (31%). The survey found that the top three things contributing to a good coastal or marine experience for respondents were clean water, a lack of rubbish, and an unspoilt/undeveloped natural environment.

There is increasing recognition of the extremely high value of ecosystem services (benefits for humans and other species due to natural functions of ecological systems) provided by marine and coastal environments. There has long been appreciation of the value of natural products, such as fish, but only very recently has there been any attempt to identify and value other services by nature, which include the following for coastal habitats: [21]

Provisioning services: raw materials for agriculture, food (such as fish), oil and gas, wind and wave power, and tourism and recreational sites

Regulatory services: flood control, carbon storage, water treatment, erosion control and protection from extreme weather events, nutrient cycling

Habitat services: places for animals and plants to live, fish nurseries, and a diverse genetic pool that may provide the raw materials for developments in provisioning services such as food

Cultural services: places for recreation, aesthetic appreciation and spiritual experiences.

A 2013 evaluation commissioned by the Victorian Coastal Council found that the value of Victoria's coastal commercial activities arising from 'provisioning ecosystem services' is about $9.9 billion a year, due mainly to petroleum, tourism and commercial ports. A subset of non-commercial coastal services, including storm protection, flood and disease control, habitat, biodiversity, recreation and passive enjoyment, were valued at $8.4 billion per year, with the highest value services provided by beaches (for recreation), estuaries/rivers and seagrass (Table 2.1).[22]

Table 2.1 Estimated values of some non-commercial ecosystem services provided by Victoria's coastal habitats, 2013[23]

Habitat type	Area (ha)	Unit value ($/ha/yr)	Value/year ($ million)
Beaches (recreation)			2,385
Forest	252,627	1,518	383
Grassland/heathland	65,844	363	24
Wetlands/marshes	48,422	4,265	207
Estuaries/rivers	71,264	35,768	2,549
Mangrove	71,264	38,750	320
Seagrass	61,961	29,771	1,845
Other marine	806,141	904	729
Total			**8,441**

Source: WorleyParsons

2.1.3 Important places

National park and conservation system

The 5.3% of Victoria's marine waters formally and securely protected for nature conservation include sites with exceptional natural values. In 2002, following a decade of campaigning led by the Victorian National Parks Association and the Marine and Coastal Community Network, Victoria became the first place in the world to seek to implement a biologically representative system of marine protected areas, declaring 13 marine national parks and 11 marine sanctuaries (the marine national park estate), covering about 54,000 hectares. A greater although less representative proportion of the coast is also securely protected, with about 37% of the coastal zone (to 500 metres inland) included in the 'national park and

conservation system' (see section 1.4 for an explanation of this term and the protected area criteria).

Ramsar wetlands

Of 11 Victorian wetland sites of global significance recognised under the Ramsar Convention, five are found on or near the coast.[24]

Corner Inlet is a marine embayment and tidal mudflat that supports more than 390 native plant species and 160 native animal species. It is internationally significant for migratory wading birds and its barrier islands are nationally significant for the botanical biogeography and geomorphology.

Gippsland Lakes support more than 540 plant species and 300 native animal species including more than 60 that are rare or threatened. They include sites of international and national geological and zoological significance. Lake Reeve is one of the five most important areas for shorebirds in Victoria.

Port Phillip Bay (Western Shoreline) and Bellarine Peninsula support more than 330 native plant species and 285 native animal species, including 50% of the world population of the critically endangered orange-bellied parrot. They support large numbers of migratory shorebirds and are an important drought refuge for waterbirds.

Western Port is a large bay supporting more than 350 native plant species and 330 native animal species. It is nationally significant for migratory shorebirds and for extensive saltmarsh communities. It has sites of international and national geomorphological significance.

Edithvale-Seaford Wetlands are the last remnants of the once extensive Carrum Carrum Swamp, which was drained in the nineteenth century. They have 41 regionally significant plant taxa and regularly support more than 1% of the world population of sharp-tailed sandpipers as well as many other migratory birds.

Important bird and biodiversity areas

Twenty 'important bird areas' (IBAs) – sites that are globally significant for bird conservation – have been identified in coastal Victoria.[25] (These areas are now also known as 'important bird and biodiversity areas' in recognition of their importance to other species as well.) They provide critical non-breeding habitat for large numbers of migratory shorebirds each year.

Although the designations have no legal status, they are a reminder to land managers and planners that these areas have high conservation values and they can help guide conservation priorities. BirdLife Australia is establishing a monitoring program for Victorian sites.

Box 2.1 Criteria for important bird areas

Each area meets one of the following three criteria:

- it regularly supports threshold numbers of a threatened species
- it forms one of a set protecting 'restricted-range species' (birds with a global range of less than 5 million hectares)
- it supports greater than 1% of the world population of a waterbird (similar to the Ramsar Convention criteria) or seabird.

Anderson Inlet IBA has intertidal mudflats that attract internationally significant numbers of red-necked stints, and may also regularly support critically endangered orange-bellied parrots.

Bellarine Wetlands IBA supports orange-bellied parrots, endangered Australasian bitterns and more than 1% of the world populations of chestnut teal, red-necked stints, sharp-tailed sandpipers and banded stilts.

Carrum Wetlands IBA regularly supports more than 1% of the world populations of sharp-tailed sandpipers, blue-billed ducks and chestnut teal, and is an important refuge for Australasian bitterns.

Cheetham and Altona IBA regularly supports more than 1% of the world populations of chestnut teal, red-necked stints and Pacific gulls.

Corner Inlet IBA contains the most extensive intertidal mudflats in Victoria and supports more than 1% of the world populations of red-necked stints, eastern curlews, chestnut teal, pied and sooty oystercatchers and threatened hooded plovers. It may regularly support orange-bellied parrots.

Discovery Bay to Piccaninnie Ponds IBA provides habitat for orange-bellied parrots, breeding habitat for Australasian bitterns, and supports populations of hooded plovers, restricted-range rufous bristlebirds and striated fieldwrens.

Gabo and Tullaberga Islands IBA supports more than 1% of the world population of little penguins and white-faced storm-petrels.

Gippsland Lakes IBA regularly supports more than 1% of the world population of black swans, chestnut teal and musk ducks, and substantial numbers of vulnerable fairy terns.

Lawrence Rocks IBA supports more than 10% of the world population of Australasian gannets.

Lower Brodribb River IBA supports a small breeding population of Australasian bitterns.

Nadgee to Mallacoota Inlet IBA supports an isolated southern sub-population of endangered eastern bristlebirds and a population of restricted-range pilotbirds.

Otway Ranges IBA supports populations of rufous bristlebirds as well as striated fieldwrens and pink robins.

Phillip Island IBA supports more than 1% of the world populations of little penguins, short-tailed shearwaters and Pacific gulls and small numbers of orange-bellied parrots.

Port Fairy to Warrnambool IBA regularly supports orange-bellied parrots and a breeding population of hooded plovers.

Shallow Inlet IBA supports more than 1% of the world's double-banded plovers and red-necked stints.

Swan Bay and Port Phillip Bay Islands IBA supports significant numbers of orange-bellied parrots and fairy terns, and more than 1% of the world populations of blue-billed ducks, chestnut teal, Australian white ibis, straw-necked ibis, red-necked stints and silver gulls.

Werribee and Avalon IBA supports orange-bellied parrots, and more than 1% of the world populations of blue-billed ducks, Australian shelducks, freckled ducks, Australasian shovelers, chestnut teal, musk ducks, pink-eared ducks, hoary-headed grebes, red-necked stints and sharp-tailed sandpipers.

Western Port IBA regularly supports small numbers of orange-bellied parrots, fairy terns, and more than 1% of the world populations of eastern curlews, red-necked stints and pied oystercatchers.

Wilsons Promontory Islands IBA supports more than 1% of the world populations of short-tailed shearwaters and Pacific gulls, and possibly also of black-faced cormorants.

Yambuk IBA supports orange-bellied parrots, Australasian bitterns, and a breeding population of hooded plovers.

2.1.4 Major habitat types

The typology of marine and coastal habitats in Table 2.2 and their description below is a summary of work by Australian Marine Ecology. [26]

Table 2.2 Marine and coastal habitats

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-vegetation 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-vegetation 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
Non specific	Non specific	Marine non-vegetation communities	Pelagic fauna aggregations
			Plankton and nekton
			Sponge clump

Coastal and exposed supralittoral dunes: Wind-blown sand often accumulates as dunes between the high tide line and established coastal vegetation. Colonisation by hardy grasses can stabilise dunes, allowing other vegetation to take hold. Many estuaries and wetlands are protected from storm surge flooding by coastal dune systems.

Coastal dune grasses, heaths, moonah, scrub and woodland: With sandy, infertile soils and exposed to strong, salt-laden winds and sea spray, coasts are tough environments for plants. Coastal vegetation usually occurs in bands parallel to the shore: foredunes inhabited by dune grasses and succulents grade to low, salt affected scrub, with a ground layer of sedges, grasses and herbs, and then to taller shrubs behind the primary dunes, where there is some protection from wind, and then to low woodland. In swales between dunes and behind primary dunes, the tea-tree moonah (*Melaleuca lanceolata*) may occur as a scrub or low forest. Highly diverse heath communities often grow on headlands. Coastal habitats are foraging, breeding and roosting habitat for birds, small mammals and reptiles, many of conservation importance. They are 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.

Coastal islands: Island communities are often unique, and their relative isolation has helped to conserve more pristine habitats than on the mainland. Many function as sanctuaries, free from introduced predators and competitors, such as cats, foxes, rabbits and rodents. Coastal islands are home to breeding colonies of fur seals and seabirds, including Australasian gannets, little penguins and short-tailed shearwaters.

Saltmarsh and mangrove communities: These communities often inhabit the intertidal sand and mudflats of protected bays and estuaries in parallel zones, with saltmarsh growing inshore of mangroves. Saltmarsh vegetation includes succulent shrubs and herbs, grasses and sedges, and in Victoria is often dominated by a few plant species, particularly glassworts. Mangroves are at the southern limit of their range and just one species, grey mangrove, grows in Victoria. Saltmarshes and mangroves are foraging and nursery habitat for diverse marine and estuarine fauna. The endangered orange-bellied parrot is dependent on saltmarshes for winter food. Mangrove and saltmarsh habitats trap and stablise coastal sediments and protect against coastal erosion, as they form a barrier against the effects of flooding, currents, waves and storms. Victoria has suffered extensive loss of saltmarsh and mangrove habitats. Weeds have invaded saltmarshes, and mangroves were cleared for land reclamation and port development. Swamp drainage for agriculture has caused decline in these communities by increasing freshwater runoff and reducing salinity.

Seagrass and estuary grass: Seagrasses (flowering plants) grow in shallow coastal waters, some as meadows in bays and estuaries and others in sheltered areas along the open coast. In Victoria, the main seagrasses are eelgrasses (*Heterozostera tasmanica*, *H. nigricaulis* and *Zostera muelleri*), sea-nymph (*Amphibolis antarctica*), paddlegrass (*Halophila australis*) and strapweed (*Posidonia australis*). Estuary grass (*Ruppia megacarpa*) is related to seagrass and provides similar habitat in shallow estuaries, coastal lagoons and salt lakes. Seagrass communities are important to ecological processes, including primary productivity, nutrient cycling and trophic pathways. They provide surfaces for the attachment of algae and sessile invertebrates, and refuge for mobile invertebrates. Seagrass beds are primary habitat for many pipefishes, seahorses and sea dragons, and important fish nurseries. There have been dramatic declines in seagrass habitat stemming from population pressures in the coastal zone.

Estuaries: Estuary habitats are subject to influences from both marine and riverine environments. Estuaries provide a wide variety of sheltered habitat types, including intertidal and subtidal reef, channels, seagrass, *Ruppia*, mangroves and saltmarshes. They are dominated by intertidal sandflats and mudflats, and subtidal sediment beds, which have diverse and productive infaunal invertebrate communities that provide productive feeding grounds for local and migratory shorebirds. They also serve as fish nurseries.

Exposed littoral beach: As the interface between ocean and coast, beaches are mobile and unstable. Beach organisms must survive wave action, sand deposition, erosion, high and low temperatures, regular inundation with sea water and exposure to desiccation. They have an important role in cycling nutrients between coastal and near-shore environments. Accumulations of deposited marine algae support

diverse microbes and invertebrate fauna, an important food source for many fish. Beaches are important foraging and breeding habitat for shorebirds, some of high conservation status, such as hooded plover.

Intertidal reefs: Occurring mostly around headlands and points, and often isolated from each other by stretches of beach, intertidal reefs are inhabited by specialist intertidal species adapted to extreme environmental variability due to alternate tidal inundation and exposure. A thin layer of microscopic algae growing on rock surfaces is an important food source for grazing molluscs. Larger algae such as the mat-forming Neptune's necklace provide food and refuge at low tide. Gastropod molluscs are the dominant fauna, and there are also small crustaceans such as barnacles and crabs, the seastar *Parvulastra exigua* and tubeworm *Galeolaria caespitosa*. They are important foraging habitats for shorebirds at low tide and for fish at high tide. Because of their accessibility, intertidal reefs are vulnerable to human pressures, including collection of animals for fishing bait and food, trampling and pollution.

***Pyura* and sponge clumps**: *Pyura stolonifera* is a seasquirt that inhabits hard and soft surfaces in intertidal and subtidal habitats and provides a surface for attachment by many other organisms. In subtidal soft sediment habitats, *Pyura* beds are important habitat for sponges, other sessile invertebrates and algae, which in turn provide surfaces for further attachment, forming large clumps of biogenic reef (generated by living organisms). *Pyura* beds also provide habitat for mobile invertebrates such as brittlestars, seastars and sea urchins. Species richness is often higher in *Pyura* bed habitats than in comparable seagrass or bare sediment habitats. The recovery of *Pyura* beds after disturbance is slow or non-existent, so they are a high priority for protection.

Caulerpa: This diverse genus of green algae grow on shallow and intermediate reefs and in sediments. They are fast growing and can quickly spread into adjacent areas by vegetative growth. They can form dense meadows that exclude other algae. *Caulerpa* are important to ecological processes, including habitat provision, primary productivity, nutrient cycling and trophic pathways. *Caulerpa taxifolia* is an invasive species from the Mediterranean Sea, now widespread along the Australian coast.

Drift weed: Many large algae do not need to be attached to the sea bottom to survive and, carried by tides and currents, they can form vast mats. In Port Phillip Bay, drift algae sometimes cover up to 90% of the seabed along the northwest shore, probably benefiting from discharge from the Western Treatment Plant. Drift algae are important to local ecological processes, including primary productivity, nutrient cycling, trophic pathways and biogenic habitat.

Channels: Soft sediment channels are prevalent in sheltered bays and inlets. Major Victorian embayments, including Port Phillip Bay, Corner Inlet, Nooramunga and especially Western Port, are dominated by intertidal and subtidal sand and mud flats interwoven with deeper channels. The tidal currents that create channels also carry food particles. Many species occur only in channel habitats and species assemblages are often unique. Brachiopods and some molluscs are locally abundant within Western Port channel habitats but have very restricted ranges, so these populations are of particular conservation importance.

Subtidal reefs: Kelp and other seaweeds provide the dominant habitat structure on subtidal reefs. The robust bull kelp dominates on reefs that are most exposed to wave and swell, and large brown algae, such as the common kelp and crayweed form a canopy 0.5-2 metres high in less exposed reefs. Smaller kelps and filter-feeding sessile invertebrates (sponges, corals, bryozoans, hydroids and ascidians) form an understory 5-30 centimetres high. A hard layer of pink crustose coralline algae encrusts the rocks of most subtidal reefs. As depth increases, kelps become less dominant and other algae and sessile invertebrates make up a greater proportion of the cover. Seaweeds and sessile invertebrates provide important habitat structure for other organisms on the reef. Gastropods, crustaceans, echinoderms and fishes inhabit these communities. Shallow reefs have high biological complexity, species diversity, biomass and productivity. Dense seaweed beds are among the most productive habitats in the world.

Intermediate depth reefs (15-30 metres depth): 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.

Deep reefs: The difficulties of working at depth have limited the ecological study of deep reef habitats. Recent technological advances have made this environment somewhat more accessible and there are currently numerous Victorian deep reef studies in progress. The biota 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. They may filter up to hundreds of litres of ocean water per square metre of reef every day, and are therefore a potentially vital link for the cycling of nutrients and energy in the marine ecosystem. Small crustaceans, echinoderms and molluscs are commonly found in the spaces created by the sessile invertebrates. Fishes are also abundant in deep reef areas, taking refuge within the reef structure or feeding on the wide range of organisms. The importance of deep reef biota in supporting high trophic-level carnivores is unknown.

Pinnacles and canyons: Pinnacles (steep-sided peaks) and canyons (steep-sided gorges) provide vertical and overhanging surfaces inhabited by highly diverse, filter-feeding, sessile invertebrate communities, typically dominated by sponges, and supporting a high diversity of mobile invertebrates, including molluscs, crustaceans, polychaetes and echinoderms, as well as fish. They are associated with high density aggregations of seabirds, whales and dolphins and often have high fish densities. Pinnacle and canyon communities are often small in area and endemic, having evolved in isolation from other such habitats. It means they are particularly vulnerable to disturbance, as an entire patch is likely to be affected and there will be little potential for recolonisation and recovery.

Upwellings: Important upwellings occur in Discovery Bay (Bonney Upwelling) and along east Gippsland (Bass Canyon Upwelling). Seasonal winds drive warm, nutrient-depleted surface water away from the coast, which draws deeper, colder, nutrient-rich water to the sunlit surface, where it sustains high rates of phytoplankton growth.

Plankton: Organisms that drift in the water column, plankton are important in carbon, nitrogen and other nutrient cycles. Photosynthetic plankton, such as diatoms and dinoflagellates, are highly productive – they are responsible in Port Phillip Bay for at least two-thirds of primary production. Concentrations are often highest in estuaries and river mouths, where there are nutrient inputs from terrestrial runoff. Phytoplankton are preyed on by zooplankton, small floating animals including amoeboids, crustaceans, jellyfish, invertebrate larvae and fish larvae.

Nekton: In Victoria, actively swimming pelagic (open sea) organisms, nekton, are mostly fish and cephalopods (eg. octopuses, squid, cuttlefish), but also include mammals, penguins and crustaceans (e.g. krill). Nekton play an important role in trophic pathways, facilitating the transfer of energy from plankton, through lower trophic levels, to higher order predators. High abundances are often associated with areas of high phytoplankton productivity, such as upwellings.

Pelagic fauna aggregations: Many pelagic (open sea) fish school for protection against predators or converge in favourable habitats. Orange roughy, for example, aggregate around seamounts, pinnacles and canyons. Seabirds, predatory fish and marine mammals congregate where there is a reliable food supply, such as nutrient-rich upwellings. Aggregations provide opportunities for courtship and breeding for species that are normally scattered. Blue whales congregating along the Bonney coast to feed also engage in courtship. Species that aggregate are more vulnerable to recreational and commercial fishing pressures, diseases and localised environmental disturbances.

Artificial habitats: Although artificial habitats are less ecologically complex than natural systems they can be ecologically important if their primary purpose is for conservation. Popes Eye and South Channel Fort, artificial islands in Port Phillip Bay, provide reef habitat for a diverse fish fauna, as do shipwrecks, particularly in the Ships' Graveyard area between Port Phillip Heads and Torquay, with about 50 wrecks. White-faced storm petrels nest on South Channel Fort, Australian fur seals haul out regularly at the purpose-built Chinaman's Hat, and little penguins breed on the breakwater built at St Kilda. The largest winter-breeding population of pied cormorants in Victoria nests in and around Lake Borrie at Melbourne Water's Western Treatment Plant, which is the primary source of nutrients into Port Phillip Bay and the Geelong Arm in winter.

2.2 State of marine and coastal ecosystems

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.

Australian Marine Ecology, 2010[27]

2.2.1 Biodiversity and native vegetation

Threatened species

More than 180 species in coastal and marine environments are considered threatened (listed in the Victorian government's advisory lists) (Table 2.3 and Table 2.4). These advisory lists are not statutory: unless species are formally listed under the Flora and Fauna Guarantee Act, there are no legal requirements to protect them beyond what is required for any other native species. Only about half the threatened marine and coastal species on the advisory lists have been formally listed, and only about half of these listed species have action statements (which set out actions needed for their recovery) (see chapter 5). There are many more species identified in the advisory lists as near threatened or as too poorly known to determine their conservation status. Information is particularly lacking for marine invertebrates.

Two marine and three coastal ecological communities are listed as threatened under the Flora and Fauna Guarantee Act (Box 2.2) and two-thirds of ecological vegetation classes on the coast have been assessed as threatened in at least one of the subregions in which they occur (Table 2.7). With no equivalent to the ecological vegetation class classification, and many marine habitats not mapped, the conservation status of marine ecological communities is mostly unknown.

Table 2.3 Marine threatened species (based on Victorian government advisory lists)[28]

Group	Critically endangered	Endangered	Vulnerable	Total threatened	Extinct
Marine fish	0	0	2	2	0
Catadromous fish(1)	2	0	2	4	1
Seabirds	0	2	8	10	0
Mammals	2	1	2	5	0
Reptiles	1	0	0	1	0
Invertebrates	0	0	17	17	0

Source: State government advisory lists. Catadromous species are born in the sea, but live much or all their adult life in freshwater.

Table 2.4 Coastal threatened species, in government advisory lists, formally listed and with action plans[29]

Group	Critically endangered	Endangered	Vulnerable	Total threatened (advisory)(1)	Listed FFG Act(2)	Action plan
Fish	2	1	4	7	7	4
Birds	4	20	32	56	33	17
Mammals	1	4	3	8	5	3
Reptiles	1	2	2	5	3	3
Frogs	1	0	2	3	1	0
Invertebrates	1	2	1	4	4	1
Plants	NA	27	49	76	34	17

Notes: (1) State government advisory lists: vertebrates (2013), invertebrates (2009), plants (2005). (2) Listed under the Floral and Fauna Guarantee Act. There is some overlap with Table 2.3 (marine threatened species) for coastal species that use marine environments, such as fish that have freshwater and marine stages, and shorebirds. Some of the coastal species are also found further inland (so there are overlaps with threatened species discussed in chapters 3 and 4).

Box 2.2 Threatened marine and coastal ecological communities

The San Remo marine community, at the eastern entrance to Western Port, occurs over a nine hectare area of patchy basalt, sand and mud, and is dominated by opisthobranch molluscs (marine slugs) and bryozoans (moss animals). It is subject to potential threats from dredging, invasive species and coastal development.[30]

The Port Phillip Bay entrance deep canyon marine community is highly diverse, with many endemic species. It is restricted to the 120 hectare canyon between the Port Phillip Heads, and subject to threats from rock dredging and invasive species, as well as potential shipping accidents and sub-sea infrastructure developments.[31]

Coastal moonah woodland is a scattered forest, woodland or shrubland community occurring on calcareous dune systems in central southern Victoria in the Gippsland and Otway Plains bioregions. More than 90% has been cleared or highly fragmented, and weeds and recreational activities threaten what is left. It usually occurs on hind dunes, and is important for preventing erosion and as habitat for several threatened species.[32]

Warm temperate rainforest (coastal East Gippsland) occurs on relatively dry coastal sites, usually in shallow gullies and on abandoned sea cliffs, on or near the Gippsland Lakes (especially Lakes King and Tyers) and at the mouth of the Snowy River near Marlo. It has been severely depleted by clearing for agriculture and grazing, and is threatened by weed invasion and fires of high intensity and frequency.[33]

Plains grassland (South Gippsland) ranges from closed tussock grassland to seasonal wetlands on the South Gippsland coastal plain between Seaspray and Welshpool and the head of Western Port, on grey, often seasonally waterlogged soils.[34] More than 99% has been lost to clearing and degradation, and what remains is threatened by weed invasion and inappropriate fire regimes.

Coastal native vegetation

Close to two-thirds of the coast (to 500 metres inland) still has remnant vegetation, 57% of which is protected (Table 2.6). Vegetation loss increases with distance from the coast. Within the zone out to five kilometres from the coastline, half the vegetation has been cleared and 52% of what remains is protected (Table 2.6).

Victoria's plants communities have been mapped as ecological vegetation classes based on their structure, ecology and floristic and environmental associations. Their conservation status has been assessed within each bioregion and subregion, based on a comparison with their estimated pre-1750 extent (Box 2.3). Of 300 ecological vegetation classes described for Victoria's bioregions, 95 occur within 500 metres of the state's shoreline (Table 2.7). Thirty-four are found only on the coast, while the other 61 have largely inland ranges.[35]

Almost two-thirds (62%) of ecological vegetation classes within 500 metres of the shoreline are threatened within at least one subregion in which they occur (Table 2.7). The losses have been greatest for hinterland vegetation in the Warrnambool Plains, Otway Plains, Victorian Volcanic Plains and Gippsland Plains subregions, for they were settled early in Victoria's colonial history to graze sheep because of their relatively fertile soils and ease of clearing. Other vegetation losses have resulted from forestry and urban settlements. Table 2.7 shows the extent of remnant vegetation, fragmentation and threatened ecological vegetation classes found within 500 metres of the shoreline in each of the 10 coastal subregions. Swamp and coastal scrubs, grassy woodlands, herb-rich woodlands and forests, estuarine wetlands and saltmarshes are the most consistently threatened vegetation types across the ten subregions (Table 2.5).

Table 2.5 Threatened ecological vegetation classes (EVCs) in coastal subregions

EVC	Number of subregions		
	E[1]	V[2]	NT[3]
Coastal EVCs			
Estuarine wetland	4	0	3
Coastal headland scrub	0	6	2
Coastal tussock grassland	0	5	1
Coastal alkaline scrub	2	1	2
Hinterland EVCs			
Damp sands herb-rich woodland	1	6	0
Herb-rich foothill forest	0	5	1
Swamp scrub	5	1	0
Damp heath scrub	2	1	0
Plains grassy woodland	3	0	0
Plains grassland	3	0	0
Shallow freshwater marsh	3	0	0
Grassy woodland	4	0	0

Data source: Trust for Nature. Notes: [1] Endangered. [2]Vulnerable. [3] Non-threatened, including least concern, rare or data deficient.

Table 2.6 Coastal remnant vegetation protected in the national park and conservation system

Distance from coastline	Remnant vegetation (hectares)	Remnant vegetation (%)	Wetlands (hectares)	Wetlands (%)	Reserves (hectares)	Reserves (%)	Remnant vegetation in reserves (%)
0-200m	36,541	71	7,439	14	20,931	41	57
0-500m	73,467	65	12,683	11	41,727	37	57
0-1km	121,477	60	18,568	9	68,656	34	57
0-5km	440,011	49	43,746	5	228,286	26	52

Data: VNPA analysis of data from the Department of Environment and Primary Industries.

Box 2.3 Victoria's ecological vegetation classes (EVCs)[36]

EVCs are the basic mapping units used for biodiversity planning and conservation assessment at landscape, subregional and bioregional scales in Victoria. They are used in this review, mostly at the subregional scale, as the main basis for determining priorities for completing the national park and conservation system (unfortunately, there is no equivalent system for the marine environment).

The state government has classified the state's native vegetation into EVC units based on ecological characteristics (eg dominant species, vegetation structure) and physiographic variables (eg aspect, elevation, geology and soils, landform, rainfall, salinity and climate). Each EVC represents one or more plant communities that occur in similar types of environments. The communities in each EVC tend to show similar ecological responses to fire and other environmental factors. The EVC system includes EVC complexes, mosaics and aggregates for situations where specific EVCs cannot be identified at the spatial scale used for vegetation mapping.

The conservation status of each EVC has been assessed – as endangered, vulnerable, depleted, rare or least concern – as a measure 'of the current extent and quality of each EVC compared to its pre-1750 extent and condition and with consideration of threatening processes' in each bioregion or subregion in which it occurs. The pre-1750 extent is estimated from predictions derived from existing vegetation, a variety of physical environmental attributes, and expert knowledge.

Table 2.7 Remnant vegetation and ecological vegetation classes (EVCs) in coastal subregions[37]

Subregion	Remnant vegetation (%)	Fragmentation (%)	Coastal EVCs (number)	Coastal EVCs threatened	Coastal EVCs threatened (%)
Victorian Volcanic Plain	16	100	17	17	100
Warrnambool Plain	17	100	19	17	89
Gippsland Plain	26	100	63	43	68
Strzelecki Ranges	31	100	5	4	80
Otway Plain	32	96	22	15	68
Glenelg Plain	46	100	9	6	67
East Gippsland Lowlands	62	33	18	7	39
Bridgewater	68	100	13	10	77
Otway Ranges	76	68	19	8	42
Wilsons Promontory	91	2	20	1	5

Data: VNPA and Smyth (2014) analysis of data from the Department of Environment and Primary Industries.

2.2.2 National park and conservation system

Victoria's marine and coastal national park and conservation system includes 5% of state waters and 37% of coastal land (to 500 metres inland) (Table 2.8).

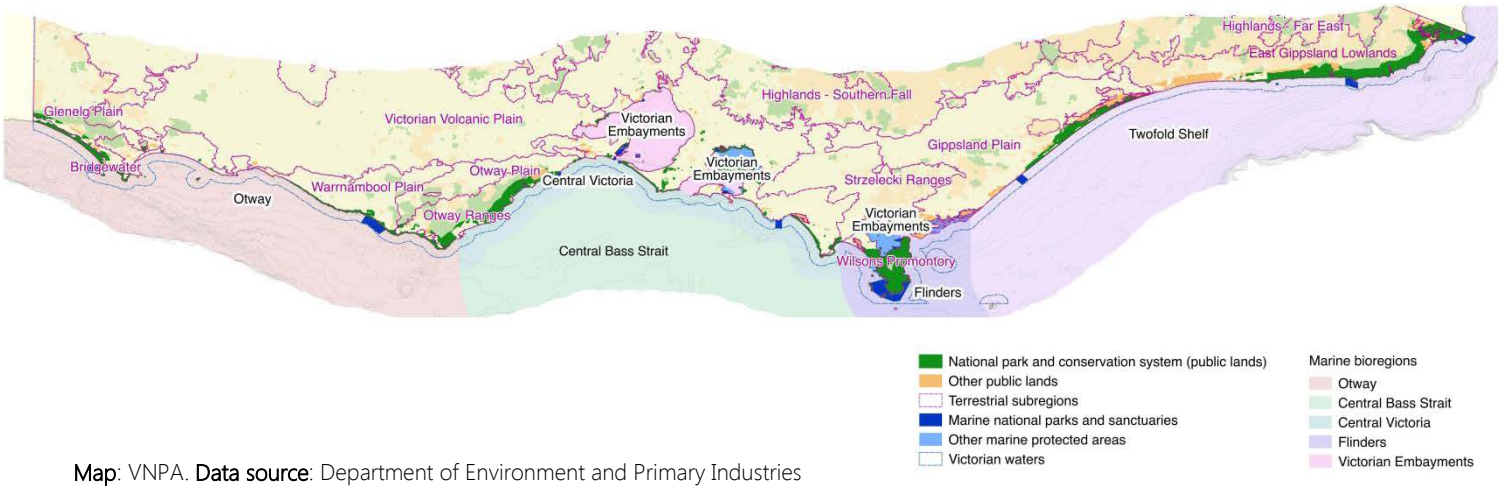
The marine national parks and sanctuaries were all declared in 2002 following a statewide investigation by the Land Conservation Council initiated in 1991. They include the near-shore environment, seabed and marine waters out to 5.5 kilometres (the state limit), islands, and the foreshore up to 200 metres inland from the high water mark. Extractive and damaging activities such as dredging, waste disposal, aquaculture, mining, and commercial and recreational fishing are prohibited, but a loophole allows petroleum exploration.[38]

Close to a quarter of coastal land (23%) is in the national park estate (mainly national and state parks) and 14% is in other securely protected conservation properties (eg coastal parks and nature conservation reserves). The area of private land protected under perpetual conservation covenants is very small, just 0.2% of the coastal area.

Coastal protection has been greatly assisted by an 1881 decision by the Victorian government to reserve all unalienated land within one-and-a-half chains [30 metres] of the colony's 'rivers, rivulets, creeks, channels, aqueducts, lakes, reservoirs, swamps, inlets, loughs and straits'.[39] All but 4% of land abutting the high water mark is still in public ownership, although under multiple management arrangements, some incompatible with conservation. Many stream and river frontages are also in public ownership (chapter 4). The privatised proportion of land increases with distance from the shoreline: three-quarters of the land area to 200 metres from the shoreline is in public ownership but only half of the land from 200 to 500 metres is.[40] Squeezed between sea and development, many conservation properties and other public lands are exceedingly narrow, and set to be further squeezed as sea levels continue to rise. Their shape makes conservation management very challenging, for they are subject to severe edge effects and impacts from adjoining land uses.[41]

Other marine sites and many dozens of coastal properties called protected areas or reserves are not sufficiently secure or managed for conservation to meet the VNPA criteria for the national park and conservation system (section 1.4). These insufficiently protected tenures include marine parks, marine reserves, and marine and coastal parks in which various forms of exploitation (eg fishing) are allowed and which do not require a strong focus on conservation management. As noted by the Victorian Environmental Assessment Council, the environmental management required in multiple-use marine parks 'is generally the same as that of the surrounding marine environment'.[42] There are also marine protected areas in Commonwealth waters adjacent to Victorian waters, all of them multiple use reserves that permit fishing, so not part of the national park and conservation system (Box 2.4).

Figure 2.1 Victoria's marine and coastal national park and conservation system



Map: VNPA. Data source: Department of Environment and Primary Industries

Table 2.8 Victoria's marine and coastal national park and conservation system

Marine national park estate	Marine bioregion	Area (hectare)
Twelve Apostles Marine National Park	Otway	7,500
The Arches Marine Sanctuary	Otway	45
Merri Marine Sanctuary	Otway	25
Discovery Bay Marine National Park	Otway	2,770
Mushroom Reef Marine Sanctuary	Central Victoria	80
Bunurong Marine National Park	Central Victoria	2,100
Barwon Bluff Marine Sanctuary	Central Victoria	17
Point Danger Marine Sanctuary	Central Victoria	25
Point Addis Marine National Park	Central Victoria	4,600
Eagle Rock Marine Sanctuary	Central Victoria	17
Marengo Reefs Marine Sanctuary	Central Victoria	12
Wilsons Promontory Marine National Park	Flinders	15,550
Cape Howe Marine National Park	Twofold Shelf	4,050
Point Hicks Marine National Park	Twofold Shelf	4,000
Beware Reef Marine Sanctuary	Twofold Shelf	220
Ninety Mile Beach Marine National Park	Twofold Shelf	2,750
Corner Inlet Marine National Park	Victorian Bays and Inlets	1,550
Yaringa Marine National Park	Victorian Bays and Inlets	980
French Island Marine National Park	Victorian Bays and Inlets	2,800
Churchill Island Marine National Park	Victorian Bays and Inlets	670
Point Cooke Marine Sanctuary	Victorian Bays and Inlets	290
Jawbone Marine Sanctuary	Victorian Bays and Inlets	30
Ricketts Point Marine Sanctuary	Victorian Bays and Inlets	115
Port Phillip Heads Marine National Park	Victorian Bays and Inlets	3,580
Total area (marine)		53,776
Coastal national park estate	**Subregion**	
Port Campbell National Park	Warrnambool Plain	1,069
Point Nepean National Park	Gippsland Plain	357
Mornington Peninsula National Park	Gippsland Plain	1,110
French Island National Park	Gippsland Plain	2,235
Great Otway National Park	Otway Ranges Warrnambool Plain	3,712
Wilsons Promontory National Park	Wilsons Promontory	7,619
Croajingolong National Park	East Gippsland Lowlands	9,697
Cape Nelson State Park	Glenelg	112
Subtotal		25,910
Other coastal conservation properties		**Area**
Nature conservation reserves etc (tenures identified in Table 1.3)	All	15,402
Trust for Nature covenants	All	261
Subtotal		15,633
Total area (coastal)		**41,543**

Table 2.9 Public land tenures on the coast (0 to 500 metres from the high water mark)

Land category	Area (hectares)	Coastal land (%)
National park estate		
National park, state park	25,911	
Marine national park, marine sanctuary	419	
Subtotal	26,330	23
Other conservation properties		
Schedule 3 parks	11,652	
Nature conservation reserves	1,490	
Flora and fauna reserves	203	
Wildlife reserve (no hunting)	688	
Natural features reserves	109	
Phillip Island Nature Parks	1,260	
Subtotal	15,402	14
Other public land		
Schedule 4 parks or reserves	10,141	
Historic reserves	62	
Lighthouse reserves	332	
Wildlife reserves (hunting)	1,545	
Proposed NP Act	381	
Coastal reserve	7,277	
Commonwealth land	1,250	
Metropolitan park	363	
State forest	278	
Port & coastal facility	40	
Other or unclassified	6,757	
Subtotal	28,426	25
Totals		
Total public land	71,599	63
Total coastal area	113,639	

Analysis: VNPA. **Data sources:** Department of Environment and Primary Industries.

Box 2.4 Commonwealth marine protected areas adjacent to Victorian state waters

The following Commonwealth marine protected areas are all multiple use zones with fishing permitted, and so do not meet the VNPA criteria for the national park and conservation system:

- East Gippsland Commonwealth Marine Reserve covers 413,700 hectares, and contains representative samples of an extensive network of canyons, continental slope and escarpment in depths from 600 metres to deeper than 4000 metres.
- Beagle Commonwealth Marine Reserve, covering 292,800 hectares within the shallow Bass Strait (mostly 50 to 70 metres), has its north-western edge abutting Victorian waters to the south-east of Wilson's Promontory.
- Apollo Reserve, off Apollo Bay on Victoria's west coast in shallow waters (80 to 120 metres) on the continental shelf, covers 118,400 hectares.

2.2.3 Bays, inlets and estuaries

'There remains little data available on the ecological condition of estuaries, although it is evident that most of Victoria's estuaries have been degraded. It is estimated that as many as half of Victoria's major estuaries are significantly modified.'

State of the Environment Victoria 2013

The many wriggles in its coastline and a high density of coastal waterways have endowed Victoria with a multitude of diverse bays, inlets and estuaries of immense value to both humans and wildlife. There are more than 123 bays and inlets greater than one square kilometre in area.

At the intersection of freshwater and sea water, estuaries are a dynamic transitional environment, linking catchments to marine environments and affected by conditions both in local catchments and far upstream. Biological information has been collected for very few Victorian estuaries, and usually only over a short time. A 2008 assessment of threats noted that data of 'sufficient quality or spatial and temporal extent to measure the condition of Victoria's estuaries' is lacking.[43] The majority of Victoria's estuaries have been modified and degraded by human activity (Table 2.10) due to:[44]

- land uses and degradation of catchments
- changes to freshwater inflows
- coastal urbanisation (including increased recreational and commercial use and physical modification of waterways)
- modification of estuary entrances or opening of estuary mouths.

Victoria's only 'near-pristine' estuaries are located in the far east, and 'largely unmodified' estuaries occur around South Gippsland, along the Great Ocean Road and along the south-west coast.

More than half of Victoria's estuaries are naturally closed by sand bars from time to time, the frequency and duration of which is affected by altered land uses and water flows. Closure may render them more vulnerable to human threats because flooding around closed estuaries can lead to pressure for artificial opening, the consequences of which (such as large fish kills) can be 'catastrophic'.[45]

Table 2.10 Condition of Victoria's estuaries[46]

Subregion	Estuary condition				
Bridgewater	Glenelg River				
Warrnambool Plain	Merri River	Fitzroy River	Moyne River	Port Campbell River	Surry River
	Hopkins River	Curdies Inlet	Gellibrand River	Sherbrook River	Lake Yambuk
Otway Plain	Aire River	Barham River	Port Phillip	Skeleton Creek	Aireys Inlet
	Anglesea River	Spring Creek	Thompson Creek	Barwon River	Anderson Creek
	Swan Bay	Limeburners Bay	Little River	Werribee River	Wild Dog Creek
Otway Ranges	Skenes Creek	Grey River	Kennett River		
	Erskine River	Jamieson River	St George River		
Victorian Volcanic Plain	Kororoit Creek	Laverton Creek	Port Phillip		
Gippsland Plain	Gippsland Lakes	Western Port	Anderson Inlet	Corner Inlet	Merriman Creek
	Patterson River	Port Phillip	Powlett River	Shallow Inlet	Jack Smith Lake
Wilsons Promontory	Tidal River	Darby River			
East Gippsland Lowlands	Snowy River	Sydenham Inlet	Yeerung River	Thurra River	
	Lake Tyers	Basby Creek	Red River	Betka River	
	Tamboon Inlet	Mallacoota	Shipwreck Creek	Benedore River	

Source: Barton et al (2008)

Near pristine	Largely unmodified	Modified	Extensively modified

Port Phillip Bay

Victoria's largest embayment is the extraordinarily diverse Port Phillip Bay (1950 square kilometres, with 250 kilometres of shoreline). It has a multitude of habitats - deep muds, sandy shores, *Pyura* beds, shallow reefs and sheltered reefs, seagrass, drift algae and estuarine habitats – and great biodiversity values, including many unique to the bay. Of more than 270 sponge species at the Heads, at least 115 are endemic to that site.[47] The bay's wildlife include about 300 fish species, and several hundred species each of molluscs, crustaceans, bristle worms and cnidarians. The west coast has internationally significant bird habitats recognised in the declaration of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site, which annually supports more than 40,000 waterbirds.

As well as extremely high conservation values, and in tension with those values, Port Phillip Bay has Australia's most densely populated catchment and one of the most urbanised coastlines in the world.[48] It has Australia's busiest port, and supports commercial and recreational fisheries and aquaculture. It is also immensely popular for recreation – swimming, beach activities, sightseeing, diving, sailing, boating and recreational fishing.[49] The bay's ecosystems are therefore under great and increasing pressure from urban and agricultural runoff, fishing and the spread of introduced marine species – it is one of the most invaded marine sites globally (section 2.3.2).[50]

Western Port

Victoria's second largest embayment, Western Port (680 square kilometres) is semi-enclosed with two large islands. Its internationally significant values have been recognised by its listing as a Ramsar wetland and designation as an important bird area. At low tide about 40% of the bay is exposed as mudflats, which are highly productive habitats for crustaceans and shorebirds.[51] It regularly supports more than 10,000 migratory shorebirds and 10,000 waterbirds.[52] Other important wildlife habitats include deep channels, seagrass meadows, mangroves and saltmarsh.[53] This diversity of habitats supports an abundant fish fauna.

But Western Port also hosts a major commercial port, with most ships carrying liquid fuel, and is popular for recreational fishing. Extensive vegetation clearing within the catchment (leaving less than one-quarter of the catchment with native vegetation), draining of the large Koo Wee Rup swamp and the growth of agriculture, industry and urban areas have wrought major ecological changes.[54] From 1971 to 1984, about 70% of Western Port's seagrass meadows were lost (from 250 to 72 square kilometres) due to physical smothering of the leaves and reduced light levels. There has been some recovery since then, to about 154 square kilometres in 2000. The losses and limited recovery are 'symptomatic of nutrient and sediment loads exceeding the system's capacity to process and assimilate them', and the bay is susceptible to further losses due to increased sedimentation or nutrients resulting from urbanisation, catchment and coastal development or climate change.[55] Of 38 species of aquatic birds that have been regularly counted over about four decades, 25 have declined, as have the total numbers of aquatic birds.[56]

The cessation of commercial netting has reduced the risk of overfishing in Western Port but recreational effort has been increasing with a growing human population and more sophisticated technology (echo sounders and GPS navigation systems).[57] The impacts may be particularly serious for elephant fish, due to intense targeting of breeding aggregations (the recreational catch is equivalent to the entire commercial catch of south-eastern Australia), and for gummy sharks and school sharks, for which Western Port is an important breeding area.

The Victorian government is proposing to expand the Port of Hastings to make it an international container port. This would increase shipping traffic from fewer than 100 ships a year to more than 3000 annually. This will increase the risk of oil spills and the spread of marine invasive species. It will require extensive dredging and some land clearing. According to a series of expert reports commissioned by VNPA, even a moderate-sized oil spill could reach shorelines within minutes and most high conservation value areas would be reached in less than six hours. This would be virtually impossible to stop.[58] A single oil spill could have severe and long-lasting impacts on internationally significant populations of migratory shorebirds and damage large areas of seagrass, mangrove and saltmarsh, depending on tidal and weather conditions.[59]

Gippsland Lakes

The Gippsland Lakes are under enormous pressure from catchment inputs, with nutrient levels and sediments threatening the ecological health of the Lakes by maintaining it at an eutrophic level.

Environment Protection Authority, 2013

The third-largest embayment is the Gippsland Lakes (600 square kilometres), an internationally significant (Ramsar-listed) system of coastal lagoons and marshes separated from the sea by a barrier system of sand dunes fringed by Ninety Mile Beach. Once an intermittently open system of brackish (primarily freshwater) lagoons, the Gippsland Lakes have been extensively modified. The entrance has been permanently opened and deepened, and combined with reduced freshwater inflows (due to dams and water extraction in the catchment) has made the lakes a much more saline environment. Clearing in the catchment and land use practices have caused serious degradation, reflected in losses of fringing wetlands, bank erosion, high nutrient and sediment loads and recurring algal blooms.[60]

Coastal lagoons and seagrass, estuarine grass and saltmarsh habitats are among many different wetland habitats in the lakes system. They regularly support more than 20,000 waterbirds, and are important as a drought refuge. With about 179 fish species, the lakes provide important feeding, dispersal and spawning sites for numerous fish species.[61]

Corner Inlet

The fourth-largest embayment, Corner Inlet (600 square kilometres), is also a Ramsar wetland. It has large intertidal sand and mud flats, seagrass beds, a network of incised channels connected to Bass Strait and large sand islands. Due to the diversity of relatively undisturbed habitats, Corner Inlet supports internationally significant populations of several aquatic and semi-aquatic species. At times it hosts more than 40,000 shorebirds. The seagrass beds are highly productive for many fish and invertebrates. The fish fauna is diverse, with more than 170 species. About 390 indigenous plant species and 160 species of indigenous terrestrial animals have been recorded.

Corner Inlet has four ports servicing commercial fishers, offshore oil and gas production and boating visitors. It is one of only three estuaries or bays where commercial fishing is allowed in Victoria and is popular for recreational fishing. Threats assessed as medium to high risk include recreational boating (eg boat wash, anchor damage), modified flow regimes, sediment and nutrient pollution, future infrastructure development, oil spills, habitat loss due to seawalls and urban development and climate change.[62]

The proposed expansion of Port Anthony to cater for coal exports from Latrobe Valley is a potential threat to Corner Inlet. It would involve construction of a one-kilometre conveyor belt and channel dredging to allow the entry of larger ships.

2.3 Major threats

Victoria's marine and coastal ecosystems are under pressure from a multitude of human-driven extinction processes. Listed under the Flora and Fauna Guarantee Act, for example, are seven 'potentially threatening processes' specific to marine and estuarine habitats and another 30 or so directly affecting coastal habitats or their catchments. Following is an outline of threats in four major categories: climate change, habitat loss and degradation (eg coastal development), dysfunction of biological interactions (eg invasive species and algal blooms) and overexploitation (fishing). [63] Threats in a fifth major category, changes to disturbance regimes (eg fire and hydrological regimes), are covered in chapters 3 and 4. Most threats discussed in chapters 3 and 4 are relevant to coastal habitats, and many are also relevant to marine habitats, with catchment degradation typically compromising the condition of coastal marine habitats.

Many long-term threats – coastal development and invasive species, for example – are undiminished or intensifying as the potentially overwhelming threat of climate change builds. Information about many threats is inadequate, particularly those involving biological interactions, such as the loss of top predators and impacts of introduced species, and there is uncertainty about region-specific climate change predictions.

As well as directly affecting specific sites and species, major marine and coastal threats disrupt natural ecological processes, 'all the physical processes and the plant and animal activities which influence the state of ecosystems and contribute to the maintenance of their integrity and genetic diversity, and thereby their evolutionary potential'. [64] There are seven categories of ecological processes (described in section 3.3), all relevant to marine and coastal ecosystems:[65]

- climate, eg storm frequency, light climate, seasonal changes in water temperatures
- primary productivity, eg benthic nutrient cycling
- hydrological processes, eg tides, river flows
- formation of biophysical habitats, eg the formation of biogenic habitats such as *Pyura* and sponge clumps
- interactions between organisms, eg predation, competition between species
- movements of organisms, eg migration from marine to freshwater habitats
- natural disturbance regimes, eg fire regimes, storm frequency

Actions to protect particular species, habitats, sites or communities are unlikely to be effective unless the ecological processes sustaining them are also maintained.[66] So, to protect a fish species on which a fishery depends is likely to require measures to protect its habitat, its prey and their habitats, and all associated components of a healthy ecosystem, which may require management of impacts far away, including on land.

2.3.1 Climate change

A major question for several coastal ecosystems is whether they are likely to face a threshold with modest climate change beyond which they will flip into a less desirable state.

Climate Change Risks to Australia's Coast, 2009[67]

Human interference with the global climate system will inevitably bring dramatic change. For good reason, most accounts of climate change start off by emphasising the immense complexity of potential impacts, for the effects of accumulating greenhouse gases are driving multiple changes – in temperatures, rainfall, storms, currents, sea levels, sea chemistry etcetera – which in turn drive multiple cumulative and synergistic changes at many different scales of space and time. Many climatic changes are inevitable, but their extent and consequences will depend on whether human actions over the next few years increase or decrease the potential for species and ecosystem to adapt.

Victorian waters have been rapidly warming in recent decades. The greatest warming measured in Australia's oceans has been in the western Tasman Sea, where increases in sea surface temperatures have been more than 0.2°C per decade, much higher than the global average (due to the shifting East

Australian Current).[68] Coastal regions have experienced temperature rises, a decline in autumn to winter rainfall and sea level rises (at an increasing rate, Table 2.11).[69]

The following environmental changes in recent times are probably partly due to climate change:[70]

- increased salinity in Port Phillip Bay due to drought conditions
- persistent decline of seagrass beds in southern Port Phillip Bay
- almost complete loss of string kelp forests
- the westward spread of long-spined sea urchins.

Table 2.13 summarises climatic changes predicted for 2070, with examples of likely impacts on marine and coastal environments. The levels of uncertainty for some of these predictions are high due to the complexity of interactions. It is not only averages (in temperature, rainfall, sea level rise, for example) that will change but variability too, and many of the most severe impacts are likely to come from more extreme and more frequent extreme events. Many of the changes will be cumulative or synergistic. Coastal inundation risks, for example, are due to a combination of higher sea levels, storm surges and high rainfall events.

Of the three main types of climate changes (physical, biophysical and chemical, see Table 2.12), the most readily resisted will be physical changes due to increased storm frequency and sea level rise. Biophysical changes due to increased ocean temperatures and El Niño frequency are much more difficult to manage, and there is no potential at all to control chemical changes due to ocean acidification, which are almost certainly irreversible and one of the tipping points that will lead to ecosystem collapse unless global greenhouse gas emissions are limited to a 'safe' level (Box 2.5).

In the short-term, protecting against physical threats will require conserving and restoring habitats that stabilise coastal soils, absorb wave energy and disperse flood waters. The 'first line of defence' habitats include saltmarsh, mangroves, seagrass, and any coastal vegetation. If they are not protected, there are likely to be significant feedback effects that will reduce resilience in other habitats as well.

Biophysical changes are likely to be too rapid for many species to adapt to through natural selection and evolution. Adaptation will have to be at the level of ecological communities, and is most achievable in relatively natural habitats with complex trophic (food web) interactions. Areas of high biodiversity value are potential sources of ecological resilience. Protecting and restoring ecological processes will be critical to providing biodiversity with the greatest adaptation potential (chapter 5).

Table 2.11 Sea level rise experienced and projected[71]

	1961-2003	1993-2003	1990-2100
Increase	7.5 cm	3 cm	26-59 cm
Rate of increase	1.8 mm/year	3 mm/year	up to 5.4 mm/year

Source: Hennessy et al (2008)

Table 2.12 Options for building resilience to the threats of climate change[72]

Threats	Type of change	Options for building resilience
Increased storm frequency Sea level rise	Physical	Protect and restore physical coastal features and processes.
Increased ocean temperature Increased El Niño frequency (and associated changes in nutrient regime)	Bio-physical	Very difficult to manage. May depend on restoring population structures and ecological complexity, providing ecosystems with flexibility to adapt to change. May require considerable intervention to maintain species and processes.
Ocean acidification	Chemical	No options. Total ecosystem collapse. Irreversible.

Source: Australian Marine Ecology

Table 2.13 Predicted 2070 climatic changes and potential impacts on marine and coastal environments[73]

Climatic change	Changes for 2070 compared to 1990	Examples of predicted consequences
Rises in mean atmospheric temperatures	1 to 2.2 °C (low emissions scenario) 1.9 to 4.2 °C (high emissions scenario)	Changes in growth rates, abundance and distribution of plankton Changes in photosynthetic and respiration rates of marine seagrasses and macroalgae Increased distribution of mangroves Losses of giant kelp forests Species distribution shifts, including invasive species and pathogens
Rises in mean sea temperature	Sea surface: 1- 2 °C 500 m depth: 0.5-1°C	
Rises in sea level	0.18 to 0.59 metres	Inundation of low-lying coastal areas (intertidal areas, mangroves and wetlands) Erosion of cliffs, beaches and foreshores Loss of habitats that are constrained from movement due to coastal development
Strengthening of the warm East Australia Current (but depends on changes to the El Niño–Southern Oscillation)	20% (by 2100)	Altered population dynamics and distributions of many native species Dispersal of some harmful invasive species Impacts due to warmer water
Increased ocean acidity, leading	pH reduced by 0.2 units	Reduced growth and calcite production by dominant calcifying phytoplankton Deterioration of the shells of holoplanktonic molluscs
Greater stratification in ocean layers & a shallower mixed surface layer	Mixed layer shallower by about 1 metre	Reduced nutrient inputs from deeper waters Lower production, biomass and sinking export of phytoplankton Changes in the distribution and abundance of zooplankton
Increased solar radiation	2 to 7 watts/square metre	Increased photosynthetic efficiency in plants such as phytoplankton, seagrass, kelp Reduced photosynthesis in mangroves past a certain level of radiation Damage to phytoplankton, intertidal animals, zooplankton, seagrass due to UV radiation
Increased sea surface winds & water column turbulence	0 to 1 metres/second	Destruction of sensitive plankton Enhanced or suppressed nutrient upwelling, affecting productivity positively or negatively Increased sediment suspension, reducing water clarity and productivity
Reduced annual rainfall & runoff	6 to 11 % less rainfall	Impacts on coastal plankton, organisms in intertidal areas, mangroves Changes in stratification of the water column & nutrient supply, affecting productivity & nutrient cycling
Increased severity and frequency of storms & coastal flooding		Losses of seagrass & macroalgae due to destruction or increased turbidity Destruction of mangroves in fierce storms Erosion of beaches, foreshores & cliffs Pollution from sewer overflows

Box 2.5 Ocean acidification[74]

The current rate of carbon dioxide release 'stands out as capable of driving a combination and magnitude of ocean geochemical changes potentially unparalleled in at least the last ~300 [million years] of Earth history'.

Bärbel Hönisch & others, 2012[75]

About a third of carbon dioxide released has been absorbed by oceans, making them more acidic. Seawater is already 0.1 pH units lower than in pre-industrial times and is projected to drop another 0.2 to 0.3 units by 2100. An increasing CO_2 concentration in oceans will have many physical, chemical and biological effects. For example, it is likely to reduce the availability of iron and nitrogen for phytoplankton, and fundamentally alter nitrogen cycling in the sea.[76] It will reduce the concentration of carbonate ions, which are used by a wide variety of marine organisms (plankton, coralline algae, crustaceans, echinoderms, fish and molluscs) to construct their shells and skeletons (made of calcium carbonate). Experiments have shown that acidification reduces the growth rate and calcite production of dominant phytoplankton, and causes shell deterioration in holoplanktonic molluscs.[77] '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.'[78]

Box 2.6 Shores and shorebirds under climate change

By the end of the century, according to recent projections, sea levels could rise by an average 75 to 190 centimetres relative to 1990 levels.[79] South-eastern Australia is projected to experience greater sea-level rises than the global average because the warming East Australian Current is moving further south.

One-in-100 year events are used as a benchmark for assessing extreme risk. Even if sea levels rise just 0.5 metres in the 21st century, current 1-in-100 year events could occur several times a year and 1-in-10 year events would happen about every 10 days.[80]

Rising sea levels in combination with extreme events will inundate and erode coastal ecosystems. About three-quarters of the Victorian coastline is sandy or soft, so is vulnerable to erosion. One simple approximation is that each centimetre rise in sea level is likely to cause sandy shoreline recession of 50 to 100 centimetres (for a 1 metre sea rise, this implies 50 to 100 metres recession).[81] This will put at risk billions of dollars of coastal housing and infrastructure. A 2009 first-pass assessment of the risks to Victoria's coastal infrastructure under a 2100 climate change scenario of a 1.1 metre rise in sea level and a 1-in-100 storm-tide predicted that from 27,600 to 44,600 residential buildings (current replacement value $6.5 billion to $10.3 billion) could be at risk of inundation. It estimated that there are 4700 residential buildings within 110 metres of erodible shorelines.[82]

To survive, coastal ecosystems such as seagrasses, mangroves and saltmarshes will need to shift landward but coastal infrastructure will prevent natural movement in many areas. Saltmarshes in particular will be trapped by a coastal squeeze, between urban development on the land side and migration of mangroves on the sea side. Loss of saltmarsh would not only compromise the future of dependent wildlife but could liberate a huge pool of carbon stored in wetland sediments. Beaches too will be lost to coastal squeeze unless buffers are created to accommodate landward migration.

The loss of saltmarsh and beach habitats will deprive many shorebirds of important habitat. Other climate change impacts on shorebirds include increased mortality and reduced breeding success due to heat stress, and alterations to the synchronised timing of shorebird migration and the abundance of food species.

2.3.2 Dysfunction of biological interactions

Processes that change interactions between species, reducing their functionality or disrupting life-cycle processes, threaten many species. The most obvious are invasions of introduced species – new predators (foxes and cats) eliminating native animals, new pathogens (myrtle rust) inflicting heavy losses on immunologically naïve species and rampant weeds outcompeting native plants. They also include native species benefiting from anthropogenic changes – altered fire regimes, climate change or assisted spread – that detrimentally affect other species. Examples are long-spined urchins spreading to new areas via the strengthening East Australia Current, and noisy miners dominating fragmented woodlands (section 3.4.2). Another major cause of dysfunction less well recognised (and not covered here) is the decline or loss of a key partner in multispecies relationships – for examples, declines of top predators (sharks and dingoes), pollinators and seed dispersers (honeyeaters, parrots, flying-foxes).

The Victorian government has listed more than 16 threatening processes, mostly invasive species, that fall into this category and affect coastal and marine environments.

Invasive species

Port Phillip Bay is one of the most invaded marine ecosystems globally, with at least 100 to 160 introduced species, representing 8 to 13% of all species, and including half of the 10 most abundant species in the bay. The number of introduced and cryptogenic species found there is higher than reported 'for a comparable body of water anywhere else in the world'.[83] The current invasion rate could be as high as three or more new benthic species yearly. Sources include hull fouling, ballast water and mariculture. The extent to which the ecological resistance of the bay has been altered by invaders is unknown, but an 'invasional meltdown' may be occurring, whereby invasions become mutually reinforcing with established species facilitating additional invasions.[84] Other sites are vulnerable to invasion from Port Phillip Bay – by natural or human means. Japanese kelp (recently found in Apollo Bay) and Pacific seastars can spread on fishing gear and boats.[85] Recreational fishers are permitted to transport live European shore crabs across the state. Although

they are not allowed to be used as live bait, there is a risk that crabs will escape or will be carrying eggs.[86]

Coastal terrestrial ecosystems have been severely damaged by invasive species, with weeds invading vegetation remnants (Box 2.7), foxes and cats preying on wildlife, and rabbits, goats and other herbivores degrading habitats (chapter 3).

Native species can also be harmful if they are introduced or move to new areas, or become more abundant due to human-caused changes, a problem that will grow under climate change, exemplified by the native long-spined sea urchin denuding coastal reefs.

Box 2.7 Weeds destroying coastal saltmarsh[87]

About half the plant species in Victoria's coastal saltmarshes are exotic (118 species). Weeds have caused major degradation, shifts in the composition of saltmarshes and changes in ecosystem function. Tall wheat grass, introduced and promoted by the Victorian government for grazing on saline lands, 'is unquestionably the most serious invader because of its very broad ecological amplitude and robust life form'. A 2001 risk assessment found that it could 'destroy most upper saltmarsh in western Victoria' and it has been listed as a potentially threatening process by the government.[88] Yet, it is still promoted by the government as a pasture species and there are no restrictions on its sale or planting.

Another deliberately introduced plant of saltmarshes, also listed as a potentially threatening process, is the 'ferocious weed' cord grass (*Spartina* species), which can grow in tidal locations, including amongst mangroves. *Spartina* can colonise mudflats, destroying the feeding grounds of shorebirds and invertebrates.[89]

Feral animals too have substantially degraded saltmarshes, with rabbits having so profoundly affected the composition and structure of upper saltmarsh that 'we are unaware of the full extent and nature of their impacts'.

Aquaculture

Land-based aquaculture facilities involving seawater exchange are sited around Geelong Arm, Phillip Island and Port Fairy. The greatest risks are genetic alteration of wild animals, and the introduction or amplification of disease. An abalone disease outbreak at a Port Fairy facility in 2007 has caused substantial declines in wild abalone in the Otway bioregion (Box 2.8).

Sea-based aquaculture occurs mostly in leases within Geelong Arm, southern Port Phillip Bay, and at Flinders, Western Port, focused mostly on passive rearing of molluscs. The main risk is the accidental release of invasive species when transferring stock between farms. Other risks include organic enrichment, release of antibiotics and growth stimulants and harvesting pressure on wild species to produce food for cultivated species.

Wild 'stock enhancements'

In February 2013, 300,000 eastern king prawns bred in an aquaculture facility were released into Lake Tyers for recreational fishers to catch later in the year. Focused just on benefits for fishers, it was done without an environmental impact assessment. There are substantial risks associated with stock enhancements, including impacts on genetic diversity, trophic interactions and the translocation of disease.[90]

Box 2.8 Abalone disease outbreak

In 2006, wild abalone in Victorian waters became infected with a severe disease caused by the herpes-like abalone ganglioneuritis virus, thought to have originated from an abalone farm at Taylor Bay which discharged untreated effluent into coastal waters. The virus has spread more than 200 kilometres along Victoria's coast, causing up to 90% mortality in infected abalone populations and major economic losses in the wild abalone fishery.[91] The quota in the western region dropped from 280 tonnes in 2001-02 to 20 tonnes in 2011-12. In eastern Victoria the abalone fishery has also suffered declines due to the proliferation of long-spined sea urchins, which have denuded some reefs of vegetation creating 'barrens'. Their spread into cooler near shore waters of Victoria's eastern Bass Strait coastline is most likely due to a strengthening of the East Australian Current.[92]

Algal blooms

Phytoplankton blooms occur naturally but their frequency and severity is increased by nutrients, introduction of new species and through compromised nutrient cycling by marine plants such as seagrasses.

Blooms of conservation concern occur in northern Port Phillip Bay and Western Port, particularly of toxic dinoflagellates. Algal blooms can persist for months in Gippsland Lakes, severely affecting water quality.

2.3.3 Habitat loss and degradation

Victorians do indeed love their coast— on average they visit it more than 20 times each year—but love can be lethal. Each poor planning and management decision adds to the pressure from previous ones—death by a thousand cuts.

Chris Smyth, 2014[93]

At broad scales, habitat loss results from clearing of native vegetation or dredging of the sea bottom, but it also occurs at smaller scales by the loss of habitat elements such as hollow-bearing trees, woody debris and rocks. Degradation, caused by erosion, sedimentation, eutrophication, pollution, overgrazing and weed invasion, reduces the productivity of habitats, while fragmentation limits interactions between and within species, constrains species movements across the landscape, interrupting gene flow and recolonisation, and exacerbates degradation.[94]

The Victorian government has listed at least a dozen potentially threatening processes under the Flora and Fauna Guarantee Act that contribute to loss and degradation of coastal and marine environments, including the degradation of riparian vegetation, habitat fragmentation, input of organotoxins, petroleum and related products to marine and estuarine waters, input of toxicants to rivers and streams, loss of coarse woody debris and hollow-bearing trees, removal of woody debris from streams, discharge of human-generated marine debris and wetland loss and degradation.

Coastal development

The Victorian coastline has already suffered much damage from urbanisation, industrialisation and visitation. Much remnant habitat exists in a narrow strip, hemmed in by roads, car parks, caravan parks and buildings, and vulnerable to fragmentation, weeds, vandalism and dieback. The pressures are increasing, with the number of applications for development under the Coastal Management Act increasing by about one-third between 2003-04 and 2009.[95] Between 1980 and 2004 urban areas increased by 15%, extending from 270 to 311 kilometres, 17% of the coastline.[96] This trend will continue as Victoria's population grows. About 16% of the population lives within five kilometres of the coast, and in the decade from 2001 the coastal population grew an average 1.3% a year to 840,000.[97]

Other development pressures come from high rates of visitation, an estimated 13 million visits a year by Victorians.[98] A 2012 survey found that four of five (84%) Victorians had made at least one trip to the coast in the previous year, and the average was 23.4 trips a year. [99]

Box 2.9 Inappropriate coastal development[100]

In January 2013, the Victorian environment minister gave consent for a breakwater, boat ramp and beach road on crown land at Bastion Point, Mallacoota. In so doing, he approved the burial by concrete and asphalt of a significant landscape, the town's only safe swimming beach, archaeological sites and a rare surfing break.

Under the Coastal Management Act, ministerial consent is to be given only to proposals proven to be appropriate, and consistent with the *Victorian Coastal Strategy 2008*, the relevant coastal action plans and the purposes for which the land was reserved. There had been overwhelming opposition to it in the local community, and a safe and less costly alternative with far fewer impacts was proposed.

An independent planning panel in 2009 found that the project would have 'considerable impact on the wilderness and landscape values of Bastion Point and an overall net detriment to tourism', that the economic case for it was 'very weak', that it would impact in cultural heritage values and that it would have 'no overall societal

benefit'. The panel recommended a small-scale upgrade of the existing ramp.

The then ALP environment minister rejected the panel's advice. A Supreme Court judicial review of the planning minister's decision, mounted by the Friends of Mallacoota, found that the minister's decision was 'surprising' and the panel report was 'a careful, fair, and balanced evaluation.'[101]

Box 2.10 Climatically irresponsible development[102]

Development of the coast along the Dutton Way and out to Narrawong is fraught with great risk, for this region is highly prone to erosion. For many years a special use zone froze development on land at greatest risk of erosion. In 2007 the Shire of Glenelg introduced an assessment process for house construction in this zone, which required extensive documentation by applicants. In 2008 the then planning minister, Justin Madden, gave the go-ahead for construction on 24 blocks, leaving another 525 in limbo. At the November 2010 state election the Coalition committed to removing the local government impediments to development in this zone.

This decision could be costly for Victorian taxpayers. A study commissioned by the Glenelg Shire Council in 2010 estimated that sea-level rise, shoreline erosion and increased storm intensity would result in the following:

- by 2030: shoreline recession of 43 to 63 metres and damage worth $101 million
- by 2070: shoreline recession of 124 to 146 metres by 2070, and damage worth $158 million
- by 2100: shoreline recession of 183 to 211 metres and damage worth $168 million.

The study assessed four adaptation options ranging from doing nothing to reconstructing and extending rock walls, with additional groynes, to the mouth of the Surry River at an estimated cost of $125 million. It considered four planning options that ranged from doing nothing to prohibiting further development. In response, the shire developed a decision matrix that measured the level of risk to property access and the risk of flood and erosion to guide decisions on applications for subdivision and house construction.

In 2012 the state planning minister overturned the Glenelg Shire's rejection of a rezoning application for houses on freehold coastal land west of the Surry River's mouth. The 2010 erosion study indicated this land could be partially eroded by 2070 and completely gone by 2100 due to sea level rises.

In July 2013 the Shire of Glenelg and the planning minister struck a deal to allow future coastal development between Portland and Narrawong, which would 'exclude council's liability for the area and enforce a build-at-your-own-risk policy'.[103] This will create an incentive for future construction of a seawall. The development will also facilitate weed and feral animal invasion of the narrow coastal crown land reserve, stymie movement of plants and animals as the sea rises, and prevent revegetation to improve habitats for coastal wildlife.

Ports, harbours and shipping

There is also industrial development on the coast in the form of ports and harbours. Threats include dredging, oil spills, land reclamation and modification of estuarine habitats, pollution, establishment of marine pests and recreational fishing. Shipping threats include oil spills, groundings, litter/rubbish and effluent dumping at sea, translocation of marine pests and release of toxic antifouling substances. Shipping is increasing as population and trade increase.

In April 2013, the state government announced funding for the design and environmental assessment of a fast-tracked expansion of Port of Hastings as a major container port, which would involve channel dredging, land reclamation and upgrading road and rail corridors. Shipping traffic is predicted to increase from 100 to 3000 ships per year, which could expose Western Port to damaging spills of heavy fuel oil and diesel from container ships and port support vessels, with terrible consequences for the sensitive habitats of the Ramsar listed wetland and internationally significant populations of shorebirds. [104] It will add to the growing pressure on the bay from the spread of Melbourne into its catchment (the city of Casey's population has been growing at 3.3% a year.

Dredging and channel deepening

Maintenance dredging occurs at most of Victoria's major ports, causing suspension of sediments, which reduces water clarity and smothers plants and animals.[105] Most ports have seagrass habitats, which are highly sensitive to turbidity. Due to a lack of studies, the specific consequences of past and present dredging activities are largely unknown. Channel deepening on

the rocky seabed at the entrance to Port Phillip Bay has occurred since the late 19th century. Blasting and dredging in 2008 resulted in rubble being moved by swells and currents into adjacent canyon habitats of high conservation value.

Subsea infrastructure and discharges

Subsea structures in Victoria are mostly pipelines for effluent discharge, gas and oil transfer, and water intake and discharge (for the desalination plant), and electricity and telecommunications cables. There are also three 50 square metre reef ball style artificial reefs in Port Phillip Bay for recreational fishers, and plans for more along the Victorian Coast. They alter seabed habitat and attract aggregations of fish, some species of which are vulnerable to fishing pressure. Renewable energy projects are another emerging source of subsea infrastructure. A proposed demonstration offshore wave power station near Portland will require buoys, undersea pods and a submarine power cable. Offshore wind farms, which require subsea infrastructure to anchor turbines and connect to the electricity grid, are being built overseas and are likely to be proposed in future. Polluting discharges into coastal waters include sewage at Boags Rocks (Gunnamatta) and Black Rock (Barwon Heads) and industrial waste at Corio Bay (Geelong) and Seaspray (Latrobe Valley). When operating, the desalination plant at Wonthaggi will discharge up to 280 billion litres of brine annually. There have been substantial oil leaks in the Otway basin, with unknown impacts.

Oil and gas mining

Victoria's seas are mined for oil and gas: substantial amounts of both are extracted from the Gippsland Basin and there is a smaller but expanding gas industry in the Otway Basin. Oil production peaked in 1985 and annual production is declining, but gas production is increasing. There are considerable undiscovered gas reserves in the Gippsland and Otway Basins. Origin Energy conducted seismic testing offshore from the Bays of Islands Coastal Park in 2011 and in Commonwealth waters off the Otway coast in 2013. Other companies are also exploring for gas. Oil and gas exploration and mining causes hydrocarbon pollution from leaks, accidents and chronic discharges from process water. Seismic testing can affect sensitive marine mammals and potentially other species such as rock lobsters and abalone.[106] Often, the construction of artificial features is necessary for resource extraction, with impacts on the seabed or the coast.

Catchment activities[107]

Inherent to integrated coastal zone management is recognition that catchment activities have consequences for coastal health. The poor health of many of Victoria's catchments is highly detrimental for coastal processes. A 2005 assessment found that fewer than half of Victoria's coastal river basins had more than a third of their stream lengths in good health (Table 2.14).[108] A 2012 assessment found that rivers and streams were in poor or poor to moderate condition in three of five coastal catchments (explained in chapter 4).[109] Catchment-related threats include erosion and sedimentation due to land clearing, forestry and burning; contamination by agricultural nutrients and chemicals, and urban-derived chemicals, nutrients, litter and bacteria; the reduction of freshwater flows; and the disturbance of acid sulphate soils. There is a legacy of pesticides, heavy metals and other contaminants within the sediments of Victorian bays and inlets due to past activities. The siltation of waters flowing into Western Port has caused extensive seagrass loss (section 2.2.3).

Table 2.14 Percentage of stream lengths in good or excellent condition in coastal river basins, 2004[110]

<10%	11-30%	31-60%	61-70%	>70%
Glenelg	Weribee	Otway Coast	Tambo River	Mitchell
Portland Coast	Yarra	Latrobe	Snowy River	East Gippsland
Hopkins	South Gippsland			
Barwon	Thomson			
Moorabool				
Maribyrnong				
Bunyip				

2.3.4 Overexploitation

[While] modern-day fishing practices are generally much improved over practices used as recently as 30 years ago, the legacy effects from the intense fishdown phase of virgin stocks... are a dominant feature of the population structure of most fishable species.

Australia State of the Environment 2011[111]

Fishing, both commercial and recreational, is the major form of exploitation affecting coastal and marine ecosystems. In addition to depletion of targeted species, fishing can affect species caught for bait or incidentally (bycatch), and damage habitats.

Commercial fishing[112]

All large edible species in Victoria have suffered dramatic reductions in biomass and abundance due to historically high levels of commercial exploitation. An initial 'fish down' caused some population collapses, for example of barracouta and elephant seals, which were harvested to commercial extinction. Other species have since been maintained at or below the estimated maximum sustainable fishery production, which has probably led to other collapses – of flat oysters, scallops, pilchards and greenlip abalone.[113] Other fisheries, such as that for school shark, remain tenuous, and declines of white sharks, grey nurse sharks and blue fin tuna are also fishing related. Fishing pressure occurs at or above ecologically sustainable levels throughout all marine habitats, except for the larger marine national parks.

In addition to removal of biomass, fishing can damage habitats. Demersal and scallop trawling, operating out of Portland and Lakes Entrance, cause great damage to bottom communities.

In 2009-10, Victorian commercial wild-caught fisheries production was 4638 live tonnes based on more than 120 species: molluscs (abalone, scallops, pipis, periwinkles), crustaceans (rock lobster, crabs, prawns), cephalopods (squid, octopus, cuttlefish), echinoderms (sea urchins, sea cucumber), polychaetes (sand worms), teleosts (scale fish, more than 75 species) and elasmobranchs (sharks, chimeras, skates, rays).

The Victorian government has assessed wild catch commercial fisheries in Victoria as, 'in general, at or near capacity in terms of fishing effort', with most targeted species classified as 'fully exploited' (defined as sustainable levels of fishing and satisfactory abundance of fished species) or 'environmentally limited' (non-fishing issues are influencing productivity) (Table 2.15).[114] Such stock assessments are typically based on a target biomass of only about 40% of undepleted levels; they mostly do not account for recreational fishing, and a lack of data constrains the capacity to assess ecosystem impacts.[115]

However, improvements have been made in commercial fishing practices in Victorian marine waters in recent years. The Australian Conservation Foundation's Sustainable Australian Seafood Assessment Program assessed several Victorian wild caught fisheries as sustainable in 2011 (Table 2.16).

Table 2.15 Victorian fisheries assessments 2010[116]

Fishery	Stock status	Recreational effort
Rock lobster	Fully exploited	Moderate (eastern) Minor (western)
Giant crab	Fully exploited	Negligible
Abalone	Fully exploited	Minor
Scallop	Fully exploited	Minor
Snapper	Environmentally limited	Large
Black bream	Environmentally limited	Large
King George whiting	Environmentally limited	Large
Sea urchin	Underexploited	Minor
Calamari	Environmentally limited	Large
Garfish	Fully exploited	Large
Rock flathead	Environmentally limited	Minor
Sand flathead	Environmentally limited	Large
Dusky flathead	Unknown	Large
Australian salmon	Unknown	Moderate

Source: Adapted from Department of Primary Industries by Ford & Gilmour (2013). The status of some species was deduced from stock assessment reports. Definitions of terms: Underexploited: The fishery could potentially tolerate additional harvest pressure. Fully exploited: There are sustainable levels of fishing and satisfactory abundance of fishery stocks. Over exploited: Stock abundance is not satisfactory or overfishing is occurring. Environmentally limited: Significant non-fishing (ecosystem) issues are influencing productivity in the fishery and considered to be driving stock status.

Table 2.16 Wild-caught fisheries assessed as 'sustainable' (Sustainable Australian Seafood Assessment Program)[117]

Species	Location
Southern calamari	Corner Inlet, Port Phillip Bay
King george whiting	Corner Inlet, Port Phillip Bay
Snapper	Port Phillip Bay
Rock flathead	Corner Inlet
Silver trevally	Corner Inlet, Port Phillip Bay
Black bream	Gippsland Lakes

Recreational fishing[118]

So many people, so many places, so many methods, so many species – this is the challenge that fisheries and environment agencies face when attempting to evaluate the extent and impact of recreational fishing.

John Ford and Patrick Gilmour, 2013[119]

According to surveys in 2000 and 2009, about one in eight Victorians goes fishing for recreation each year. Because of a lack of monitoring there is little information about the environmental impacts of recreational fishing but the substantial fishing effort – combined with that from commercial fishing – implies far from benign impacts.

Whether commercial or recreational, fishing has three types of impacts: (1) direct impacts on targeted species, (2) direct impacts on non-target species (bycatch, discards, bait), and (3) general ecosystem impacts.

Fishing pressure: The main data on recreational catch from a national survey more than a decade ago (1999–2000) showed that the recreational catch of several species is similar to or exceeds the commercial catch. For example, the recreational catch of snapper was an estimated 332 tonnes, more than seven times the commercial catch (see Table 2.17 for other examples). It is likely that recreational effort has increased since then. But fisheries assessments, including for species considered 'fully exploited', do not include recreational fishing effort, and the combined commercial and recreational catch for some species may be unsustainable – Elephant Fish, for example.[120] Because recreational fishing pressure tends to be highly localised and correlated with population centres and access points, local populations may become depleted. As much as 88% of the recreational catch from Victorian bays and inlets may come from Port Phillip Bay. Recreational pressure may be maintained even when catch rates are low, which prevents recovery, whereas commercial fishers abandon unprofitable sites.

Table 2.17 Estimated recreational and commercial catch 1999–2000 of some target recreational species in Victorian marine and estuarine waters[121]

Species/group	Estimated recreational catch (millions)	Estimated recreational catch (tonnes)	Commercial catch (tonnes)	Estimated % of commercial catch
Flathead	3.32	597	151	395%
Snapper	0.47	332	47	706%
Australian salmon	0.54	271	803	34%
King George whiting	0.98	215	213	101%
Black bream	0.51	203	196	104%
Rock lobster	0.05	61	543	11%
Mullet	0.30	60	>51	<115%
Leatherjacket	0.17	50	17	294%
Trevally	0.11	38	42	90%
Garfish	0.25	26	>118	<225%
Tailor	0.06	14	13	108%
Morwong	0.03	4	>4	<100%
Abalone	0.01	3	1418	<1%
Australian herring	0.01	1	1	100%
Whiting	0.004	1	8	13%

Table 2.18 Other recreationally caught species, estimated 1999-2000 catch

Species/group	Estimated catch
Pipi	640,000
Mussels	620,000
Pike	260,000
Squid/cuttlefish	200,000
Wrasse	120,000
Barracouta	110,000
Sharks/rays	90,000
Scallops	80,000
Prawns	70,000

Bycatch/non-target catch: Recreational fishers, mostly using fishing lines, typically catch a wide range of species while targeting a few favoured species. The survival of fish returned to the water as discards or returns is variable, and discard impacts could be substantial given the magnitude of the recreational catch of some fish, particularly for low-productivity, low-abundance species vulnerable to even low levels of catch. Dive surveys of grey nurse sharks off Australia's east coast between 1991 and 2001 found that the number with embedded fishing hooks and line increased from 2% to 12%.[122]

Bait collection: Impacts on species collected as bait can be similar to those targeted for sport or consumption.

Trophic effects: Fishing of single species can have flow-on ecosystem impacts – for example by favouring competitors, reducing predator abundance, altering benthic habitat or reducing mean trophic levels.

Entanglements: Birds, turtles, fish and marine mammals become entangled in discarded hooks, lines, pots and ropes. Of 537 pelicans rescued in the Richmond River, New South Wales over nine years (1993–2002), 94% were entangled in fishing line and hooks.

Habitat impacts: Fragile habitats can be damaged by anchors or propellers (in shallow water). The use of four-wheel-drive vehicles on sandy beaches and dunes – for launching boats or for shore-based fishing – may contribute to erosion and harm nesting shorebirds.

Invasive species: Fishers can contribute to the spread of invasive species attached to their boats or in fishing gear (see above). Victorian legislation allows recreational fishers to transport live European shore crabs.

Pollution: Fishers contribute to air pollution and greenhouse gas emissions through the use of motorboats and to water pollution by waste (eg bait bags, lead sinkers, discarded or lost fishing line and nets).

2.3.5 Changes to disturbance regimes

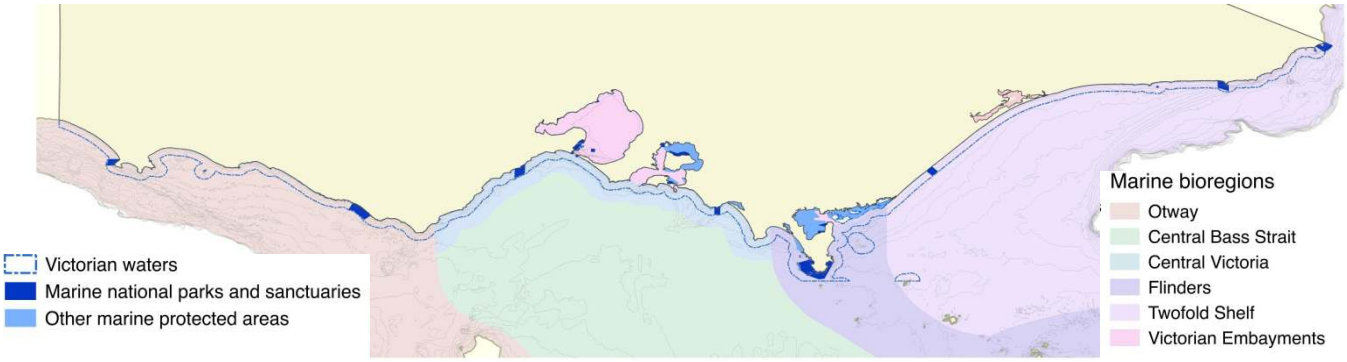
Changes to disturbance regimes – such as fire regimes and water flows - can interrupt species' life cycles or reduce the availability of food, shelter and breeding sites. Harmful fire regimes threaten remnant coastal vegetation (see chapter 3) and changes to water flows by dams and water extractions (see chapter 4) harm coastal and marine ecosystems, for example due to higher salinity levels. Alteration to the natural flow regimes and natural temperature regimes of rivers and streams, inappropriate fire regimes and high frequency fires that disrupt life cycles and compromise vegetation structure and composition are listed as potentially threatening processes.

2.4 Marine bioregional values and priorities

This section briefly summaries the features and values of Victoria's marine bioregions and the results of a gap analysis by Australian Marine Ecology of Victoria's marine protected areas, with recommendations for improving the national park and conservation system.[123] The recommendations in this section are based on the gap analysis, but are modified in a few instances from the original recommendations by Australian Marine Ecology to be consistent with VNPA's criteria for protected areas (section 1.4).[124] See Box 2.11 for the method used for the gap analysis.

Victoria's marine environment has been classified into five bioregions – Otway, Central Victoria, Flinders, Twofold Shelf, and Victorian Bays and Inlets (previously known as Victorian Embayments) – according to a nationally agreed scheme, the Interim Marine and Coastal Regionalisation for Australia.[125] A sixth bioregion – Central Bass Strait – is offshore, in Bass Strait beyond the jurisdiction of the Victorian government. The Environment Conservation Council used the five bioregions to make its recommendations for a representative marine protected area network, which resulted in the 2002 creation of 13 marine national parks and 11 marine sanctuaries encompassing 5.3% of Victorian marine waters.[126]

Figure 2.2 Victoria's marine bioregions



Box 2.11 Method for gap analysis by Australian Marine Ecology

Gaps were identified based on the principles of comprehensiveness, adequacy and representativeness. Comprehensiveness was assessed by first identifying 'provisional biounits' and ecosystems for each bioregion. The criteria for delineating biounits were:

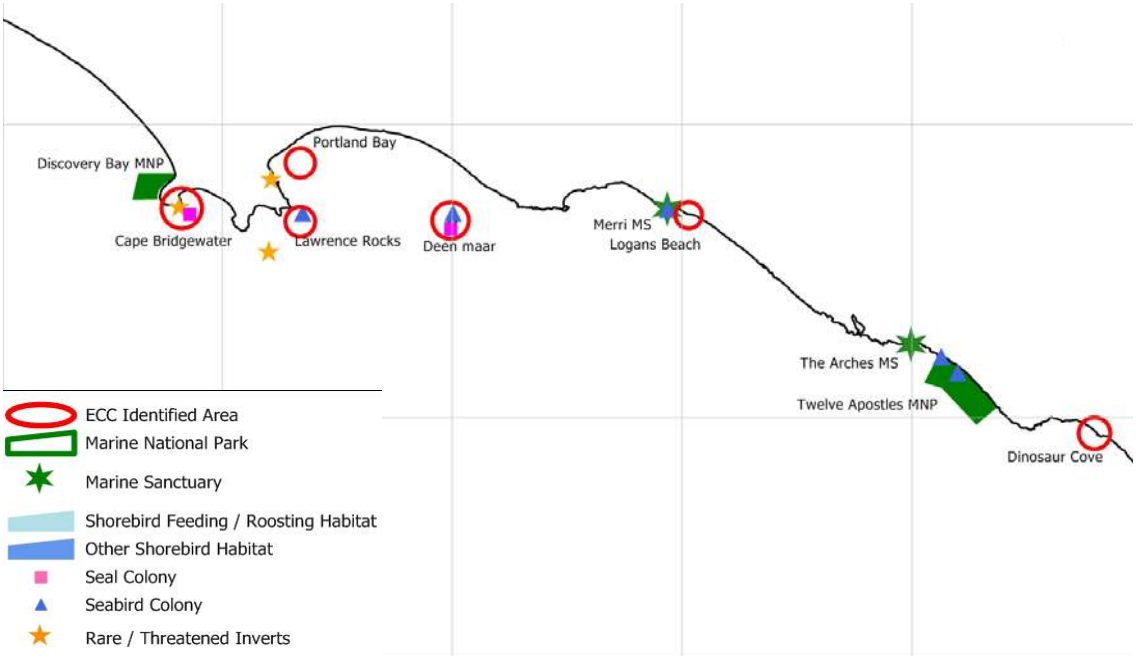
- ecologically functional structural units with recognisable natural boundaries at a scale of tens to hundreds of kilometres
- depth: above or below 30 meters
- exposure: ocean swell exposure, wind exposure, aspect
- water system: upwelling, Southern Ocean, Bass Strait, Tasman Sea
- estuarine influence: size, enclosure, barriers, tides, salinity, suspended sediments, light climate, inputs/catchment.

Adequacy was assessed by the extent to which the area, boundaries and level of protection of each marine protected area (MPA) met the ecological objectives of the MPA, as identified by the Environment Conservation Council (2000) and MPA management plans.

Using the prioritisation criteria listed above, further areas suitable as MPAs were identified and priority MPA areas were compared with the actual MPA coverage for each bioregion to determine gaps, particularly of special or unique communities and species. The existing MPAs and the MPA areas recommended by the Environment Conservation Council (2000) were included in the analysis by default. Other areas were identified from the review of conservation values for each bioregion. Tabulated results of the MPA gap analysis are provided in the appendices for each bioregion in the report by Australian Marine Ecology.[127]

2.4.1 Otway bioregion

Figure 2.3 Areas of high conservation value in Otway bioregion



This bioregion covers 37,331 square kilometres in Victoria, South Australia and Tasmania, from Cape Jaffa to slightly north of Apollo Bay and including King Island. It is characterised by cold, nutrient-rich waters and a rugged coastline of high cliffs and sand dunes lashed by powerful waves.

The Otway bioregion has a narrow continental shelf, a small barrier coast and a steeply sloping seafloor. The coast consists of headlands of volcanic outcrops, dune rock cliffs, shore platforms and offshore reefs, and sand. Seascapes include submerged volcano cones, drowned river channels, and highly eroded underwater steps and reef faces. There are extensive seaweed beds and sponge garden communities on shallow inshore reefs and deep offshore reefs, the latter still largely unexplored.

The waters are highly productive, due to nutrients welling up from deep water at the edge of the continental shelf. The Bonney Upwelling sustains large populations of seabirds, fur seals and whales, and commercially exploited species such as abalone and the southern rock lobster. The Bonney coast is one of only 13 areas globally known for frequent aggregations of blue whales, the largest animals on earth. From Warrnambool to Port Fairy is an important calving and nursery area for southern right whales.

The marine flora and fauna is typically cold temperate. The intertidal and near-shore fringes on wave-exposed coasts are dominated by bull kelp, and rocky seabed communities are dominated by large brown fucoid algae. Seagrasses carpet sheltered bays and occur in pockets in the lee of reefs. Plant species diversity is very high, particularly among the red algae, as is fish diversity.

The islands of Lawrence Rocks and Deen Maar are remnants of extinct volcanos and important breeding sites for seabirds and seals. Lawrence Rocks has the largest colony of Australasian gannets in Australia and hosts rare plants. It is a popular diving site. Deen Maar Island supports one of Australia's largest breeding colonies of Australian fur seals, and recent surveys have found unique deep reef habitats in surrounding waters. It is of special cultural significance to local Gunditjmara people and is also listed as a geological monument of national significance by the Geological Society of Australia.

Estuaries such as Yambuk Lake estuary are important nurseries for juvenile fish. Numerous wetland habitats at Yambuk Lake and along the Shipwreck Coast act as nitrogen and phosphate sinks, reducing coastal water pollution.

Table 2.19 Otway bioregion: biounits, ecological features and protected areas

Provisional biounits	Location	Protected Areas	Gaps in representation
Discovery biounit	Discovery Bay to Portland	Discovery Bay MNP	*Heterozostera* seagrass, intertidal reefs, subtidal patchy reefs, subtidal reefs
Shipwreck biounit	Portland to Cape Otway	Merri MS The Arches MS Twelve Apostles MNP	*Heterozostera* seagrass, *Amphibolis* seagrass

Gap analysis

The Otway bioregion can be divided into two biounits and has four marine national parks or marine sanctuaries (Figure 2.3, Table 2.19).

The four protected areas are generally representative of the bioregion but are inadequate in the following ways (by not according with stated objectives or values):

- Seagrass is not encompassed within any of the protected areas.
- The Discovery Bay Marine National Park does not encompass intertidal and subtidal reef habitats and linkage to coastal habitats is poor.
- The Merri Marine Sanctuary does not adequately encompass subtidal reef biota.
- There is no survey data to properly assess the adequacy of The Arches Marine Sanctuary.

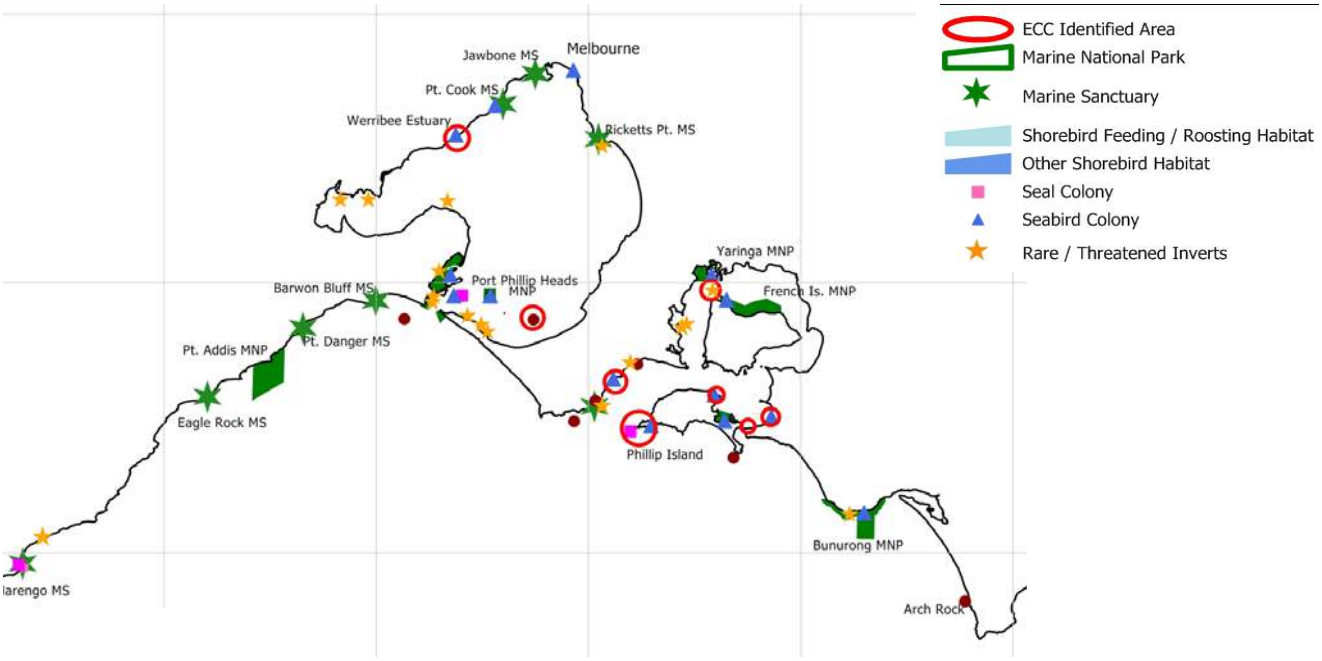
Recommendations

Increase the extent of protected areas in the Otway bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Dutton Bay: to protect seagrass beds and the rare seaweed *Cystophora cymodocea*.
  - Deen Maar Island and deep offshore habitats: to protect breeding sites for Australian fur seals and seabirds, white sharks, seaweed habitats and offshore deep reefs.
  - Bridgewater Bay: to protect a seal haulout, seagrass and a listed crustacean.
  - Lawrence Rocks: to protect bird breeding sites and unique flora.
  - Logans Beach: to protect a southern right whale calving and nursery area.
  - Moonlight Head or Cape Otway: to protect intertidal communities.
- Expand the following protected areas:
  - Discovery Bay Marine National Park: by removing the 500 metre excision between the park and Cape Duquesne and by extending the westward shore boundary, to increase protection of intertidal and subtidal reefs and link to shorebird and wetland habitats.
  - Merri Marine Sanctuary: by extending the southern boundary 200-300 metres seaward to improve protection of subtidal biota, including algae.

2.4.2 Central Victoria bioregion

Figure 2.4 Areas of high conservation value in Central Victoria bioregion



This bioregion covers 444,700 hectares from Cape Otway to west of Wilsons Promontory. It features coastal headlands interspersed with sandy beaches, underwater sandy plains and extensive offshore reefs of diverse types. During the Pleistocene (lasting from about 2.6 million to 12,000 years ago), the sea intruded on and regressed from the coastal plain multiple times. Each regression left a coastal dune field, the oldest of which have consolidated to form limestone ridges. Ridges above sea level are mostly dune covered and those below sea level have formed reefs. Limestone outcrops feature as occasional rocky cliffs and headlands, and as small near-shore islands. The flora and fauna are mostly of southern Australian affinity, but there are also west coast and tropical elements.

A prominent seascape feature is the three kilometre long, 100 metre deep canyon reef complex at Port Phillip Heads. It supports an endemic sessile (fixed) invertebrate community known as the 'sponge garden', which contains 271 sponge species, including 112 known only from Port Phillip Heads. There are also hydroid corals, soft corals, gorgonian corals, crustose and aborescent bryozoans, colonial and solitary ascidians. The Port Phillip Bay entrance deep canyon marine community is listed as threatened under the Flora and Fauna Guarantee Act.

Unique sessile invertebrate and rhodolith (coralline plant) communities occur offshore from Point Addis, and other significant communities are likely to occur in deep areas yet to be surveyed at Apollo Bay, Cape Schanck, Phillip Island (southeast pinnacle) and Cape Liptrap.

Other significant communities include bull kelp beds in the Apollo Bay region and at Barwon Bluff, a high diversity (96 species) of sea slugs (opisthobranchs) 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. Forests of string kelp were once prevalent, but since 1998 this habitat type has almost disappeared.

The Barham River Estuary is a regionally significant saltmarsh and estuary system, providing nesting, roosting and feeding habitat for many bird species. A large fur seal colony lives on Seal Rocks, Phillip Island.

From Apollo Bay to Torquay, long sandy beaches, backed by dunes, offer some of the world's best surfing, and provide habitat for many seabird species. Coastal heathland and scrub are dominant vegetation types, including the threatened coastal moonah woodland community.

Table 2.20 Central Victoria bioregion: biounits, protected areas and gaps

Provisional biounits	Location	Protected areas	Gaps in representation
Surf Coast biounit	Cape Otway to Barwon Heads	Marengo MS Eagle Rock MS Point Addis MNP Point Danger MS	
Mornington biounit	Barwon Heads to Coal Point	Barwon Bluff MS Port Phillip Heads MNP Mushroom Reef MS	Offshore sediments, intermediate reefs, deep reefs
Canyon biounit	Port Phillip Heads Canyon	Port Phillip Heads MNP	
Heads biounit	Port Phillip Heads and Western Port entrances	Port Phillip Heads MNP	
Bunurong biounit	Coal Point to Sandy Point	Bunurong MNP	

Gap analysis

The Central Victoria bioregion can be divided into five biounits and has 10 marine national parks or sanctuaries (Figure 2.4, Table 2.20).

The 10 marine protected areas are considered representative of the bioregion but are inadequate in the following ways (by not according with stated objectives or values):

- The protected areas in the Mornington biounit do not adequately encompass deeper and offshore communities, in particular intermediate and deep reefs.
- Eagle Rock Marine Sanctuary only patchily encompasses subtidal reef habitat.
- Barwon Bluff Marine Sanctuary only encompasses a small area of bull kelp habitat.
- The Point Nepean section of the Port Phillip Heads Marine National Park only partially encompasses *Amphibolis* seagrass habitat, which is not adequately encompassed within any Victorian protected areas.
- Mushroom Reef Marine Sanctuary does not adequately protect fish and most other subtidal biota.
- Bunurong Marine National Park does not adequately encompass deep reef habitat or include the listed holothurian *Pentocnus bursatus*.
- The boundaries of Marengo Marine Sanctuary do not provide an adequate buffer to protect subtidal habitats.

Several areas outside protected areas warrant protection, including:

- 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
- Bunurong seagrass and subtidal reef
- Western Port moderately exposed entrance habitats.

Recommendations

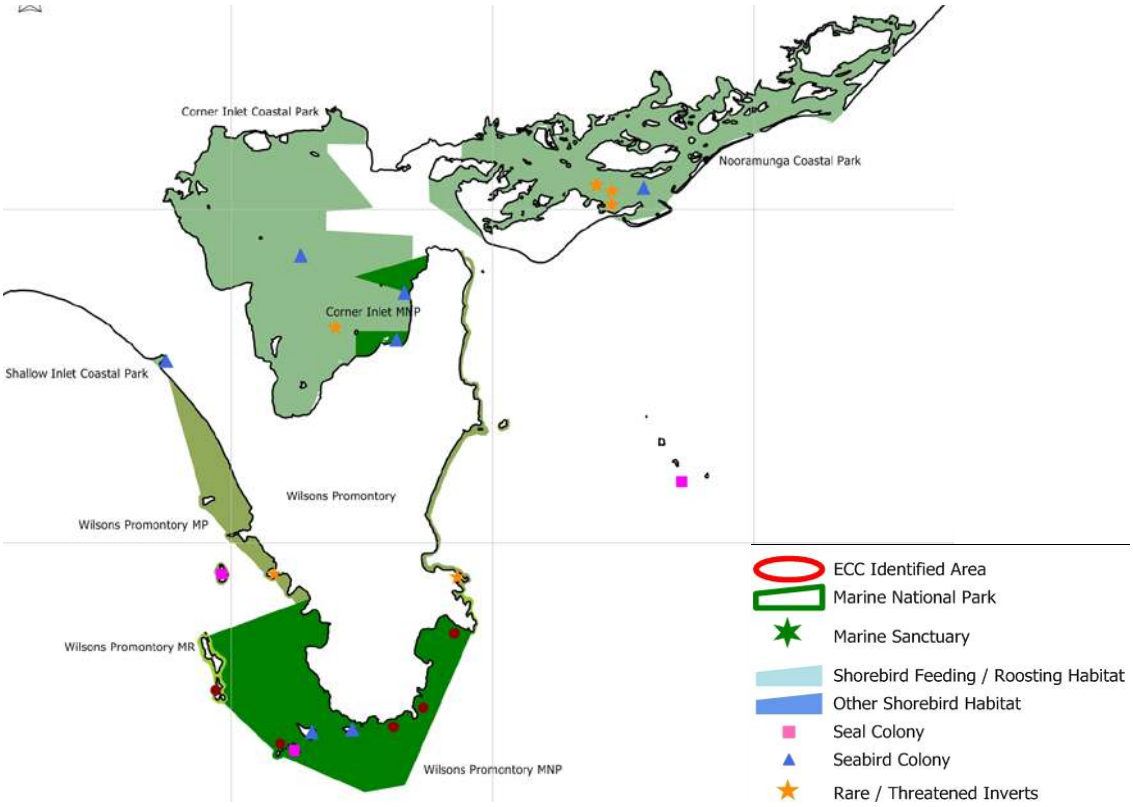
Increase the extent of protected areas in the Central Victoria bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Summerlands Peninsula and Seal Rocks: to protect the seal breeding colony, the penguin colony, white sharks, the muttonbird rookery, *Macrocystis* kelp habitat and areas of high productivity.
  - Flinders/Honeysuckle/Merricks: to protect listed species, *Amphibolis* seagrass and sea dragon colonies.
  - Cape Schanck and Phillip Island Pinnacles, to protect deep reef and offshore sediment habitat and sessile invertebrate diversity.
  - Bunurong Marine Conservation Park: to protect listed species, *Amphibolis* seagrass habitat and crevice fauna.
- Expand the following protected areas:
  - Port Phillip Heads Marine National Park: by extending it in the north to encompass the full extent of *Amphibolis* seagrass and including Tricondera Bay as a dolphin refuge.

- Marengo Marine Sanctuary: by extending it to the natural reef-sand boundaries to better protect subtidal reefs.
- Eagle Rock Marine Sanctuary: by extending the northeastern boundary to encompass continuous reef (subject to a review of the objectives of the protected area).
- Barwon Heads Marine Sanctuary: to provide a buffer for protection of bull kelp habitat (subject to a review of the objectives).

2.4.3 Flinders bioregion

Figure 2.5 Areas of high conservation value in Flinders bioregion



This bioregion covers 2.1 million hectares in Victoria and Tasmania, from Eastern Entrance to Bass Strait, including Wilsons Promontory, Flinders Island and other islands. It features long sandy beaches separated by rocky headlands and promontories, seagrass beds and diverse granitic reef communities.

The geology is mostly granite (Wilsons Promontory, Flinders and other islands) and sediments. In the south are low offshore slopes and extensive reefs while in the north around Wilsons Promontory the shores plunge steeply onto a sandy sea floor. Wilsons Promontory is the southernmost part of the mainland, part of a chain of granite mountains extending across Bass Strait, most underwater.

The waters off Wilsons Promontory are under the influence of the South Australia Current, East Australia Current, and Northern Bass Strait and subantarctic surface waters, and host many species at the edge of their ranges. The bioregion has high fish and plant diversity, mostly of cold temperate species but with a few warm temperate species more common in NSW waters like Eastern Blue Gropers.

The reefs are densely covered in seaweeds, particularly coralline seaweeds, while deeper reefs have diverse communities of sponges, sea whips and soft corals.

Small estuaries at Shallow Inlet and Tidal River and 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 fish and invertebrates. Offshore islands support colonies of Australian fur seals.

The Flinders bioregion is popular for recreation – its sandy beaches, coastal and estuarine waters for recreational fishing, and its reefs for scuba diving and snorkelling.

Table 2.21 Flinders bioregion: biounits, protected areas and gaps

Provisional biounits	Location	Protected Areas	Gaps in representation
Wilson Exposed biounit	Sandy Point to Cape Wellington	Wilsons Promontory MNP	Subtidal sediments (gravel/pebble), *Amphibolis* seagrass
Wilson Moderate biounit	Cape Wellington to McLoughlins Entrance		Intertidal sediments: bare sand, subtidal sediments (beach-surf zone, inshore sand, shelly sand), *Heterozostera* seagrass, intertidal reef, subtidal reef, intermediate reef, deep reef
Flinders Offshore biounit	Seal Islands, Forty Foot Rocks		Offshore sediment, subtidal reef, intermediate reef, deep reef

Gap analysis

The Victorian component of the Flinders Bioregion can be divided into three biounits and has just one protected area (Figure 2.5, Table 2.21).

With no marine national parks or marine sanctuaries in the Wilson Moderate biounit and Flinders Offshore biounit, there are substantial gaps in representation. In the third biounit, most community types are encompassed by Wilsons Promontory Marine National Park, with the exception of *Amphibolis* seagrass and mixed brown algal communities, and it adequately encompasses the stated values and objectives for protection. Some high-value island habitats, such Norman Island, the Glennie Group and the Cliffy Group, warrant protection.

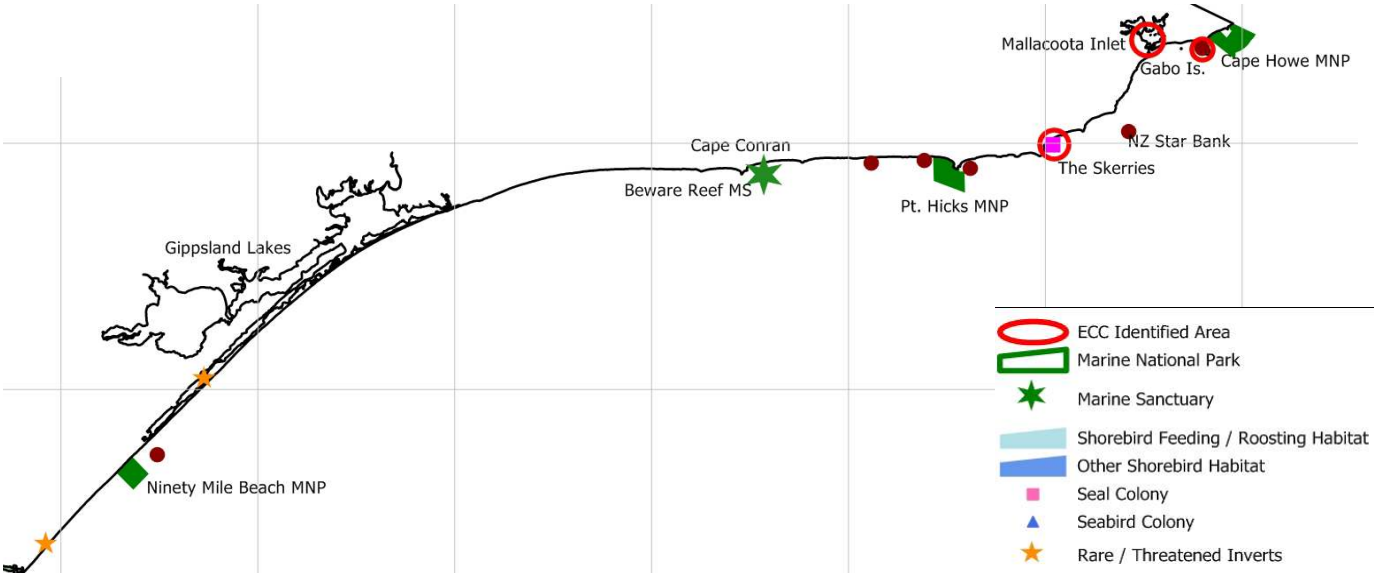
Recommendations

Increase the extent of protected areas in the Flinders bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Sites in the Wilsons Moderate biounit: to protect intertidal and subtidal sediments, *Heterozostera* seagrass, and intertidal, subtidal, intermediate and deep reefs.
  - Sites in the Flinders Offshore biounit: to protect offshore sediment and subtidal, intermediate and deep reefs (review protected area possibilities in conjunction with the Tasmanian strategy).
  - Various islands (eg Norman Island, the Glennie group and the Cliffy Group): to protect representative areas of high value island habitats.
- Expand the following protected area:
  - Wilsons Promontory Marine National Park: to encompass and upgrade protection for Wilsons Promontory Marine Reserve, Marine Park and marine protected zones, and to protect subtidal sediments and *Amphibolis* seagrass beds.

2.4.4 Twofold Shelf bioregion

Figure 2.6 Areas of high conservation value in Twofield Shelf bioregion



This bioregion covers 3.2 million hectares in Victoria, Tasmania and New South Wales, from east of Wilsons Promontory and north to Tathra NSW. It features long sandy beaches broken by rocky headlands, numerous coastal lagoons, and sandy underwater plains.

Sea temperatures and the biota reflect the influence of the East Australian Current that flows from the Coral Sea. Reefs are generally dominated by warm temperate species, including the long-spined sea urchin, which removes kelps from shallow reefs.

Nutrient-rich upwellings along the coast between Lakes Entrance and Gabo Island provide productive feeding areas for seabirds, fish and marine mammals.

The long beaches of Ninety Mile Beach region backed by vegetated dunes shelter a complex of lagoons and wetlands that provide rich habitats for fish, invertebrates and shorebirds. Ninety Mile Beach is an important shorebird breeding area, and the Ramsar-listed Gippsland Lakes support a rich diversity of wetland birds.

Off Ninety Mile Beach, sandy underwater plains harbour an extremely high diversity of invertebrates, among the most biologically diverse sediment beds in the world.

Estuarine lagoons (such as Sydenham Inlet and Tamboon Inlet) along the Croajingolong coast and Mallacoota Inlet are high in nutrients (from freshwater and marine sources), and serve as nurseries for juvenile fish and invertebrates. Mallacoota Inlet is an important feeding and roosting area for birds. The area has important sandflat and saltmarsh habitat as well as estuary grass and lagoon habitats, of high conservation value.

Table 2.22 Twofold Shelf bioregion: biounits, marine protected areas and gaps

Provisional biounits	Location	Protected areas	Gaps in representation
Ninety Mile biounit	McLoughlins Entrance to Marlo	Ninety Mile Beach MNP	intermediate reef [?]
Croajingolong biounit	Marlo to Big Rame Head	Beware Reef MS Point Hicks MNP	
Mallacoota biounit	Big Rame Head to Cape Howe	Cape Howe MNP	
Hogan biounit	Hogan Island Group		offshore sediment, intermediate reef [?], deep reef [?]

Gap analysis

The Twofold Shelf Bioregion can be divided into four biounits and has four marine protected areas (Figure 2.6, Table 2.22).

Australian Marine Ecology identified the following main gaps:

- Ninety Mile Beach Marine National Park has not been surveyed, so its adequacy is unknown. It probably does not encompass any reefs, and may be inadequate to conserve shorebird breeding sites.
- The Cape Howe Marine National Park excludes an area with high richness and diversity of reef fishes that was recommended for protection by the Environment Conservation Council.

Additional areas and habitats warranting protection include:

- the Gabo Island Harbour area
- D*urvillaea* habitat
- areas containing rare seaweeds and with unique community structure such as at Bemm Reef
- probably unique communities in the vicinity of New Zealand Star Banks, which are unsurveyed.

Conservation priorities include the dune and coastal habitat of Ninety Mile Beach and Lakes Entrance region, and Croajingalong subtidal reef (upwelling area).

Recommendations

Increase the extent of protected areas in the Twofold Shelf bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Gabo Island and harbour: to the extent necessary to protect representative areas of urchin barren habitat, fish diversity and little penguins.
  - East Hicks (Durvillaea Flats): to protect bull kelp and red algae diversity.
  - Rame Head, Skerries and Wingan Inlet: to protect an Australian fur seal breeding colony, crested tern breeding site, white sharks and an upwelling region.
  - New Zealand Star Bank: to protect offshore deep habitats and upwelling region (if these values are confirmed by a survey)
  - Bemm Reef: to protect areas of upwelling and high productivity, filter feeding assemblages and Seaweed biodiversity, including rare species.
- Expand the following protected area:
  - Ninety Mile Beach Marine National Park: survey the park, including for reef, sediment invertebrate diversity and shorebird breeding habitat, and expand it to include representative areas of these habitats, including intermediate depth low profile reef.
- Improve management in Cape Howe Marine National Park by fostering interstate cooperation.

2.4.5 Victorian Bays and Inlets

This bioregion encompasses more than 120 confined bodies of water that range in size from 195,000 hectares to less than 100 hectares, covering more than 300,000 hectares in total. Some are drowned river valleys, others are drainage areas impounded by dune barrier systems. They are mostly basin-shaped, less than 25 metres deep, sheltered and with muddy or silty bottoms. Western Port has a bed of lamp shells (brachiopods), which arose in the Cambrian Period (490 to 545 million years ago).

The bays are diverse, with habitats including saltmarsh, seagrass, mangroves, swamps and beaches. The largest, Port Phillip Bay, is a marine embayment fringed by seagrass beds, rocky reefs and sandy beaches, with a muddy central region and sandy in the west and east. Western Port and Corner Inlet are large muddy estuaries with extensive mudflats and seagrass beds.

Extensive diverse salt marsh communities can be found at Port Phillip Bay, Corner Inlet, Gippsland Lakes and Western Port – habitat for orange-bellied parrots and many other species, and important for nutrient cycling, trapping of pollutants and sediments and stabilisation of the shoreline. Large seagrass beds occur

in the Geelong Arm, southern Port Phillip Bay, Corner Inlet, Western Port, Nooramunga and Gippsland Lakes. They are nursery areas for juvenile fish and invertebrates, and stabilise and trap sediments. Mangroves, important habitats for aquatic life and for nutrient cycling and pollutant trapping, are found in parts of Port Phillip Bay, Corner Inlet, Western Port and Nooramunga. Swamp areas, which trap sediments and provide habitats for waterbirds, fish and crustaceans, are present in Gippsland Lakes and at Yallock Creek in Western Port. Sandy beaches, popular for recreation, occur in southern Port Phillip Bay, Western Port, Corner Inlet and Nooramunga.

Figure 2.7 Areas of high conservation value in Victorian Bays and Inlets bioregion

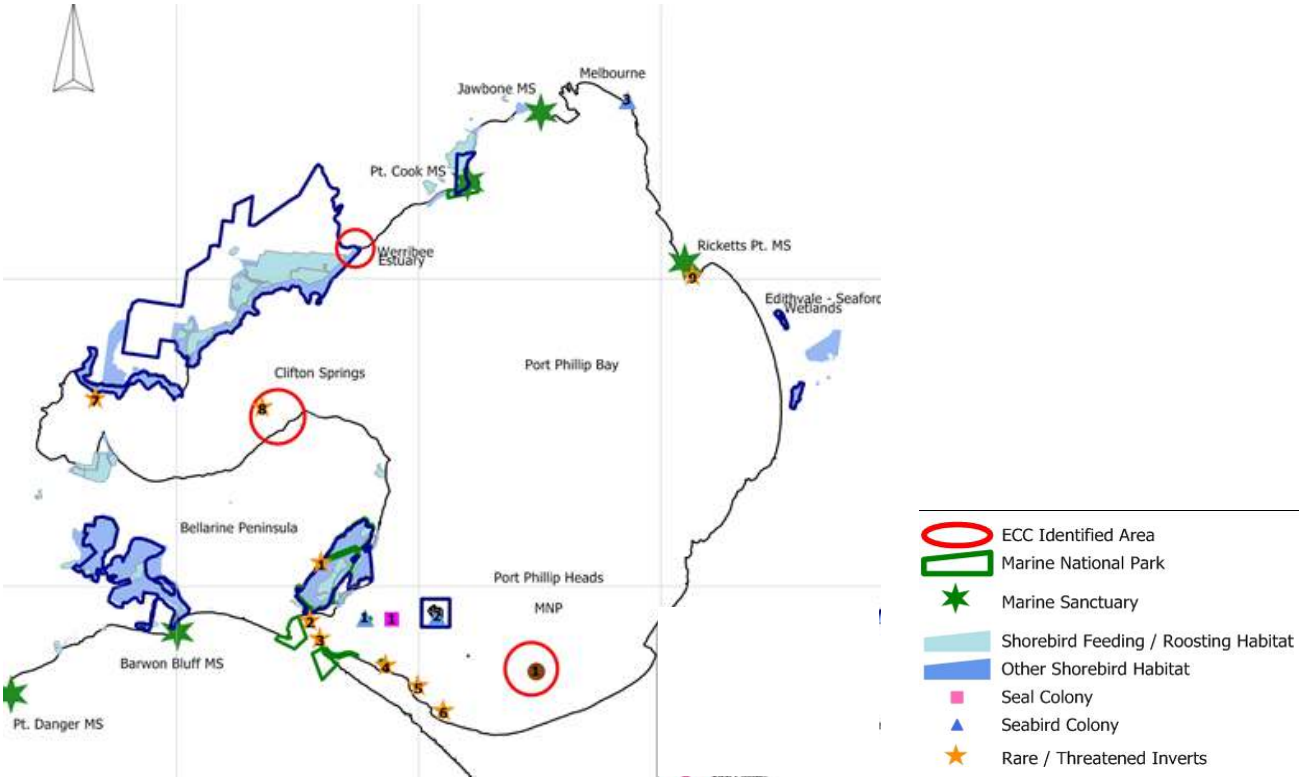


Table 2.23 Victorian Bays and Inlets bioregion: biounits, protected areas and gaps

Provisional biounits	Location	Protected areas	Gaps in representation
Geelong Arm biounit	Geelong Arm and Corio Bay	Point Cooke MS Port Phillip Heads MNP	*Halophila* and *Heterozostera seagrasses*, drift weed mats, *Pyura* clumps
Port Phillip biounit	Port Phillip Bay	Port Phillip Heads MNP Jawbone MS Ricketts Point MS	subtidal sediments (channels), *Pyura* clumps, sponge clumps
Western Port biounit	Western Port	Yaringa MNP French Island MNP Churchill Is MNP	subtidal sediments (channels)
Nooramunga biounit	Corner Inlet and Nooramunga	Corner Inlet MNP	mangroves, intertidal seagrass, *Halophila* and *Heterozostera* seagrasses, *Pyura* clumps [?], sponge clumps [?]
King	Lake Victoria, Lake King		*Ruppia,* intertidal seagrass, subtidal channels, subtidal inshore sand, subtidal silts, *Heterozostera* seagrass
Minor Inlets	Anderson Inlet, Shallow Inlet, Lake Tyers, Sydenham Inlet, Tamboon Inlet, Mallacoota Inlet		*Ruppia*, intertidal seagrass, subtidal channels, subtidal inshore sands, *Heterozostera* seagrass

Gap analysis

The Victorian Bays and Inlets Bioregion can be divided into six biounits and has eight marine protected areas (Figure 2.7, Table 2.23).

The protected areas are generally representative but have several gaps, particularly for drift weed mats and *Pyura* clumps (which are not encompassed in any protected area), channel habitats and seagrass meadows. Other areas warranting protection include:

- some of the nine areas recommended by the Environment Conservation Council for special management zones, including Clifton Springs, Crawfish Rock, San Remo listed community and Mallacoota Inlet areas
- North Arm of Western Port, which supports rare and listed ghost shrimp species
- sediment channel communities of seapens *Virgularia mirabilis* and the 'fossil' shells species of *Neotrigonia margaritacea*, *Anadara tripezia* and *Magellania flavescens*, which are presently unmapped
- sections of Gippsland lakes, consistent with managing the Ramsar wetland values of the area.

Recommendations

Increase the extent of protected areas in the Victorian Bays and Inlets bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries (to the extent necessary to protect representative areas or particular values):
  - San Remo: to protect a threatened marine community and high invertebrate diversity.
  - Mallacoota Inlet: to protect *Ruppia* and enclosed lagoon habitats and bird feeding and roosting sites.
  - Clifton Springs: to protect intertidal and subtidal seagrass beds and areas of high productivity.
  - Capel Sound: to protect *Virgularia seapens*, hard corals, fish aggregations and a sheltered brown seaweed community.
  - Rhyll Mud Banks and Observation Point: to protect bird foraging and roosting sites.
  - Werribee River Estuary: to protect the estuary, wetland and bird feeding and roosting sites.
  - Bass River Delta: to protect bird foraging and roosting sites, intertidal flats and algal beds.
  - Gippsland Lakes (parts): to better protect Ramsar wetland values.
  - West Channels, Symmonds Channel or Pinnace Channel: to protect sponge clump communities
  - Shallow Inlet Marine Conservation Park: to more adequately protect its values.
- Expand the following protected areas:
  - French Island Marine National Park: to include Crawfish Rock, Barrellier Island and channel habitat to protect a threatened ecological community, high diversity of sessile invertebrates, listed hydroid species, channel habitat, Barrellier Island bird roost and mangrove and saltmarsh habitats. (Otherwise, a new marine sanctuary could be created to protect these sites.) Channel biota needs to be surveyed.
  - Corner Inlet Marine National Park: expand northern boundary to Middle Channel to encompass all *Posidonia* seagrass, expand western boundary of the northern section to encompass *Heterozostera* seagrass and channel habitat and protect a threatened holothurian. Include Corner Inlet Marine Conservation Park to more adequately protect its values.
  - Yaringa Marine National Park: to protect channel habitat, subject to a survey of channel biota and a review of adequacy in conjunction with other protected areas in Western Port.
  - Churchill Island Marine National Park: move the southern boundary to encompass saltmarsh habitats and potentially expand the park to include channel habitat subject to a survey and review of the adequacy of protection within all Western Port marine protected areas.

2.4.6 Twenty bioregional priorities

Table 2.24 lists the 20 highest priorities identified by Australian Marine Ecology to improve Victoria's marine protected area network.

Table 2.24 The top 20 priority areas for protection in Victoria (not in priority order)

Bioregion	Region	Identified area	Habitat class	Habitat	Values
Otway	Bridgewater Bay	Bridgewater Bay	Subtidal to state limit	Sediment beds	Seal haulout Sparse seagrass Listed crustacean
	Deen Maar 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
Central Victorian	Port Phillip Heads	Port Phillip Heads MNP Point Nepean	Subtidal to state limit	Seagrass	*Amphibolis* seagrass Dolphin refuge
	Port Phillip Heads	Port Phillip Heads MNP Point Nepean	Subtidal to state limit	Deep Reef Canyon	Listed habitat High diversity sessile invertebrate community
	Western Channel, Flinders	Flinders/ Honeysuckle/ Merricks	Exposed Littoral, Subtidal to state limit	Intertidal reef Subtidal reef	Listed species *Amphibolis* seagrass Sea dragon colonies
	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
	Southern Phillip Island	Cape Schanck or Phillip Island Pinnacles	Subtidal to state limit	Pinnacle/Canyon Deep Reef	Deep reef and offshore sediment habitat Sessile invertebrate diversity
	Bunurong, Inverloch	Bunurong MCP Conservation Zones	Subtidal to state limit	Seagrass	Listed species *Amphibolis* seagrass habitat Crevice fauna
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
	Croajingolong, Marlo to Bemm	Bemm Reef	Subtidal to state limit	Subtidal reef	Upwelling High productivity. Filter feeding assemblages. Seaweed biodiversity – rare species
	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
Victorian Bays and Inlets	Lillias to Wilson	Clifton Springs	Sheltered subtidal (bays and estuaries)	Seagrass	Intertidal and subtidal seagrass beds High productivity
	Lillias to Wilson	Point Lillias to Point Wilson	Sheltered subtidal (bays, estuaries and wetlands)	Seagrass Saltmarsh	Ruppia/estuarine grass *Halophila* seagrass Saltmarsh
	Northern Geelong Arm	Point Wilson to Kirk Point	Sheltered littoral (bays, estuaries and wetlands)	Saltmarsh	Saltmarsh
	Northern Geelong Arm	Wedge Point, offshore	Sheltered subtidal (bays, estuaries and wetlands)	Drift algae	Unique community

Bioregion	Region	Identified area	Habitat class	Habitat	Values
	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
	North Arm, Western Port	Crawfish Rock	Sheltered subtidal (bays, estuaries and wetlands)	Pinnacle/Canyon Deep Reef Channels	Unique community High invertebrate diversity Listed species
	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
	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.
	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.

2.5 Coastal bioregional values and priorities

Like the marine environment, Australia's terrestrial environment has been classified into bioregions based on physical and biological features. The *Interim Biogeographic Regionalisation of Australia* identified 89 bioregions and 419 subregions, of which six bioregions and 10 subregions intersect with the 2000 kilometre Victorian coastline: [128]

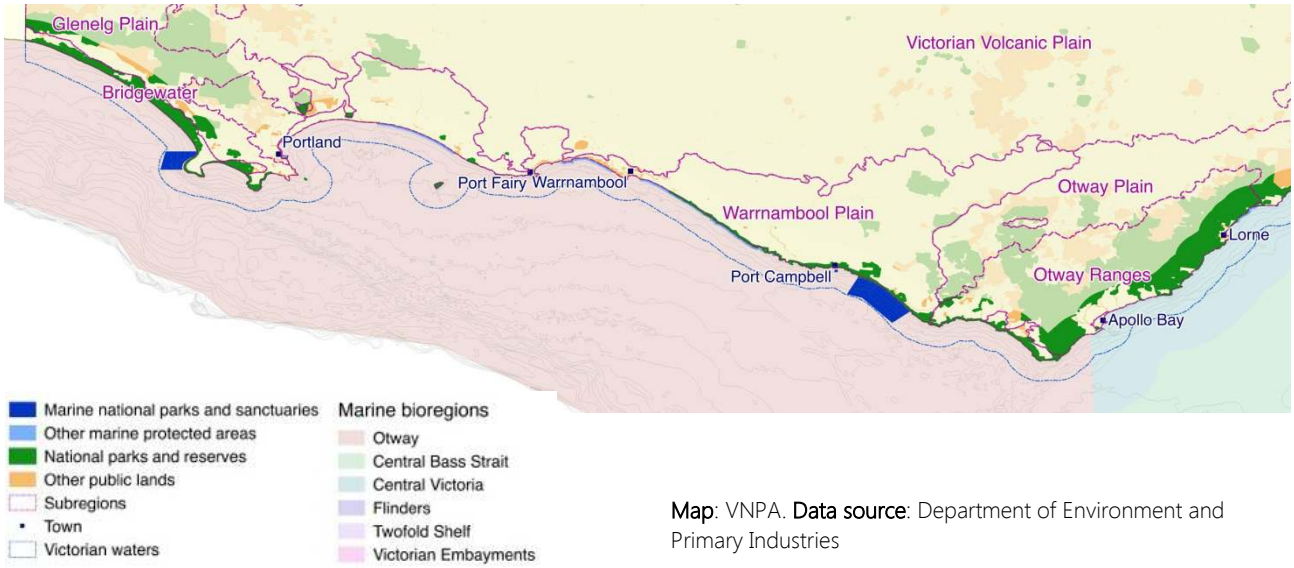
- *Narracorte Coastal Plain*: Bridgewater and the Glenelg Plain
- *South-east Coastal Plain*: Warrnambool Plain, Otway Plain, Gippsland Plain
- *Southern Volcanic Plain:* Victorian Volcanic Plain
- *South-eastern Highlands*: Otway Ranges, Strzelecki Ranges
- *Furneaux*: Wilsons Promontory
- *South-east Corner*: East Gippsland Lowlands.

This section summarises an evaluation by Chris Smyth of values, threats and recommended conservation measures in the 10 coastal subregions.[129] The recommendations focus on four main strategies:

- A coastal private land conservation program to secure the permanent protection of remnants of coastal vegetation on private land by (a) purchase through the Trust for Nature revolving fund and a government coastal land acquisition fund and (b) covenanting projects involving local councils, the state government and interested landholders.
- Establishment of new coastal reserves or expansion or merging of existing reserves, with improved management.
- Restoration of cleared, fragmented or degraded coastal vegetation with priority for threatened ecological vegetation classes or habitat of threatened species.
- Improved regulation and planning to prohibit or reverse inappropriate development on the coast.

For a few subregions, recommendations are made to merge community committees of management. These committees help manage much of the coastal land reserved under the Crown Land (Reserves) Act and have worked with the environment department, local municipalities and environmental consultants to develop coastal management plans that have improved reserve management. Reducing and reorganising some of these committees will 'reduce duplication, enable the pooling of resources, minimise the preparation and implementation costs currently spent on separate strategies and management plans, and improve the opportunities for consistent and integrated day-to-day management along the coast.'[130]

Figure 2.8 Victoria's coastal subregions from Bridgewater to Otway Ranges



Map: VNPA. Data source: Department of Environment and Primary Industries

2.5.1 Bridgewater subregion

This small 18,000 hectare region between the South Australian Border and Cape Nelson (Figure 2.8) is a volcanic plain overlaid by Victoria's largest active dune system. Much of it consists of bare sand and freshwater lagoons. With the highest coastal cliffs in Victoria, Cape Bridgewater is one of the state's most scenic coastlines. Most of the public land is in the Discovery Bay Coastal Park. On private land, which has 20% of remnant native vegetation, plantation forestry and livestock grazing are the main land uses. Drainage of saltmarsh for cattle grazing is a major threat on private land behind the coastal park. The coastline from Discovery Bay to Piccaninnie Ponds is a designated important bird area, and the area encompassing Discovery Bay Coastal Park, Lower Glenelg National Park and the Crawford River Regional Park was assessed nationally as a 'critical aquatic system'.[131]

The conservation and scenic values of Cape Bridgewater have been undermined by the installation of 29 wind turbines on its western side (as part of the Portland Wind Project). The turbines were built within remnants of coastal alkaline scrub and are associated with a network of new access roads. Their placement in this sensitive location has been detrimental both for coastal values and for the important cause of renewable energy, with resistance from coastal communities to industrialisation providing impetus to those opposed to climate change action to push for draconian statewide planning regulations for new wind turbine projects. Development in the coastal alkaline scrub was previously opposed by the environment department because of its 'significant ecological values'.

Current threats for coastal biodiversity in this subregion include the following.[132]

Habitat loss and degradation:

- edge effects in narrow strips of coastal vegetation, especially around Cape Bridgewater, and the presence of inliers of private land within the Discovery Bay section of the coastal park
- off-road driving and riding causing erosion, damage to vegetation and archaeological sites, and disturbing ground-nesting birds and other fauna
- pedestrian access to sensitive areas along cliff tops and through dunes, and unregulated and informal paths.

Dysfunction of biological interactions:

- weeds, horses, cattle and rabbits degrading vegetation
- illegal and licensed grazing in conservation reserves
- encroachment of pine plantations and spread of pine wildings into Discovery Bay Coastal Park
- predation of native wildlife by cats and foxes.

Recommendations

Expansion of protected areas

- Expand Discovery Bay Coastal Park through the proposed coastal private land conservation program by securing and restoring the following areas:
  - the inlying private land north of Long Swamp and east of Lake Minibeong
  - the small parcels of private land along the western shores of the Bridgewater Lakes with coastal alkaline scrub, coastal dune scrub and swamp scrub ecological vegetation classes
  - the large triangle of privately owned coastal alkaline scrub ecological vegetation class behind the Bridgewater Bay settlement
  - any other adjacent private land, as it becomes available.

Management and regulatory measures

- Cancel grazing licences for Discovery Bay Coastal Park and fence the boundaries with private land.
- Provide sufficient resources to park managers and adjoining landholders to fence and restore degraded sites, control illegal stock entry, manage invasive species, horse riding and disturbance of ground nesting animals, and establish wildlife corridors (especially on the largely cleared dunes of Cape Bridgewater) within and adjacent to the Discovery Bay Coastal Park.
- Through the proposed coastal private land conservation program develop a collaborative coastal nature stewardship project between the Victorian government, the Shire of Glenelg, private landholders, the local community and Trust for Nature to create a fenced vegetation buffer of 100

metres on private land abutting the narrow Cape Bridgewater section of the Discovery Bay Coastal Park, with the state government covering the cost to landholders of establishment and maintenance.

- Amend the Rural Conservation Zone 1, which applies to Cape Bridgewater, to prohibit any more wind turbines in that area. Ensure that the existing wind turbines are removed at the end of their commercial life and the site is restored.

2.5.2 Glenelg Plain subregion

This 399,000 hectare region consists of a series of low parallel dune limestone ridges that intersect the coast between Cape Nelson and Portland (Figure 2.8). About one-quarter of remnant vegetation is on private land, where the main uses are pine and blue gum plantations and sheep grazing. Flora of state significance occurs in Cape Nelson State Park and at Point Danger. Current threats for coastal nature in this subregion include the following.

Habitat loss and degradation:

- edge effects in narrow strips of coastal vegetation, and the inlier of private land in Cape Nelson State Park
- future expansion of industry in the Point Danger-Cape Sir William Grant area
- future industrial development in the Coastal Headland Scrub at Cape Sir William Grant, including the approved construction of wind turbines.

Dysfunction of biological interactions:

- Weeds, horses, cattle and rabbits degrading vegetation.
- Predation by cats, foxes and dogs.

Recommendations

Expansion of protected areas

- Expand Cape Nelson State Park:
  - secure the freehold inlier (through the proposed coastal private land conservation program) to protect the endangered coastal mallee scrub ecological vegetation class.
- Expand Discovery Bay Coastal Park by adding the following:
  - crown land from the east of She-oak Road (in Nelson Bay Coastal Reserve), to protect the rare coastal sand heathland and endangered coastal headland scrub ecological vegetation classes
  - coastal heathland/heathy woodland/damp heathy woodland/damp heathland mosaic ecological vegetation classes from Bald Hill Recreation Reserve
  - crown land from the Point Danger-Cape Sir William Grant area with coastal heathland/heathy woodland/damp heathy woodland/hamp heathland mosaic and damp heathland/sand heathland mosaic ecological vegetation classes, to protect Mellblom's spider-orchid and the nation's only mainland Australasian gannet colony.

Management and regulatory measures

- Prohibit any further expansion of industry into the Point Danger-Cape Sir William Grant area.
- Enter into an arrangement with Pacific Hydro and landholders involved in the Portland Wind Energy Project IV to ensure that the wind turbines are removed at the end of their commercial life and the land restored. At that time the coastal headland scrub ecological vegetation class in the north-western corner of Cape Sir William Grant, currently zoned Industrial Zone 2, should be purchased and added to the Discovery Bay Coastal Park.

2.5.3 Warrnambool Plain subregion

Stretching from Portland to Moonlight Head near Princetown, this 264,000 hectare region has been more than 80% cleared for livestock grazing and dairy farming, and once-vast wetlands have been drained. Almost half of the remnant vegetation is on private land and a high proportion of the coast has private land abutting high water mark.

Yambuk Lake and Princetown Wetlands are recognised as nationally important, and the estuary and dunes at the mouth of Yambuk Lake and the Port Fairy-Warrnambool coastline are designated important bird areas. Of state significance for fauna are Griffiths Island, the site of a former whaling station, with colonies of little penguins and short-tailed shearwaters, and the Belfast Coastal Reserve, which has breeding sites for crested terns, silver gulls and hooded plovers. Port Campbell National Park, internationally famous for its spectacular coastline of sheer limestone cliffs, rocks stacks and gorges, has flora and fauna of state significance. The area is at increasing risk from tourism development.

The region includes Australia's first indigenous protected area, declared in 1997 over 453 hectares of rolling sand dunes, limestone ridges and farmland to the west of Yambuk Lake. The Framlingham Aboriginal Trust has revegetated the land, and 12 wind turbines have been installed to generate income. The *Kooyang Sea Country Plan* (2004), prepared by members of the Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation, was the first of its kind in Australia. It covers land within the Glenelg Hopkins and Corangamite catchments and out to the edge of the continental shelf.

Current threats for nature in this subregion include the following.

Habitat loss and degradation:

- loss, severe fragmentation or degradation of coastal vegetation in many places
- the potential for land subdivision and intensification of land use on private land that abuts high water mark on a high proportion of this coastline
- habitat impacts from tourism developments within or adjacent to conservation reserves
- degradation of coastal habitats due to indiscriminate access tracks, grazing, clearing and burning
- the proposed coastal road between Warrnambool and Bay of Islands Coastal Park
- drainage of wetlands and livestock access to riparian habitats
- traffic hazards for native fauna along coastal roads
- vegetation removal and degradation due to road realignments, access roads, car parks, gravel stockpiles, and on disused road alignments.

Climate change:

- sea level rise, erosion and inundation associated with climate change leading to dune and beach erosion.

Changes to disturbance regimes:

- coastal defence works leading to changed coastal processes and the loss of beach and sand dune habitats
- unauthorised openings of estuaries
- compromised estuarine water quality, including algal blooms and increased salinity, due to high sediment and nutrient loads and declining freshwater flows.

Dysfunction of biological interactions:

- weed invasion
- predation of small animals by cats and foxes
- degradation and damage to revegetation projects by rabbits
- disturbance of nesting birds by horses, dogs and beach users.

Over-exploitation:

- illegal removal of orchids (Port Campbell)
- shooting and disturbance of birds by duck shooters.

Recommendations

Expansion of protected areas

- Create Yambuk Lake Coastal Park, to be co-managed by the Framlingham Aboriginal Trust and Parks Victoria:

- include Yambuk Lake Flora and Fauna Reserve, Yambuk Lake, and Yambuk Wetlands Nature Conservation Reserve
- secure (through the proposed coastal private land conservation program) coastal dune scrub remnants and cleared land between the remnants.

- Create Belfast Coastal Park, to be managed by Parks Victoria:
- include crown land and Belfast Lough in the existing Belfast Coastal Reserve (excluding the coastal strip between Port Fairy and the Port Fairy Golf Course)
- include crown land at Griffiths Island, Shelly Cove, Levy Point and Thunder Point
- investigate relocation of the Port Fairy Golf Course and Port Fairy Airstrip, which would be followed by restoration of the land and its inclusion in the coastal park.

- Expand the Bay of Islands Coastal Park:
- add Lake Gillear to the coastal park, to protect endangered remnants of aquatic herbland, swamp scrub and damp sands herb-rich woodland
- secure (through the proposed coastal private land conservation program) private land between Lake Gillear and the Bay of Islands Coastal Park, and establish a planted and fenced wildlife corridor to the threatened coastal headland scrub/coastal tussock grassland mosaic found on the coast
- secure (through the proposed coastal private land conservation program) the land above the Starlight Cave (a maternity bat cave), and fence and revegetate it
- secure (through the proposed coastal private land conservation program) private land abutting the cliff edge between the Starlight Cave and the western end of the park, to a width of 100 m from the cliff, and revegetate the coastal headland scrub/coastal tussock grassland mosaic and damp sands herb-rich woodland.

- Expand the Port Campbell National Park:
- add crown land reserves adjoining or near the national park, including the public purposes reserve and public park reserve on Port Campbell Point, the water reserve (and crown land) east of Port Campbell north of the Great Ocean Road alignment, the small, undeveloped areas of public land between the Great Ocean Road and the park within the township of Port Campbell, west of the Port Campbell Creek, including allotments 2 and 3, and the Loch Ard Public Cemetery
- add the Commonwealth-owned rifle range near Two Mile Bay and restore the land
- secure (through the proposed coastal private land conservation program) private undeveloped land on the Port Campbell headland to protect the southern brown bandicoot
- purchase (through the proposed coastal private land conservation program) private land to the north of the park for the purpose of realigning the Great Ocean Road, and add the land between the new road and the current park boundary to the national park, with restoration of the threatened coastal headland scrub and coastal tussock grassland ecological vegetation classes.

Management and regulatory measures

- Merge the committees of management from Narrawong to Port Fairy into a single committee.

- Create a new West Coast Shire by amalgamating the coastal section of the Corangamite Shire, Moyne Shire and the City of Warrnambool, combine South Gippsland and Bass Coast shires and Wellington and East Gippsland shires, and merge the Borough of Queenscliffe with the City of Greater Geelong.

- Ensure there are no further housing subdivisions along the Old Coach Road at Narrawong, so as to reduce pressure on the very narrow coastal crown land reserve with threatened coastal dune scrub.

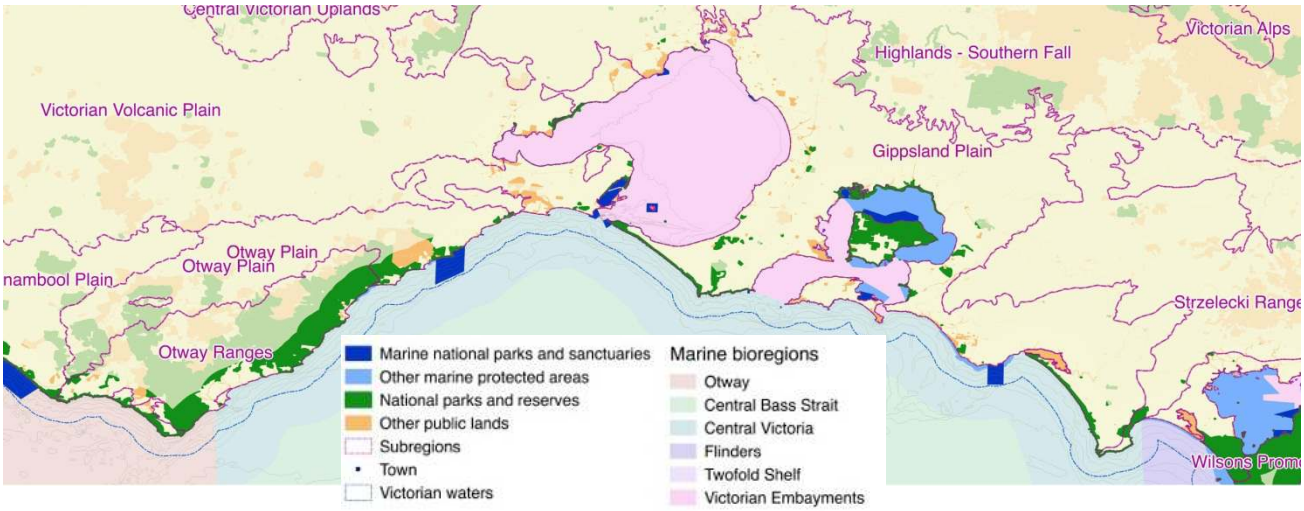
- Close the Old Coach Road reserve, add it to the existing coastal crown land reserve, and fence and revegetate it. Provide a walking track only for anglers to access the beach. Apply a vegetation restoration overlay in the planning scheme of the Shire of Glenelg to create a 50 metre buffer from the road to the adjoining freehold land to prevent development, and restore the area.

- Amend land-use zones in the planning schemes of the Shire of Glenelg, Shire of Moyne, the City of Warrnambool and the Shire of Corangamite to

prohibit wind turbines on private land abutting coastal crown land or the high water mark.

- Reject any proposals to build a coast road between the Bay of Islands Coastal Park and Warrnambool.
- Establish a collaborative coastal nature stewardship project between the Victorian government, the Shire of Moyne, Warrnambool City Council, private landholders, Landcare groups, the community and the Trust for Nature to reconnect coastal and hinterland nature on the Warrnambool Plain. Provide sufficient resources to establish wildlife corridors, rationalise access tracks, erect and maintain boundary fences, and eradicate and manage invasive plants and animals. Focus on re-establishing connections along the coast and the banks of coastal rivers and their estuaries.

Figure 2.9 Victoria's coastal subregions from Otway Ranges to Gippsland Plain



Map: VNPA. Data source: Department of Environment and Primary Industries

2.5.4 Otway Ranges subregion

This 150,000 hectare subregion (Figure 2.9) was shaped 30 million years ago by the uplift of freshwater sandstones and siltstones. Native vegetation remains on just over three-quarters of the bioregion, most of it in Great Otway National Park and the Otway Forest Park. About one-quarter of remnant vegetation is on private land, where the main uses are sheep and dairy cattle grazing and softwood plantations.

The Great Ocean Road is a dramatic drawcard for tourists. The most famous section, between Eastern View and Kennett River, was carved from the steep slopes of the Otway Ranges by unemployed workers during the great depression. It is beset with maintenance and safety problems and regular landslides.

Of state significance are excellent examples of western Victoria's coastal scrub and heathland communities at The Gables, intact woodland, forest and scrub from Point Franklin to Shelly Beach, and forest and coastal scrub communities from Cape Patton to Lorne, where fauna is also of state significance, including swamp antechinus, rufous bristlebirds, and a southern bent-wing bat roosting cave. The Otway Ranges bioregion has been designated an important bird area.

The threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- poor condition of vegetation close to the Great Ocean Road and townships due to visitor pressure, pests and altered fire regimes
- fragmentation of vegetation and accentuation of edge effects
- increased infrastructure and developments in response to growing visitor numbers

- changing land use within or adjacent to the Great Otway National Park and along the Great Ocean Road
- unauthorised roads and tracks and informal walking tracks
- Great Ocean Road upgrades, realignments and landslips.

Dysfunction of biological interactions:

- fox and cat predation of wildlife
- disturbance of habitats and wildlife by feral goats and pigs
- rabbits preventing regeneration, causing erosion and facilitating weed spread
- plant dieback at several coastal heathland and woodland sites due to the pathogen *Phytopthora cinnamomi*
- weeds such as blackberry, boneseed, bridal creeper, sweet pittosporum, ragwort and sea spurge
- horse-riding on beaches disturbing nesting birds such as the hooded plover.

Recommendations

Management and regulatory measures

- Merge the committees of management from Breamlea to Clifton Springs to create a single committee, the Bellarine Peninsula Committee.
- Conduct an independent, transparent and rigorous environmental assessment of the proposed upgrade of the Great Ocean Road, including a comprehensive analysis of the impacts on coastal nature, and robust public consultation processes.
- Maintain existing planning scheme provisions that limit the growth of coastal townships along the Great Ocean Road between Eastern View and Marengo. Do not allow any new coastal subdivisions between Eastern View and Kennett River, and between Princetown and Marengo.
- Provide park managers and adjoining rural landholders with sufficient ongoing resources to manage invasive species in the Great Otway National Park and Otway Forest Park, including in coastal areas.
- Ensure that the easing of restrictions on land development and land-use change in the Rural Conservation Zone does not allow resort and hotel developments or the installation of wind turbines on private land between existing townships on the Great Ocean Road.
- Do not permit commercial developments such as hotels and resorts within the Great Otway National Park. Confine tourist developments to the existing main settlements along the Great Ocean Road at heights and spatial extents appropriate for the landscape.

2.5.5 Otway Plain subregion

A small proportion of the Otway Plain's 237,000 hectares is on the coast (Figure 2.9), and very little is conserved within coastal protected areas. Less than a third of the subregion still has native vegetation, almost two-thirds of it on private land, where major land uses are grazing, cropping and dairying.

Dinosaur Cove, part of the Great Otway National Park, is an internationally significant fossil site. Bells Beach is an internationally famous surfing mecca and was the world's first declared surfing reserve but is suffering from the pressure of 1 million visitors a year.

The Aire River is a listed heritage river, and it and the Lower Aire River Wetlands are in the national directory of important wetlands. Rich in small mammals, Urquhart Bluff is of national significance for both flora and fauna. The large and relatively undisturbed estuary and coastal lagoon at Lake Connewarre and the Barwon River have one of the most diverse saltmarsh areas in Australia and a flora of national significance. The Reedy Lake–Lake Connewarre complex and Swan Bay, both part of the Port Phillip and Bellarine Peninsula Ramsar site are internationally significant for shorebirds, waterbirds and other fauna. The fauna of the disturbed saltmarsh at the Geelong Saltworks is nationally significant. Flora of state significance is found between Rotten Point and Point Franklin, at the mouth of Painkalac Creek, on cliffs between Anglesea and Bells Beach and at Swan Bay. The fauna of the dry saltmarsh and moonah dune scrub at Lonsdale Lakes is of state

significance. The islands of Swan Bay and Port Philip Bay and Bellarine wetlands are designated important bird areas. However, the Bellarine Peninsula is now seen as an area to accommodate much of the population growth of Geelong.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- coastal development and urban expansion including at Apollo Bay, Torquay and towns of the Bellarine Peninsula, Geelong and western shoreline of Port Phillip Bay
- roads and tracks leading to habitat fragmentation and decline
- edge effects due to extreme fragmentation of most coastal and hinterland vegetation, and narrow strips of vegetation between coastal roads and the shore
- urban encroachment on wetlands such as Lake Connewarre, Murtnaghurt Lagoon, Lonsdale Lakes and Geelong Saltworks, and on sand dunes such as at Buckley Park
- drainage and reconfiguration of wetlands, and landfill on the margins of wetlands
- car parks and other infrastructure in fragile areas such as Bells Beach due to visitor pressure
- coastal engineering works.

Changes to disturbance regimes:

- artificial opening of estuaries
- alteration of wetland hydrology
- water extraction from estuarine catchments
- landfill and altered coastal process by ports and marinas, eg Bay West project and Wyndham Cove.

Dysfunction of biological interactions:

- spread of serious weeds, such as blackberry and sweet pittosporum, and of the pathogen *Phytophthora cinnamomi*
- invasive marine organisms such as Japanese kelp at Apollo Bay
- rabbits and carp degrading habitats
- foxes and cats preying on small animals
- livestock access to riparian zones
- disturbance of shorebirds and waterbirds by shooters, boat users, anglers, off-road vehicles.

Recommendations

Expansion of protected areas

- Create a new Geelong and Bellarine Wetlands State Park managed by Parks Victoria, to protect wetland remnants of the Bellarine Peninsula:
  - include Lake Connewarre (the game reserve would be degazetted), Reedy Lake, Hospital Swamp and Murtnaghurt Lagoon
  - include Salt Lake, Edwards Point, the Barwon River estuary, Sand Island, Buckley Park Foreshore Reserve, Lonsdale Lakes Nature Reserve, Lakers Cutting, south-western shores of Swan Bay, Freshwater Lagoon, Thompson Creek and Karaaf Wetlands at Breamlea, the coastal reserves at Black Rocks, Thirteenth Beach, Barwon Heads and Ocean Grove
  - secure (through the proposed coastal private land conservation program) the Geelong Saltworks at Moolap (preventing its development), to protect endangered coastal saltmarsh/mangrove shrubland mosaic
  - secure (through the proposed coastal private land conservation program) land zoned Rural Conservation Zone and Farming Zone abutting Murtnaghurt, some of the land between the lagoon and Thirteenth Beach Road currently zoned Comprehensive Development Zone, and part of the Thirteenth Beach Golf Resort (construct a trail and boardwalk to allow golfers to pass between fairways)
  - secure (through the proposed coastal private land conservation program) Rural Conservation Zone II land between the western end of the Lonsdale Golf Course and the Collendina Caravan Park, and south of Lake Victoria, and close and rehabilitate the quarry
  - secure (through the proposed coastal private land conservation program) unsold allotments on The Point development in the Lonsdale Lakes
  - secure land (through the proposed coastal private land conservation program) in the Farming Zone around the Lake Connewarre reserve with remnants of endangered ecological vegetation classes and restore them.

- Expand the Great Otway National Park:
  - degazette the Aire River State Game Reserve and add it to the national park
  - add heathland at Anglesea currently leased by Alcoa (but outside the mine pit) to the national park (Box 2.12).

Management and regulatory measures

- Transfer the management of the Bells Beach Recreational Surfing Reserve to a new committee of management comprising Parks Victoria, the Traditional Owners and the recreational surfing community, with Parks Victoria responsible for day-to-day management. Prepare and implement a new management plan for the reserve to protect the natural, Indigenous and recreational surfing heritage of Bells Beach, and which is consistent with the vision developed by local surfing recreational groups, in collaboration with Traditional Owners, to create the Bells Beach Surf Sanctuary.
- Secure (through the proposed coastal private land conservation program) land along the Aire River between the bridge and the river mouth, to begin the rehabilitation of natural flows within the wetlands.
- Amend the Rural Conservation Zone applying to private and cleared land in the Johanna and Horden Vale areas, and between Marengo and Skenes Creek, to prohibit wind turbines and other development projects within view of the coast.
- Ensure the continuation of existing planning scheme provisions that limit the growth of coastal townships in the Otway Plain Bioregion. No new coastal subdivisions should be allowed from Eastern View to Geelong, and from Geelong to Altona.
- Do not permit the Spring Creek housing development to proceed.
- Ensure the long-term protection of the Ramsar-listed wetlands in the Western Treatment Plant by placing a covenant on the land that allows the operation of the plant but not its conversion to more intensive industrial or urban uses, and requires the land to become a nature conservation reserve or be added to the proposed Corio Bay Coastal Park if the plant closes.
- Prohibit any replication of the artificial beaches of the Wyndham Cove harbour development elsewhere along Port Phillip Bay's Ramsar-listed western shoreline.

Box 2.12 Mining in the Anglesea heathlands

'Anglesea Heath is the richest and most diverse vegetation community in Victoria. Amazingly, about a quarter of Victoria's plant species can be found here including over 80 different types of orchids.'

Parks Victoria[133]

The 7000 hectare Anglesea heathlands are a botanical treasure trove with more than 700 plants species, including more than 80 orchids, four plants endemic to the site – Anglesea grevillea, Anglesea leek orchid, large bearded greenhood (Anglesea) and the Anglesea grey-gum – and dozens of threatened species.[134] The heathlands are important also for native animals, including the critically endangered New Holland mouse.

Since 1968, Alcoa has operated an open-cut coal mine and power station in a 300 hectare portion of the heathland, having been granted a 50-year lease over more than 7000 hectares in 1961 to build a power station for the Point Henry aluminium smelter in Geelong. Recently, Alcoa was granted a new 50-year lease and permission to extend the mine.

In view of the extremely high values of the site, local and state environment groups have proposed that all heathland outside the current mine site be added to the adjacent Great Otway National Park.[135] Alcoa announced in 2014 that it is closing its operations, which should open up opportunities for a new arrangement.

2.5.6 Victorian Volcanic Plain subregion

This vast 2,356,000 hectare bioregion meets the coast only for a short stretch (Figure 2.9) and has few coastal protected areas. The bioregion formed from volcano eruptions, which began about 5 million years ago and continued intermittently until a few thousand years ago. Its flat grasslands and fertile soils attracted sheep graziers and just 16% of the original vegetation remains, almost two-thirds on private land. Its eastern edge, where it reaches Port Phillip Bay, is subject to increasing urban encroachment.

Limeburners Bay supports large numbers of shorebirds and is nationally significant for fauna. This stretch of coast is also part of the designated Werribee to Avalon important bird area. Between the Avalon Saltworks and the Western Treatment Plant is one of Australia's richest saltmarshes, with flora of national significance and fauna of international significance. It is part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site. The wet and dry saltmarsh and dune vegetation at Point Cook and the Cheetham Wetlands is of state significance, while the fauna at this Ramsar site is internationally significant. The Cheetham Wetlands were part of a complex of evaporation ponds and channels created in saltmarshes by Cheetham Salt Pty Ltd in the 1920s. Seawater from Port Phillip Bay was fed into the ponds, where it evaporated. The saltworks closed in the 1990s, but Parks Victoria maintains the channels and ponds for birdlife. From Altona to Williamstown the flora is of state significance and the fauna is nationally significant. Part of the Ramsar site, the area is an important feeding and roosting site for large numbers of shorebirds.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- large losses of coastal and hinterland vegetation leaving fragmented patches suffering from edge effects
- urban encroachment of wetlands
- continuing loss of saltmarsh
- proposals for port and marina expansions
- stormwater and urban runoff, drainage and rubbish impacting on water quality.

Dysfunction of biological interactions:

- degradation by rabbits
- predation of small animals by foxes and cats
- numerous serious weeds
- disturbance of shorebirds and waterbirds by boat users, anglers, off-road vehicles.

Recommendations

Expansion of protected areas

- Create a new Corio Bay Coastal Park to give stronger protection to Ramsar sites between Limeburners Bay and Lake Borrie:
  - include Limeburners Lagoon (Hovells Creek) Flora and Fauna Reserve, The Spit Wildlife Reserve, Point Lillias, Point Wilson and the Avalon Saltworks
  - include Avalon Coastal Reserve and other coastal crown land reserves along that coastal strip
  - negotiate with the federal government to transfer Point Wilson for inclusion.
- Create the Fawthrop Lagoon Nature Conservation Reserve:
  - through the proposed coastal private land conservation program, establish a collaborative coastal nature stewardship project between the Shire of Glenelg, the Glenelg Hopkins Catchment Management Authority and the local community to manage invasive species and reinstate more natural water flows to conserve the estuarine wetland and threatened swamp scrub and herb-rich foothill forest ecological vegetation classes along and north of Wattle Hill Creek.

Management and regulatory measures

- Provide sufficient ongoing resources to rehabilitate and maintain the threatened coastal tussock grassland ecological vegetation class along the coastal reserve at Black Rocks near Breamlea (for land not included in the proposed Geelong and Bellarine Wetlands State Park).
- Reject the Bay West port project. Any expansion of port infrastructure should focus on consolidating port operations in Port Phillip Bay, including Geelong, and Portland, not the Ramsar-listed

western shorelines of Port Phillip Bay or Western Port.

- Provide sufficient personnel and other resources to continue the environmental enhancement programs focusing on water quality, invasive species and conservation of threatened ecological vegetation classes at Point Cooke Coastal Park and Cheetham Wetlands.
- Establish a collaborative coastal nature stewardship project between The City of Hobsons Bay, the Port Phillip and Western Port Catchment Authority, Parks Victoria and nearby landholders and local friends groups to further improve the water and habitat quality of Kororoit Creek, and restore and protect coastal saltmarsh, coastal alkaline scrub, mangrove shrubland and plains grassland in the Altona Coastal Park and the Jawbone Flora and Fauna Reserve.

2.5.7 Gippsland Plain subregion

The Gippsland Plain is a vast 1.2 million hectare coastal and alluvial plain (Figure 2.9, Figure 2.11) dominated by barrier dunes, swamps and floodplains. It encompasses 27 river systems, 30 municipalities and a rapidly growing Melbourne expanding into its western edge. Only a quarter of the bioregion has native vegetation, almost half on private land.

This subregion features four Ramsar wetlands – Edithvale-Seaford Wetlands, Western Port, Corner Inlet and Gippsland Lakes – which also include designated important bird areas. The large expanse of saltmarsh, mangroves and relatively undisturbed vegetation at Corner Inlet are Victoria's most extensive intertidal mudflats, the world's most southern mangrove, and Victoria's largest stand of *Posidonia* seagrass. Corner Inlet is ideal habitat for shorebirds and up to 50% of Victoria's migratory shorebirds can be found there. Western Port is the third-most important overwintering site for shorebirds in Victoria.

Other areas designated as important bird areas are Anderson Inlet, Shallow Inlet and Phillip Island. The little penguins on Phillip Island attract nearly 2 million visitors a year. Seal Rocks has national significance, with the world's largest breeding colony of Australian fur seals. French Island National Park is of national significance for its flora, with more than 400 plant species, and Gippsland Lakes are nationally significant for their fauna. Point Nepean and Mornington Peninsula national parks are strongholds for threatened coastal moonah woodland, an ecological community with more than 90% of its former extent cleared from the Mornington Peninsula. For thousands of years, Point Nepean was used by Boonwerrung women as a mothering place.

There are many sites with flora or fauna of state significance. Of state significance for fauna are the artificial freshwater wetlands of Coolart, Point Nepean and Sorrento Coastline, the western and northern shores of Western Port, Phillip Island's south and west coasts and Conservation Hill Wildlife Reserve, French Island National Park, the Bunurong coastline, Anderson Inlet, Shallow Inlet, Jack Smith Lake, and Gippsland Lakes. Of state significance for flora are Sandy Point at Cerberus, from Crib Point to Hastings, Point Nepean and Sorrento Coastline, the western and northern shores of Western Port, Corner Inlet, Quail and Chinaman islands, Phillip Island's south and west coasts, French Island National Park, and Gippsland Lakes.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- increasing pressure and edge effects on the narrow strip of coastal vegetation
- urbanisation, industrialisation and roads leading to fragmentation and loss of vegetation
- recreational pressures within and adjacent to conservation and coastal crown land reserves
- removal of vegetation, both authorised and illegal, to 'improve' views
- loss of vegetation on private land and increased land use intensity due to rezonings
- land-based pollution
- boat traffic disturbing shoreline vegetation and causing erosion
- illegal off-road vehicle use eroding soil and damaging vegetation.

Dysfunction of biological interactions:

- numerous serious weeds

- cats, foxes and dogs preying on small animals
- feral pigs and goats degrading habitats
- rabbits causing erosion and hampering revegetation
- horses, dogs and walkers disturbing nesting sites for hooded plovers
- livestock trampling vegetation and spreading weeds
- dieback of vegetation in seabird roosting sites.

Changes to disturbance regimes:

- damaging fire regimes
- dune destabilisation due to inappropriate access, ad-hoc tracks and off-track access and horse riding
- increasing salinity of the Gippsland Lakes leading to loss of bank vegetation and erosion.

Recommendations

Expansion of protected areas

- Create a new San Remo-Cape Paterson Coastal Park comprising:
  - Punchbowl Coastal Reserve
  - Kilcunda-Harmers Haven Coastal Reserve
  - Kilcunda Nature Conservation Reserve
  - Bunurong Coastal Reserve
  - Wonthaggi Heathlands Nature Conservation Reserve
  - Cape Paterson Nature Conservation Reserve.
- Create a Safety Beach-Portsea Coastal Reserve:
  - merge the existing foreshore reserves between Safety Beach and Portsea
  - place the reserve under the management of one community committee of management.

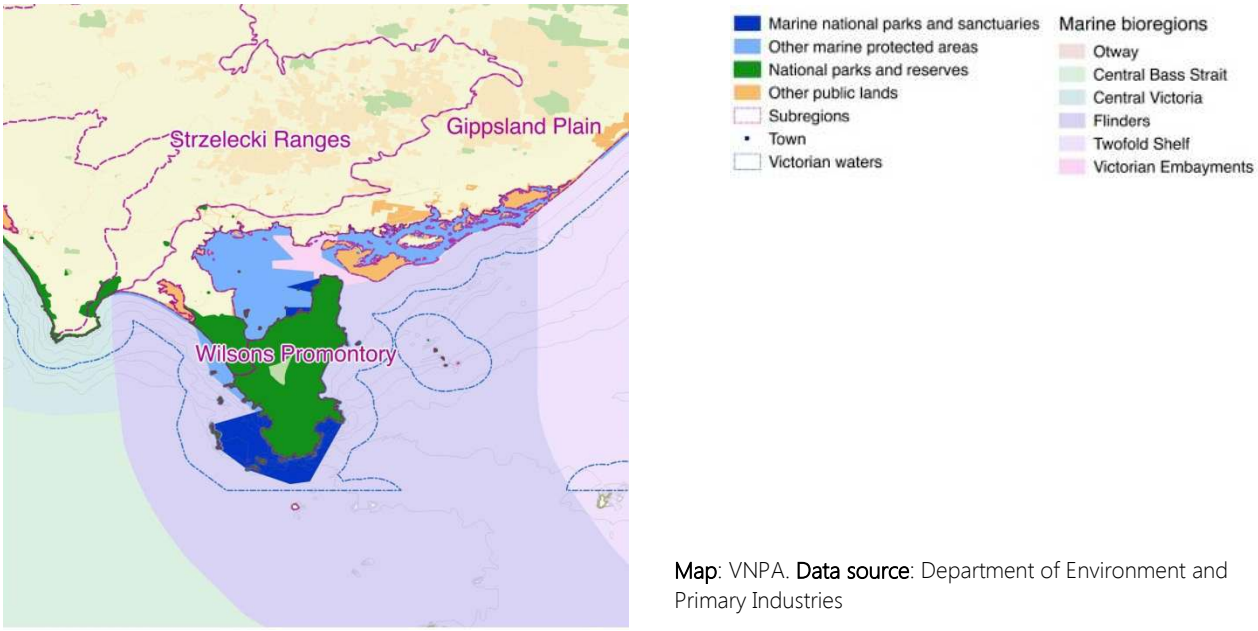
Management and regulatory measures

- Merge the committees of management along the following stretches of coast into single management committees:
  - Mt Eliza to Mt Martha
  - Safety Beach to Portsea
  - Flinders to Hastings
  - Cannons Creek to Tooradin
  - Lang Lang to Coronet Bay
  - Seaspray to Loch Sport Gippsland Plain
  - San Remo to Inverloch GP
  - Walkerville to Sandy Point GP
  - Port Franklin to Woodside Beach
  - Gippsland Lakes
- Reconfigure the boundaries of the catchment management authorities and municipalities in the Gippsland Lakes area, by establishing the Gippsland Lakes Catchment Management Authority and the Shire of Gippsland Lakes, both with their boundaries encompassing the catchment of the Gippsland Lakes. The current East Gippsland Shire Council should return to the boundaries of the Shire of Orbost, and the East Gippsland Catchment Management Authority should have the same boundary. The Shire of Wellington would be smaller and abut the western boundary of the Gippsland Lakes shire.
- Transfer the Phillip Island Nature Parks from the Crown Land (Reserves) Act to a new schedule (similar to that recommended by the Victorian Environment Assessment Council in its Yellingbo Investigation) in the National Parks Act, and support continued management by the Phillip Island Nature Parks.
- Abandon the construction of the proposed Rosebud Aquatic Centre on the coastal reserve at Rosebud.
- Reject plans to expand the Port of Hastings.
- Reject any further expansion of Port Anthony.
- Encourage and enable the Shire of Bass Coast to apply an environmental significance overlay on the private land abutting the high water mark between Tooradin and San Remo. The overlay would establish a 100-200 m buffer zone where no development is allowed and where landholders are provided with the necessary resources to rehabilitate the land with indigenous vegetation.
- Fund the Shire of Bass Coast to conduct an environmental audit of the sea walls along the north-eastern shoreline of Western Port to determine the environmental, social and economic costs and benefits of their removal or retention.
- Fund the Shire of Wellington to conduct an environmental audit of the sea walls along the shorelines of Corner Inlet to determine the

environmental, social and economic costs and benefits of their removal or retention.

- Establish an intertidal protected area under the Fisheries Act to protect pipis along sections of the Victorian coast where they are under pressure. Amend the Cape Liptrap Coastal Park management plan to ban pipi harvesting from Venus Bay.
- Use the proposed coastal private land conservation program to support collaborative projects between Parks Victoria, the Shire of Mornington Peninsula and the Mornington Peninsula and Western Port Biosphere Reserve Committee, private landholders and the local community to improve the quality and extent of coast banksia woodland and coastal alkaline scrub (coastal moonah woodland community) across the Mornington Peninsula.
- Establish a collaborative coastal nature stewardship project between the Victorian government, Parks Victoria, the Shire of Wellington, the West Gippsland Catchment Management Authority, the community and private landholders to enhance the natural values of the catchment of Shallow Inlet, and develop wildlife corridors between Shallow Inlet and Walkerville, and from Shallow Inlet to Corner Inlet.

Figure 2.10 Victoria's coastal subregions from Strzelecki Ranges to Wilsons Promontory



Map: VNPA. Data source: Department of Environment and Primary Industries

2.5.8 Strzelecki Ranges subregion

This 342,000 hectare region formed at the same time as the Otway Ranges, and has similar geology, topography and vegetation. It meets the coast for a short stretch in South Gippsland (Figure 2.10). Less than a third of native vegetation in the subregion has been retained, with more than half on private land. The Cape Liptrap Coastal Park protects much of the remnant vegetation on public land. Plantation forestry, beef and dairy farming are the main land uses in the hinterland. From Cape Liptrap to Walkerville, the flora and fauna are both of state significance.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- residential development in small rural holdings along the park boundary and at Waratah Bay
- land clearing
- inappropriately sited infrastructure on the primary dune system
- uncontrolled recreation, especially in exposed coastal sites, causing degradation
- unauthorised vehicle and pedestrian access tracks into the coastal park from neighbouring properties

- edge effects in narrow vegetation strips around Cape Liptrap
- degradation from livestock grazing.

Changes to disturbance regimes:

- harmful fire regimes.

Dysfunction of biological interactions

- invasive species.

Recommendations

Expansion of protected areas

- Expand Cape Liptrap Coastal Park:
  - secure adjacent land through the proposed coastal private land conservation program, with priority given to land with remnants of the endangered damp forest ecological vegetation class, and restore this land.
- Create Walkerville-Waratah Bay-Sandy Point Foreshore Reserve:
  - merge the foreshore reserves at Walkerville, Waratah Bay and Sandy Point and place under the management of one community committee of management.

Management measures

- Fund Parks Victoria and adjoining landholders to fence Cape Liptrap Coastal Park to minimise encroachment and impacts of adjoining land use, and to manage invasive plants and animals.

2.5.9 Wilsons Promontory subregion

This 40,000 hectare region is a spectacular area of rocky hills and granite headlands, with 91% retention of native vegetation. It is connected to the mainland by the Yanakie Isthmus (Figure 2.10). The entire bioregion is contained within the Wilsons Promontory National Park, which attracts close to half a million visitors a year. The coastal flora is of national significance, and the fauna is of state significance.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- use of roads and tracks leading to soil compaction and soil erosion
- development proposals for the national park.

Dysfunction of biological interactions:

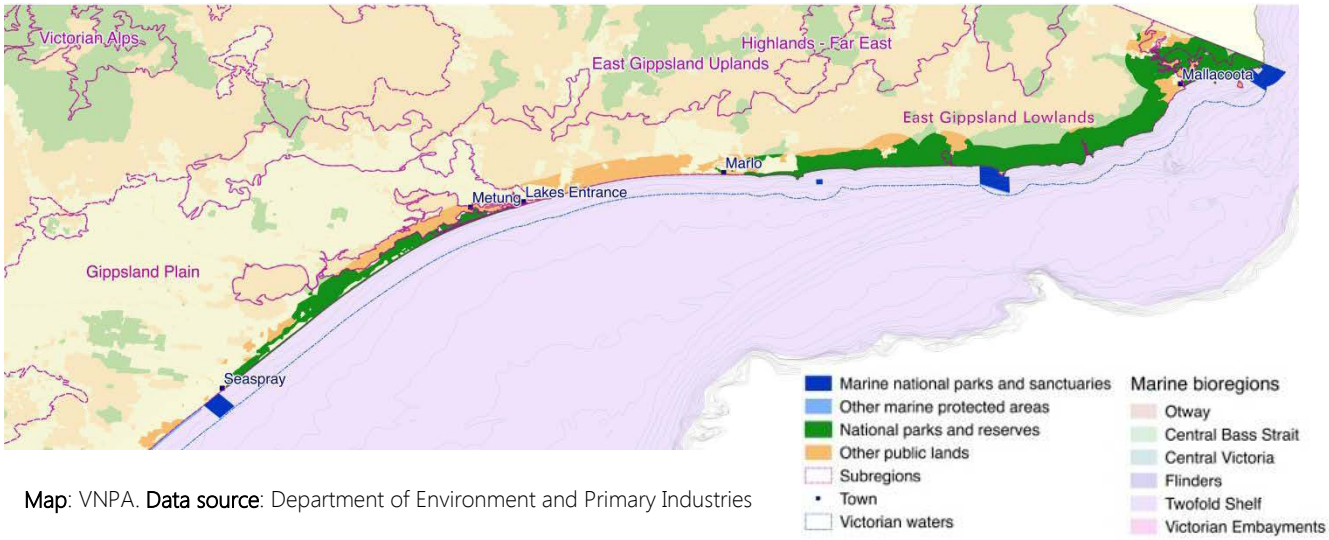
- degradation from native and introduced animals, including rabbits
- weeds, including ragwort, fleabane, sea spurge and thistles
- foxes preying on small animals.

Recommendations

Regulatory measure

- Prohibit any further commercial development within Wilsons Promontory National Park.

Figure 2.11 Victoria's coastal subregions from Gippsland Plain to East Gippsland Lowland



Map: VNPA. Data source: Department of Environment and Primary Industries

2.5.10 East Gippsland Lowlands subregion

This 531,000 hectare subregion of gently undulating terraces, coastal plains, dunefields and inlets extends from Lakes Entrance to the New South Wales border (Figure 2.11). One of the more intact coastal bioregions, it has 62% native vegetation cover, 40% of it on private land. Clearing has mainly occurred on the western edge, due to forestry and farming. Of national significance for both flora and fauna are coastal stretches from Wingan Inlet to Mallacoota, with species-rich and largely undisturbed vegetation, and the dunes from Mallacoota to Cape Howe, which are part of the Nadgee to Mallacoota important bird area.

The threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- harbour development at Bastion Point, Mallacoota
- increasing intensity of land-uses on coastal land and within catchments
- increasing traffic on coastal walking trails, use of wood for camp fires, and recreational uses in general putting further pressure on sensitive coastal environments
- boating activity degrading shorelines and disturbing breeding seabirds.

Changes to disturbance regimes:

- harmful fire regimes.

Dysfunction of biological interactions:

- serious weeds, including bridal creeper, cape ivy and dolichos pea, and the pathogen *Phytophthora cinnamomi*, especially between Mallacoota and Shipwreck Creek
- dog and fox predation on little terns and hooded plovers
- pigs and goats degrading habitats.

Recommendations

Management and regulatory measures

- Establish a collaborative coastal nature stewardship project between the East Gippsland Catchment Management Authority, Parks Victoria, the Lake Tyers Aboriginal Trust, the community and private landholders in the catchment of Lake Tyers to improve the water and habitat quality of the lake by fencing off lake shorelines and vegetation on private land, managing invasive species, and rehabilitating shoreline and catchment habitats.

- Amend the environmental significance overlay applying to private land abutting the coastal crown land reserve and the shoreline of Lake Tyers in the Shire of East Gippsland to establish a 100 metre buffer zone where development is prohibited and restoration is required. The Victorian government should ensure that private landholders have access to sufficient resources to achieve that rehabilitation.

- Abandon the option 3b Bastion Point harbour development at Mallacoota and initiate a process that establishes a lower cost and sustainable alternative that will have community support. Repair any damage caused by the initial construction works.

2.5.11 Summary – subregional recommendations

Table 2.25 summarises the subregional recommendations for protected areas.

Table 2.25 Summary of proposed new, expanded or upgraded coastal protected areas

New, expanded or upgraded protected area	Areas for inclusion in proposed protected area
Discovery Bay – Three Capes State Park	Discovery Bay Coastal Park
	Cape Nelson State Park
	Cape Nelson Lighthouse Reserve
	Nelson Bay Coastal Reserve
	Point Danger Coastal Reserve
Yambuk Coastal Park	Yambuk Lake
	Yambuk Flora and Fauna Reserve
	Yambuk Wetlands Nature Conservation Reserve
	The Crags Coastal Reserve
	Yambuk Coastal Reserve
Belfast Coastal Park	Belfast Coastal Reserve
	Griffith Island
	Shelly Cove
	Thunder Point Coastal Reserve
Part Campbell – Bay of Islands National Park	Bay of Islands Coastal Park
	Port Campbell National Park
	Port Campbell Rifle Range
	Public Purposes Reserve & Public Park Reserve on Point Campbell Point
	Undeveloped areas of public land between the great Ocean Road & the park within Port Campbell, including allotments 2 & 3, and Loch Ard Public Cemetery
Geelong & Bellarine Wetlands State Park	Lake Connewarre Wildlife Reserve
	Salt Lagoon-St Leonards Wildlife Reserve
	Swan Bay-Edwards Point Wildlife Reserve
	Barwon River estuary
	Sand Island
	Swan Island
	Lonsdale Lakes Wildlife Reserve
	Lakers Cutting
	Southwestern shores of Swan Bay
	Freshwater Lake
	Thompson Creek and Karaaf Wetlands at Breamlea
Port Phillip Wetlands State Park	Limeburners Lagoon (Hovells Creek) Flora and Fauna Reserve
	Avalon Coastal Reserve
	Avalon Saltworks
	Point Lillias
	Point Wilson
	The Spit Wildlife Reserve
	Point Cook Coastal Park & Cheetham Wetlands
	Altona Coastal Park
	Jawbone Flora and Fauna Reserve
North Western Port Coastal Park	North Western Port Nature Conservation Reserve
Reef Island-Bass River Mouth Coastal Park	Reef Island-Bass River Mouth Nature Conservation Reserve
San Remo – Cape Paterson Coastal Park	Punchbowl Coastal Reserve

New, expanded or upgraded protected area	Areas for inclusion in proposed protected area
	Kilcunda-Harmers Haven Coastal Reserve
	Kilcunda Coastal Reserve
	Kilcunda Nature Conservation Reserve
	Bunurong Coastal Reserve
	Wonthaggi Heathlands Nature Conservation Reserve
	Cape Paterson Nature Conservation Reserve
	Bunurong Marine Park
Shallow Inlet Coastal Park	Shallow Inlet Marine and Coastal Park
Corner Inlet – Nooramunga Coastal Park	Corner Inlet Marine and Coastal Park
	Nooramunga Marine and Coastal Park
	Wilsons Promontory Marine Park
	Wilsons Promontory Marine Reserve
	Coastal crown land with conservation value along the margins of Corner Inlet
Gippsland Lakes Coastal Park	Gippsland Lakes Coastal Park
	Lake Coleman Wildlife/Game Reserve
	Lake Coleman West Wildlife/Game Reserve
	Victoria Lagoon Wildlife Reserve
	Clydebank Morass Wildlife/Game Reserve
	Heart Morass Wildlife/Game Reserve
	Dowd Morass Wildlife/Game Reserve
	Blond Bay Wildlife/Game Reserve
	McLeods Wildlife/Game Reserve
	Jones Bay Wildlife/Game Reserve
	Avon River Wildlife/Game Reserve
	Tucker Swamp Gippsland Lakes Reserve
	Poddy Bay Gippsland Lakes Reserve
	The Dardanelles Gippsland Lakes Reserve
	Sale Camping Gippsland Lakes Reserve
	Andrew Bay – Grebe Bay Gippsland Lakes Reserve
	Lake Kakydra Gippsland Lakes Reserve
	Lake Melyandra Gippsland Lakes Reserve
	Clydebank Frontage Gippsland Lakes Reserve
	Avon-Perry River Delta Gippsland Lakes Reserve
	Swell Point – Roseneath Point Gippsland Lakes Reserve
	Salt Lake – Backwater Morass Gippsland Lakes Reserve
	Roseneath Point (1) Gippsland Lakes Reserve
	Roseneath Point (2) Gippsland Lakes Reserve
	Morley Swamp Gippsland Lakes Reserve
	Victoria Lagoon Gippsland Lakes Reserve
	Backwater Morass Gippsland Lakes Reserve
	Steel Bay – Newland Backwater Gippsland Lakes Reserve
	Blond Bay Gippsland Lakes Reserve
	Red Morass Gippsland Lakes Reserve
	Wattle Point Gippsland Lakes Reserve
	Raymond Island Gippsland Lakes Reserve
	Hollands Landing Gippsland Lakes Reserve
	Point Fullarton Gippsland Lakes Reserve
	Eagle Point Gippsland Lakes Reserve
	Mitchell River Silt Jetties Gippsland Lakes Reserve
	Eagle Point Gippsland Lakes Reserve
	Mitchell River Silt Jetties Gippsland Lakes Reserve
	Jones Bay Gippsland Lakes Reserve
	Nicholson Floodplain Gippsland Lakes Reserve
	Slaughterhouse Creek Gippsland Lakes Reserve

New, expanded or upgraded protected area	Areas for inclusion in proposed protected area
	Swan Reach Bay Gippsland Lakes Reserve
	Tambo Delta – Metung Gippsland Lakes Reserve
	Nyerimilang Park Gippsland Lakes Reserve
	Bancroft Bay – Kaimna Gippsland Lakes Reserve
	Flanagan Island Gippsland Lakes Reserve
	Fraser Island Gippsland Lakes Reserve
	Baxter Island Gippsland Lakes Reserve
	Rigby Island Gippsland Lakes Reserve
	All other coastal public land of conservation value along the shores of Lake Wellington, Lake King & Lake Victoria that are not the responsibility of the proposed Gippsland Lakes Coast Committee
	Land bought by Shire of Wellington for the restructure of subdivisions along the Ninety Mile Beach
	Lakes Entrance – Lake Tyers Coastal Reserve
Ewing Morass – Cape Conran Coastal Park	Ewing Morass Wildlife Reserve
	Cape Conran Coastal Park
	Lake Corrigale Wildlife Reserve
	First & Second Island Flora Reserve
	Marlo Coastal Reserve

2.6 Conservation gaps and priorities

2.6.1 Knowledge gaps[136]

A major impediment to marine and coastal conservation in Victoria is a lack of basic information about species and habitats, ecological processes and impacts of human activities (see Box 2.13 for the different types of information required). There is only patchy data about the taxonomy, distribution and conservation status of species and ecological communities, and very little of Victoria's marine environment has been mapped.

Box 2.13 Systematic information required for conservation[137]

- Taxonomy, to understand what species exist and how to identify them.
- Inventory – baseline information about 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 impacts of 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.
- Monitoring time series, to detect changes for management responses, including for prevention, improvement and rehabilitation.

Major knowledge gaps include the following:[138]

- marine habitat mapping, essential for identifying areas of ecological significance
- taxonomic and distributional information for species below the low tide mark
- information about ecologically important species, including old-age populations, recruitment source communities and keystone species
- ecosystem processes, particularly for subtidal environments, and linkages between catchments, estuaries and coastal waters
- identification of threatened species and ecological communities and an understanding of threatening processes, including the cumulative consequences of coastal developments
- impacts of increased climate variability.

Victoria's 2008 state of the environment report also highlighted the 'lack of suitable data to adequately measure the condition and trends of Victoria's coastal and marine environments', including:[139]

- no recent trend data to track changes in coastal ecological vegetation classes
- uncoordinated and disparate water quality monitoring outside the main estuaries
- limited information about environmental impacts of activities such as tourism
- little information about the condition of marine plants and animals apart from that gathered for maritime industries or in response to activities such as dredging.

Biodiversity mapping: Apart from within marine protected areas, there has been little systematic mapping of habitats. Some sediment infauna and intertidal and subtidal reef habitats have been surveyed but intermediate and deep reefs in particular remain largely unexplored.[140] Systematic mapping of all marine and intertidal habitats is essential for conservation. As a basis for habitat mapping, there needs to be a marine equivalent of the classification system used for terrestrial habitats, which is based on ecological vegetation classes. The Victorian government has been doing statewide mapping of near-shore bathymetry (marine topography), which will facilitate inventory surveys.

Taxonomy: With much of Victoria's marine biodiversity yet to be described (and some yet to be discovered) marine taxonomy requires a considerable boost. At the current level of taxonomic investment, it will take many decades to acquire a comprehensive inventory of Victorian marine species. Victorian waters host an astounding diversity of sponges but fewer than a third of the estimated total have been described, and only a small proportion of sponge collections have been sorted and identified.[141] Recent surveys in Victoria have revealed new seaweeds and echinoderms, and future surveys will undoubtedly find more.[142] There are far too few taxonomists, particularly relative to the high number of endemic species, and a lack of identification guides to assist with ecological surveys and monitoring.[143] Species could be in decline or lost before they are even identified.

Biology and ecology: Victorian marine conservation requires investment in long-term research and monitoring programs. Apart from species exploited for fishing and aquaculture, little is known about the basic biology and ecology of most Victorian marine life, including which populations are unique or rare, which habitats and areas are critical for particular life phases (such as nursery habitats), and their ecophysiological requirements (such as light levels needed for healthy seagrass, kelp and seaweed beds).

Identifying and managing threats requires a much better understanding of ecological processes such as energy and matter (trophic) flows between species, rates of primary and secondary production, nutrient cycling, competitive and predator/prey interactions. Long-term monitoring is essential to detect changes over time and understand threatening processes. Monitoring programs have been limited to a few community types and sentinel stations. The only state-wide monitoring programs are for fished species, seagrass habitats and marine protected area management. Apart from a few beach water quality monitoring programs for human health purposes, Victoria has just three stations to monitor water quality, all in Port Phillip.[144]

The state of knowledge is too rudimentary to be able to predict with certainty the ecological implications of many changes occurring in the marine environment, including recent abalone population declines from viral disease, fisheries management changes, and species shifts with climate change.

Conservation status: Protecting rare or threatened biodiversity is fundamental to conservation but there is too little information about Victoria's marine environment to know which species and ecological communities need extra protection. Apart from mammals, birds, reptiles and syngnathids (seahorses, pipefishes and seadragons), few threatened marine species or communities have been listed. Just 14 marine invertebrates, three fully marine fishes and two marine ecological communities have been formally listed, reflecting the lack of survey effort rather than a realistic conservation status. The process for nominating and assessing threatened marine biodiversity is mostly ad hoc, with just one systematic assessment completed – for molluscs, echinoderms and decapod crustaceans.[145] A program of systematic data collection, with field sampling and taxonomic support, to identify rare and threatened biodiversity, is needed.

Listing is no guarantee of conservation action. Most action statements for marine species do not explicate how recovery will be achieved – only those for the humpback whale and blue whale provide targets and performance assessment of management success – and there are no action statements at all for marine invertebrates, although they were drafted and presented for public comment. Action statements should be prepared or revised for all listed species and communities, to outline measures required for recovery, and fully implemented.

Because comprehensive listings and recovery actions are unlikely to occur in the near-term, the conservation of rare and threatened biodiversity relies in the interim on achieving a sufficiently comprehensive, adequate and representative marine national park estate.

Table 2.25 outlines actions required to address knowledge gaps about Victoria's marine environment, as recommended by Australian Marine Ecology.

A systematic approach through the development of a Marine and Coastal Research Strategy and Action Plan is needed to address knowledge gaps and improve the linkages between research and management priorities. Long-term researching and monitoring programs, including in the national park estate, are needed to establish the extent and state of marine biodiversity. More effective dissemination of information is essential to improve marine and coastal protection, planning and management.

Table 2.26 Actions to address knowledge gaps[146]

Knowledge Gaps	Recommendations
Lack of taxonomic and distributional information for marine species below the low tide mark, including levels of local and regional endemism and rarity.	More and better biodiversity surveys, sampling a wider array of habitats. Standardise methods across projects to provide complimentary data.
Lack of strategic information on marine-dependent species, including the ecological values old-age populations, recruitment source communities and keystone species.	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.
Lack of information on ecosystem linkages and processes, particularly subtidal.	
Most marine habitats not mapped. Lack of consistent approach to community description and mapping.	Hierarchical system of community characterisation 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. Develop predictive models to fill gaps until all areas have been surveyed.
Inadequate listing process for marine threatened species and communities.	More systematic and rapid listing of marine species and, in particular, communities.
Lack of long-term monitoring and time-series information – limited to a few community types and sentinel stations.	Review, standardise and integrate existing programs where possible, with data sharing between organisations. Develop and implement long-term sentinel monitoring across the state.

2.6.2 Marine national park estate

Gaps in the marine national park estate

At the time of their declaration, Victoria's marine reserves were a world-first representative marine network, and were largely based on the best available science outlined in *Marine, Coastal and Estuarine Investigation* by the Environment Conservation Council in 2000.[147] However, accumulating evidence about the biodiversity values of Victorian waters and about the benefits of highly protected marine areas provide strong reason to substantially expand Victoria's marine national park estate.

Many biodiversity values in Victorian waters are poorly or not protected in the existing national park estate. The 2000 assessment by the Environment Conservation Council suffered from a lack of information about many habitats, a situation that has only been partially rectified (section 2.6.1). The gap analysis by Australian Marine Ecology (summarised in section 2.4) found that Victoria's marine national park estate does not meet current government goals based on the accepted CAR (comprehensive, adequate and representative) principles.[148] Limited documentation of objectives, purposes and levels of protection makes it difficult to assess the extent to which Victoria's marine protected areas meet their objectives. There are considerable discrepancies between boundary locations and the stated or presumed conservation objectives of many of the marine national parks. For example, the Ninety Mile Beach Marine National Park does not include low profile reef habitat despite it being of high acknowledged value in that bioregion. The boundaries of most marine sanctuaries are poorly placed or their area is too small to provide adequate protection. Simply adjusting the boundaries of existing reserves will go some way to improving the protected area network, although surveys are needed to fill substantial knowledge gaps about many marine habitats that are poorly protected. Table 2.24 lists the top 20 priorities for additions to the national park estate as assessed by Australian Marine Ecology.

Other marine areas designated by the Victorian government as protected – various marine and coastal parks that existed prior to the 2002 declarations – lack management plans and conservation objectives altogether, and are not protected from exploitation by recreational and commercial fishers. In addition, areas designated as special management zones have not resulted in any increased protection, and there is little security for them, for the designation can be overturned without a parliamentary process.

Targets for marine protection

More than a decade on from the declaration of Victoria's marine national park estate, there is considerably more scientific evidence about the extent of protection needed to sustain marine biodiversity and ecological processes. Many marine ecologists now consider that 30% strict protection (no fishing) of marine habitats is needed (Box 2.14). This is consistent with the level of 'no take' protection in the Great Barrier Reef Marine Park – a systematic rezoning program initiated in 1999 increased strictly protected areas from less than 5% of the park to more than 33% in 2004.

Expanding the national park estate would have two broad conservation benefits – improving the conservation of biodiversity and strengthening resilience so that marine ecosystems are better able to withstand threats. Climate change is increasing the imperative for this insurance role of marine protected areas, which is based on the idea that reducing current pressures will help ecosystems adapt to climate change and be more resilient to threats that cannot be avoided.[149] There are various lines of evidence to support this – experiments showing that intact habitats are more resistant to invasions and observations that organisms in protected areas suffer less from disease, invasive species and trophic cascades (the ecological consequences of predators being added to or removed from communities).[150] The benefits of strictly protected marine protected areas are outlined in Box 2.15.

Expanding the national park and conservation system is also a high priority to protect the coast from developmental pressures and increase its resilience in the face of climate change. This review strongly recommends an investigation by the Victorian Environmental Assessment Council (or similar independent body) to recommend the best ways to achieve a comprehensive, adequate and representative national park and conservation system for marine and coastal ecosystems that will optimise resilience to current and looming threats. Given the extent of threats to these sensitive environments, and consistent with current ecological thinking, the aim should be to protect at least 30% of each habitat type in marine bioregions. Higher levels of protection are needed for the habitat of threatened species and special features, such as Ramsar wetlands. Many such features and options for protection are identified in section 2.4.

Box 2.14 Marine protected area targets, current and recommended

The current international target (endorsed by the Australian government) for marine protected areas is Target 11 of the Aichi Biodiversity Targets adopted at the 2010 Convention on Biological Diversity:

> By 2020, at least … 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Victoria has not yet achieved this target in the marine environment, either in terms of the percentage area or the requirement for 'ecologically representative and well connected systems'. However, there is a growing realisation by marine ecologists that substantially larger protected area systems are needed for ecologically healthy oceans. The 2003 World Parks Congress recommended that strictly protected areas cover at least 20-30% of each marine habitat by 2012. The following recommendations, which specify protection of a minimum of 30% of each bioregion, were compiled by The Ecology Centre (University of Queensland) as representing the 'broad consensus of the contributed opinions of more than 40 scientists who have an active involvement in the planning and management of marine protected areas in Australia':[151]

- The protected area network should consist of a minimum of 30% of the area of each bioregion.
- Individual conservation features should all be represented in high protection zones at a minimum of 30% as a proportion of their distribution within each bioregion.
- Conservation features reserved in high protection zones should be preferentially of high quality (the most undisturbed state that is available within the bioregion).
- Conservation features known to be significant, threatened or in a degraded state normally require greater proportional representation and specific design consideration, up to 100% reservation, depending on their conservation status in the bioregion.
- Additional representation of conservation features beyond that within high-protection zones can be achieved across other management zones of MPAs within a bioregion.

- Where a physical structure/feature is incorporated into the MPA, the whole feature should be included.

These recommendations have largely been achieved for the Great Barrier Reef Marine Park, with 33% of the park in highly protected no take zones.

The Australian Marine Sciences Association, a professional association of marine scientists with over 1000 members nationally, also recommends higher levels of strict protection.[152]

- No-take protection of 10% 'would slow but not prevent loss of biodiversity', whereas the 33% no-take level in the Great Barrier Marine Park is 'more likely to achieve substantial and sustained biodiversity conservation benefits'.
- 'Rare and vulnerable ecosystems, communities or populations should be provided with greater than 10% protection', and 100% of critically endangered species, ecosystems, or habitat types should be protected in no-take areas.
- Breeding aggregations, migration choke points, and threatened or unique critical habitats should all be carefully considered for inclusion in no-take protected areas.

Box 2.15 The benefits of marine protected areas

Over the last few years, there have been hundreds of peer-reviewed scientific articles confirming the beneficial effects of marine protected areas.

154 marine scientists, 2010[153]

The Australian Marine Sciences Association has identified six main functions for marine protected areas:[154]

- to protect biodiversity and ecosystem functions, including ecological processes
- to assist in maintaining ecosystem services
- to provide scientific benchmarks against which anthropogenic modifications to ecosystems and environments can be monitored and evaluated
- to protect cultural, recreational, spiritual, educational and scientific values
- to protect from disturbance into the future, representative habitats and species for both their intrinsic value and intergenerational equity
- to enhance fisheries production outside reserve boundaries.

Evidence for three main conservation and commercial benefits of highly protected (no-take) marine parks is extensive and growing:[155]

- Well-planned, managed and enforced no take protected areas 'generally harbour denser populations, larger individuals, and higher biomass of previously exploited species'.
- Recovery of exploited predatory and/or herbivorous species often results, over time, in striking differences in the community ecology of protected areas compared to surrounding areas.
- Fisheries benefits can include enhanced larval transport out of reserves, spill-over of adults from reserves, and increased catches adjacent to reserves.

A 2009 meta-analysis of 149 peer-reviewed studies in 124 no-take marine protected areas in 20 countries found they resulted in significant average increases in density, biomass, organism size, and species richness of the communities within reserve boundaries.[156] This applied both to tropical and temperate regions. Organism biomass increased by an average 446% and density by an average of 166% across these studies. The 2012 scientific audit of marine parks in NSW concluded there is 'a very significant body of research' in support of the finding that most marine species (particularly exploited species) increase in size and abundance when fishing ceases.[157] For exploited species this is the case even for 'well-managed' fisheries.

It can take many years for the benefits of protection to peak. Monitoring of marine protected areas in Tasmania found that changes in protected reef communities had steadily manifested over 16 years and were still underway. [158] The reef communities were changed markedly as the effects of fishing – decline of large predators, increased grazing invertebrates, changes in algal communities and other ripples through the food web – were reversed. 'Once fishing ceases, each of these trophic steps adds time lags of many years before the ecosystem can be considered fully recovered.' After 16 years, the biomass of large fishes and rock lobsters had increased by an order of magnitude.

Marine national park management

Parks Victoria could not demonstrate that it is effectively managing [marine protected areas] or that it is being effective or efficient in protecting marine biodiversity within [marine protected areas].

Victorian Auditor General, 2011[159]

In a 2011 audit of the management of marine protected areas, the Victorian auditor general was highly critical of many aspects of management (it wasn't a review of whether the marine protected areas are ecologically effective and achieving their conservation benefits). The audit criticisms included:[160]

- the lack of policy to guide ecosystem-based management of the marine environment
- the lack of, or poor implementation of, management plans for marine protected areas
- the lack of dedicated staff and expertise to protect the marine environment (only six park rangers with marine-specific skills, four of whom had other duties as well)
- an inability to demonstrate effective management of marine protected areas and to account for funds intended for their management
- the lack of integrated planning across agencies with responsibilities for different aspects of management.

Victoria had a management strategy for marine protected areas but it expired in 2010 without having been fully implemented.[161] Noting the interconnectedness of the marine environment, the auditor general also criticised the lack of any detailed planning policy or management strategy for habitats outside marine protected areas.

The Victorian Environmental Assessment Council found that while there had been some improvements in response to the auditor-general's report, the allocation of resources was not consistently aligned with priorities for threat management and that there was more focus on planning than on implementation. The council considered that draft conservation action plans for the marine national parks and sanctuaries could be improved by more scientifically rigorous identification of ecological values and threats, systematic reconciliation against progress with actions in existing management plans and more priority to managing recreational activities in the protected areas. The 2011 recommendations by the Victorian auditor-general should be implemented in full, informed by recommendations by the Victorian Environmental Assessment Council in 2013 (Box 2.16).

Currently, there is a loophole in the National Parks Act that could allow for mining exploration in marine national parks and sanctuaries. The Victorian Environmental Assessment Council has recommended the government consider limiting this 'by providing for the advice of the National Parks Advisory Council to be obtained prior to giving consent to petroleum exploration; and for tabling and disallowance provisions for consents to be similar to those for terrestrial national parks'.[162] Consistent with the cardinal principle of national park management that nature conservation has primacy, the national park estate should be permanently protected from all forms of mining exploration.

Box 2.16 The Victorian auditor general's recommendations in *Environmental Management of Marine Protected Areas* (2011)[163]

1. Parks Victoria should:
- document its marine environmental management programs, including program logic, implementation plans, reporting frameworks and evaluation plans
- implement a system to track time spent by staff on specific activities, particularly on activities related to protecting marine protected areas
- allocate funding dedicated to the management of marine protected areas, to that activity, as intended
- develop a capable and sufficient workforce to discharge its obligations to environmentally manage marine protected areas.

2. The biosecurity standing committee should assign expertise to develop a marine pest biosecurity plan.

3. Parks Victoria should:

- develop park management plans for all marine protected areas with supporting plans that specify actions, targets, performance indicators, accountabilities and time frames for delivery
- develop management reporting that enables the assessment of performance against park management plans
- regularly and routinely review its risk assessments, including prioritisation, for marine protected areas
- as park manager, develop and lead collaboration with other agencies to better inform its planning
- review, for effectiveness, *Victoria's System of Marine National Parks and Marine Sanctuaries: Management Strategy 2003–2010*, to inform the development of a new strategy.

4. The Department of Sustainability and Environment should implement a new services agreement with Parks Victoria that clearly specifies the responsibilities of both agencies, performance standards and indicators, funding levels and reporting requirements.

2.6.3 Coastal national park and conservation system

Expanding the national park and conservation system should be a high priority to better protect Victoria's coast from developmental pressures and foster resilience and adaptation to climate change. As noted above, this review strongly recommends an investigation by the Victorian Environmental Assessment Council (or similar independent body) to recommend the best ways to achieve comprehensive, adequate and representative protection of coastal and marine ecosystems.

The aim should be to securely protect 100% of remnant coastal vegetation. This is important because it has unique and exceptionally high environmental, social and economic values (the latter due to tourism and ecosystem services) that are under extreme pressures. The coastal zone is the land's first line of defence, forming a critical buffer against winds, storms and seawater, forces that will increase with climate change. About two-thirds of the coast (within 500 metres of the shoreline) has remnant vegetation, and about 57% of it is in the national park and conservation system (Table 2.6). An additional 27% is in some form of other reserve (eg a coastal reserve), which may not be secure or well managed (Table 2.9). This leaves about 16% (less than 12,000 hectares) not in some form of conservation tenure, most of which is public land.

Secure protection can be achieved for much of the remaining remnant coastal vegetation by upgrading the level of protection for crown land reserves, by acquiring or leasing private land for the national park and conservation system, and by protecting private land through perpetual covenants. Section 2.5 has identified coastal areas of high conservation value that warrant protection within the national park and conservation system.

About 42,000 hectares (37%) of coastal land are privately owned. This review recommends the establishment of a coastal private land conservation program to secure the future of high priority remnant vegetation. It would fund acquisitions or leases of private land with a focus on properties near reserves or abutting the high water mark. Initial priorities should be private land inliers and land next to coastal conservation reserves. A public acquisition overlay should be applied to protect high priority private land from development and give the government first option to buy when properties are offered for sale.

In addition to the specific additions to the national park and conservation system recommended in section 2.5, coastal public lands should be more securely protected for conservation and other public purposes by applying more appropriate tenure and zoning arrangements for reserves currently managed under the Crown Land (Reserves) Act. To better recognise the values of coastal nature conservation reserves and integrate their management within the national park and conservation system, they should be transferred from the Crown Land (Reserves) Act into a new schedule of the National Parks Act (see section 3.5.1). For other coastal crown land reserves, changes to the state planning policy framework are needed to strengthen protection for conservation and public purposes. Currently, the most common planning zones applied to coastal crown land are Public Conservation and Resource Zone (PCRZ) and Public Park and Recreation Zone (PPRZ). The PCRZ is usually applied to national parks, coastal parks, conservation reserves and

less developed coastal sections, and the PPRZ is generally applied to recreation and settlement nodes. The zones prohibit some activities but allow others under permit (eg renewable energy facilities and emergency service facilities) and others without a permit (eg boat launching facilities, camping and caravan parks, car parks). The two elements of the PCRZ, conservation and resource use, are in conflict. This should be addressed by splitting them into separate zones. Conservation reserves should be excluded from the application of statutory planning zones but the new zones should be applied to coastal reserves (consistent with the 1978 recommendations of the Land Conservation Council), with the Victorian Coastal Council determining the location of the zones. When coastal reserves were recommended by the Land Conservation Council and the Environment Conservation Council, the intention was to provide permanent protection for coastal crown land located between coastal conservation reserves for the purposes of public recreation, education and inspiration. Another recommended tenure change is to incorporate lighthouse reserves within adjoining national or state parks.

Improved tenure arrangements for coastal lands need to be supplemented by more effective management. Because coastal conservation reserves are mostly small and narrow, they are highly vulnerable to edge effects of weed and feral animal invasion, bushfire, livestock intrusion and impacts of adjacent land uses. Effective management planning and implementation are essential for specifying management actions and informing the community about the values at stake.

All protected areas should have management plans and, as noted, coastal protected areas have particularly challenging management issues arising from edge effects and high visitation pressures. Each national, state and coastal park has a management plan but most are more than a decade old and need reviewing.[164] Most coastal reserves and nature conservation reserves lack management plans (the exception being where they are included in plans for other protected areas). This is despite the Crown Land (Reserves) Act requiring a management plan for each nature conservation reserve.

The agencies jointly responsible for park planning – Parks Victoria and the Department of Environment and Primary Industries – are taking a new approach to planning by developing a series of landscape-wide management plans to encompass multiple protected areas. While this approach is sensible in theory, it has mostly been poorly implemented (see section 3.5.1), and there is a risk that the prime objective of protected areas to protect natural and cultural heritage will be compromised by the elevation of tourism and economic goals as major drivers of day-to-day management.

The Victorian government has passed legislation to allow developers to hold leases for up to 99 years in national parks, and has invited applications for developments in two-thirds of Victoria's national park estate. Several iconic national parks on the coast are likely to be impacted: Port Campbell, Great Otway, Point Nepean and Wilsons Promontory national parks. Problems with the state government's push for commercial tourism developments, discussed in chapter 3, include that they are likely to undermine the primary aim of park management of protecting natural values, diverting focus and resources from conservation. History shows that they tend to expand over time, and that developers, rather than most visitors and protected areas, are the beneficiaries

2.6.4 Bays, inlets and estuaries

Although greatly appreciated by the community for their natural, aesthetic and recreational values, many of Victoria's bays, inlets and estuaries also host industries and settlements that threaten those values, and they are sensitive to polluting and degrading activities in their catchments both near and far upstream. Sea level rise and other aspects of climate change will bring many more pressures. A special conservation focus on bays and inlets is warranted because both values and threats are high. Currently, divided agency responsibilities and a lack of strategic direction and formal protection are undermining Victoria's capacity to effectively manage these areas.

An independent authority is needed to oversee the health of Victoria's two largest bays – Port Phillip Bay and Western Port – and their catchments (amalgamating the catchment management functions of Melbourne Water, Central Coastal Board and the Port Phillip Westernport Catchment Management Authority).

Other measures to foster more effective management of bays and inlets are five-yearly reports

on their environmental condition, and clear improvement targets for water quality, ecosystem health and social values (recreation and open space). To assess progress, monitoring programs are needed to establish both baseline condition and chart changes over time. A 2008 analysis of Victoria's estuaries concluded there was a lack of data on water quality and biota, estuarine condition, the number and size of estuaries, how they function and the threats they face.[165] The 2013 state of the environment report also noted there 'remains little data available on the ecological condition of estuaries'.[166]

New planning measures are needed to ensure that future developments and land use changes are compatible with achieving improvement targets for bays and inlets. One vital instrument is a state environment protection policy for estuaries to provide clear statutory objectives and controls to protect estuaries.

Protecting shorebirds

Few birds inspire birdwatchers more than the shorebirds: a diverse group of elegant, active, predominantly wetland dwelling species which carry out some of the most amazing migrations in the natural world.

Julie Oldland & others, 2009[167]

As reflected in the listed values of five coastal Ramsar wetlands and the many sites designated as 'important bird areas', coastal Victoria has immensely important habitats for shorebirds (also known as waders). At least half of the 20 important bird areas support more than 1% of the world populations of certain migratory shorebirds (eg red-necked stints and sharp-tailed sandpipers) which travel up to 25,000 kilometres a year between Victorian shores and breeding grounds in the high Arctic.[168] Many are also important for resident shorebirds like hooded plovers.

All over the world shorebirds are declining, mainly due to loss of habitat. In coastal Victoria, they are under pressure from this, and also from human recreation, and predation by cats, foxes and black rats. Disturbance from human recreation (walking, dogs, horse-riding) can reduce the birds' feeding and resting time, and undermine their ability to put on enough weight to migrate. Proposed developments such as port expansions are likely to cost shorebirds even more habitat.[169]

A substantial proportion of the eastern subspecies of hooded plovers, endemic to southeastern Australia and assessed as threatened in the recent action plan for Australian birds, occur on Victorian beaches.[170] Victorian populations declined by about one-third between 1980 and 2008 (from 600 to 400 individuals) due to threats such as coastal development, disturbance and egg and chick trampling by humans, dogs and illegal vehicles, predation, and weeds.[171] There has been considerable work in Victoria by BirdLife Australia to monitor populations and raise public awareness about safe recreation.

This review recommends the development of a shorebird protection strategy to promote measures to address the major threats to shorebirds.

2.6.5 Marine and coastal management

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.

Australian Marine Ecology, 2010[172]

Marine management is plagued by shortcomings arising from a predominant focus on single sectors and single species. The complex interconnectedness of marine environments requires a holistic focus on ecosystems and ecological processes (see Table 2.25 for the differences), including for sustainable exploitation of commercial species: 'A single commercially valuable fish species, for example, may depend on a range of widely separated habitats over its life, depending on whether it is young or adult, feeding, spawning, or migrating. It needs access to each habitat at the right time, as well as ample food, clean water, and shelter.'[173]

Australia's Oceans Policy outlines the aims of ecosystem-based management as being to maintain:

- ecological processes in all ocean areas, including, for example, water and nutrient flows, community structures and food webs, and ecosystem links
- marine biological diversity, including the capacity for evolutionary change
- viable populations of all native marine species in functioning biological communities.

In essence, it requires maintaining (or restoring) environmental 'structure, function and composition' in a holistic network approach rather than a piecemeal focus on protected areas.[174]

Table 2.27 Contrasting single-issue focused management with ecosystem-based management[175]

Single issue focus	Ecosystem-based management
Manage individual species	Manage entire ecosystems
Manage single sectors (eg fisheries)	Integrate management of all sectors affecting the ecosystem
Focus management at a local scale	Coordinate management at all levels relevant to the ecosystem
Take a short-term perspective: what do we need from the ecosystem this year?	Take a long term perspective: what will the ecosystem be like in 20 years?

Although governments have accepted that an ecosystem approach is essential, there are few examples of implementation. Ecosystem-based management is challenging due to incompatible goals of different stakeholders and 'perceptions that it is too complicated and has prohibitive information requirements'.[176]

Australian Marine Ecology emphasised the importance of placing 'absolute limits' (setting thresholds) on changes to important ecosystem components or processes.[177] One example is protection of marine benthic vegetation in Western Australia, where limits are placed on the cumulative loss of marine plant habitats.[178] Thresholds range from none in highly impacted areas to 1% in highly protected areas and 10% in development areas. Examples of ecosystem components or processes that could be protected with this approach include primary carbon production rates (linked to light availability), denitrification (removal of nitrogen) efficiencies in sediments, and abundance of functional species (such a predators).

One of the main goals of ecosystem-based management is to build ecological resilience – to sustain or restore the capacity of ecosystems to 'resist, buffer or recover from changes caused by increased environmental pressures, at lower disturbance levels'.[179] This is vital in the face of climate change.

Building resilience can require multiple approaches:

- restore ecosystem components or processes, such as large predators (most Victorian reefs are missing large predators)
- provide a buffer above minimum sustainable limits of exploitation
- reduce controllable perturbations to increase capacity for response to uncontrollable or unforeseen disturbances
- maintain redundancy of functional components or species and areas (such that multiple species are present to fulfil ecological roles and there are multiple sources of recruitment)
- have a representative and comprehensive system of highly protected marine areas, including areas with minimal human disturbance to maximise the potential for rebuilding fully functional systems and areas that act as biogeographical buffers.

Coastal protection and restoration

Where land, sea and air merge is naturally a place of high energy and natural dynamism. Victoria's coast is also the interface between multiple, often conflicting human agendas – for recreation, industry, habitation and conservation – which greatly accelerate the scale and rapidity of change.

With climate change already impacting coastal nature and much more change seemingly inevitable, 'resilience' and climate 'adaptation' need to become much more than buzzwords. Easing existing pressures on coastal habitats (due to development, invasive species, bushfires among others) and restoring natural habitats are the most effective ways of fostering the capacity of coastal nature to absorb or adapt to climatically induced changes. As a starting point, objectives to foster resilience and adaptation should be included in Victorian planning provisions and the state planning framework, complemented by changes to

coastal statutory zoning and overlays to provide for in situ protection of coastal nature for as long as possible and assist inland retreat as sea levels rise. Planning is needed to identify how coastal settlements and biodiversity will be accommodated as sea level rises and the priority areas that should be protected to permit species movement

With developmental and other threats to coastal habitats mounting, stewardship programs (such as BushBroker and CoastalTender) to support landholders to protect and restore remnant vegetation on private land should be expanded. Protection and restoration of native vegetation is fundamental to coastal health. A new vegetation restoration overlay in the Victorian planning provisions is recommended to protect a 100-200 metre buffer around vegetated coastal public lands, including estuaries and wetlands, within which development is prohibited and management of invasive species and other threats is required. Any changes in land use zones for the coast should be referred by the planning minister to the environment minister (the Planning and Environment Act will need to be amended to require this).

Because they are so attractive to people, coastal habitats are being burdened by an accumulation of infrastructure – roads, tracks, car parks, buildings and utilities – that compromise natural, scenic and recreational values. Much of this infrastructure is unnecessary or could be sited elsewhere. An independent review of infrastructure adjacent to the coastal national park and conservation system should be commissioned with the aim of relocating, removing or better managing it to minimise impacts on natural values. Commercial tourism developments in national, state and coastal parks should be prohibited, and any construction or upgrade of boat ramps, and the impacts of fishing enabled by such development, should be rigorously assessed.

In addition to compromising coastal values, much infrastructure on the coast is at risk from eventual inundation under climate change. An initial assessment by the Australian government (in 2009) predicted that by 2100, under a scenario of a 1.1 metre rise in sea level with a 1-in-100 storm tide, from 27,600 to 44,600 residential buildings in Victoria would be at risk of inundation.[180] Much other infrastructure (commercial buildings, roads, sea walls, bridges, groynes, power lines water and sewer mains, septic tanks, gas pipelines, stormwater drains, jetties) would also be at risk. It makes economic, social and environmental sense to ensure that coastal infrastructure is assessed, designed, constructed and maintained taking future climate change into account, as is consistent with the principles of ecologically sustainable development. Priority areas for defence (eg by sea walls) and retreat will have to be identified, and the issue of coastal dependency (which infrastructure is reliant on a coastal location) will have to be addressed. It would be wasteful of public resources and unnecessarily environmentally damaging to build defensive structures for infrastructure that need not be located on the coast.[181] A coastal infrastructure unit (modelled on the Victorian Ports and Harbours Division of some years ago) should be established to assess and manage boating infrastructure, coastal defensive works, artificial reefs and the planned retreat of coastal infrastructure for all coastal locations except for the major ports (Portland, Geelong, Melbourne and Hastings).

Boating infrastructure

Victoria has extensive boating infrastructure but there is pressure to build even more access points and upgrade existing facilities. In boating coastal action plans, the environmental impacts of such infrastructure have been considered in terms of site impacts and the effect on coastal currents and sand movement but no consideration has been given to environmental impacts of the activities (boating and fishing) facilitated by new infrastructure. Limits on boating infrastructure should be set based on an assessment of the boat 'carrying capacity' of Victoria's estuaries.

Managing oil spills

Oil spills can have catastrophic impacts on wildlife and marine and coastal habitats. Planning and management systems are needed to minimise the risk of spills – prevention should be the first goal – and to maintain response preparedness. Planning should be shaped by risk assessment of current and projected shipping traffic from each Victorian port and high priority given to protecting the national park estate (Parks Victoria has emergency response plans for parks and reserves that include oil spills).[182] Decisions about port expansions such as at the Port of Hastings should take into account the heightened risk of oil spills.

Managing invasive species

Current approaches to invasive species tend to be the opposite of ecosystem-based management – more reactive than proactive, mostly focused on just a few harmful species, and prioritising short-term commercial benefit from use of invasive species over long-term ecological health. The well-accepted prevention-first hierarchy has not been comprehensively implemented – exotic plants, in particular, are generally permitted into Victoria without the most basic precaution of assessing their invasion risks. For some widespread invasive species, control to protect particular habitats or species may be all that is feasible. But ecosystem-based management requires a broader focus, including management or restoration to bolster resilience to invasive species impacts (eg. by restoring predators or reducing nutrient enrichment) and integration with management of interacting threats – such as harmful fire and water flow regimes, over-fishing, and disturbance. There also needs to be a strong focus on preventing new invasions by requiring risk assessment of all introductions and responding quickly to new incursions.

In a 2011 audit of marine protected area management, the auditor general found that the then Department of Sustainability and Environment was ill-prepared to respond to new incursions of invasive marine species. Deficiencies included a lack of detailed planning to assign roles and responsibilities to prepare for, detect and respond to incursions, poor integration between departments, and a lack of resources. There was no marine pest monitoring system (no systematic or routine monitoring occurs in any Victorian port). The auditor general recommended that the cross-agency biosecurity standing committee develop a marine pest biosecurity plan. This is essential, and it should have a strong prevention focus.

2.6.6 Governance structures and processes

Ecosystem-based management – in contrast to species-based, industry-based or site-based management –has not been incorporated into state laws and institutions. Victoria's governance structures and processes are too disparate and unfocused to achieve the state's goals for marine and coastal management. Recommendations specific to the coast and seas include new legislation to implement ecosystem-based management and ecologically sustainable development (a Marine and Coastal Planning and Management Act) and a marine and coastal strategy to provide an over-arching framework. The specific measures and targets for each region would be set out in regional marine and coastal plans, encompassing the current multiple action plans for coasts, estuaries and boating, and including strategies to prepare for climate change.

To provide the necessary oversight and integration, an independent authority – a proposed Victorian Marine and Coastal Authority – should be established to absorb and expand on the functions of the existing Victorian Coastal Council, with regional marine and coastal boards to replace the existing coastal boards. Integration with catchment management would be facilitated by aligning the boundaries of coastal regions with those for catchment management authorities (splitting the three coastal regions into five regions) and by establishing close links between the relevant policies and plans.

2.6.7 Commercial and recreational fishing

Ecosystem-based management

Victoria's Fisheries Act includes the following objective relevant to ecosystem-based management: 'to protect and conserve fisheries resources, habitats and ecosystems including the maintenance of aquatic ecological processes and genetic diversity'. Although a requirement for ecosystem-based management is recognised in some Victorian fisheries (such as for southern rock lobster, giant crab and abalone) there has been no rigorous evaluation of their ecosystem effects and knowledge of ecosystem processes on which to base evaluations is largely lacking.[183] Criteria to assess the ecological sustainability of all fisheries, whether commercial or recreational, and site-specific ecological risk assessments are needed. The introduction of ecosystem-based limits – such as the abundance of particular functional species in fished ecosystems – is 'a

partial solution' to the difficulties of insufficient ecosystem knowledge,[184] and a precautionary approach where information is lacking is essential.

One of the goals of ecosystem-based management is to maintain or build resilience (discussed above). This will require reducing fishing pressure on some targeted populations, which are maintained at very low proportions of virgin biomass, to buffer communities against other disturbances. For example, maintaining healthy populations of large adult rock lobsters can help prevent the destruction of giant kelp marine forests by long-spined sea urchins, as demonstrated in Tasmanian marine protected areas.[185] Rock lobsters are efficient sea urchin predators but are currently fished down to low densities.

Ecosystem-based management also requires better protection of habitats critical to targeted species (such as fish nurseries and important feeding grounds) and whole-of-catchment programs to improve water quality and protect coastal habitats.

Recreational fishing

While commercial fishing pressure in Victoria has declined or stayed stable, recreational fishing has surged in popularity. For several species the recreational catch is similar to or exceeds the commercial catch and pressures on some species and ecosystems are substantial (Table 2.17). Participation rates, where fishing occurs and total catches of target and non-target species are basic information required to manage recreational fishing but there is no program to collect such data. The most recent survey was about eight years ago and focused only on the catch of snapper in Port Phillip Bay and Western Port.[186] It should be a high priority to assess recreational fishing catch and impacts by a range of methods, including regular large-scale surveys of participation and catch, licencing all recreational fishers with endorsements for particular coastal regions, expanding the angler diary program, monitoring the main targeted species and conducting annual trawl surveys of Port Phillip Bay. Recreational fishers typically catch a wide range of species and discard most, retaining a few favoured species. The impacts of this on discarded species could be substantial, particularly for rare or declining species (such as grey nurse sharks), and need to be investigated.

Enforcement

With about 570,000 participants in recreational fishing, enforcement is difficult – 'governments experienced in managing commercial fisheries are finding unique challenges in the recreational sector and experiencing the failure of traditional monitoring, evaluation and enforcement methods'.[187] Enforcement is also hamstrung by the typical problems of too few resources and low priority (for there is little 'political reward' in rigorous enforcement of this sector).[188] Parks Victoria is accountable for compliance in the national park estate but mostly relies on Fisheries Victoria for implementation. This has resulted in a blurring of accountability, and there is widespread concern that the values of marine protected areas are being compromised by poaching.[189] Education, surveillance and rigorous enforcement are needed to better protect marine national parks and sanctuaries from illegal take. The Victorian Environmental Assessment Council has recommended a review of cross-agency coordination to clarify roles and accountabilities, sufficient funding and education and interpretation programs.[190]

Indirect fishing impacts

There is need for 'a better-defined and more collaborative system of identifying and addressing' fishing-related impacts that are of high or moderate risk such as bird and mammal entanglements with lost fishing gear, death or injury of marine animals due to boat strikes, the spread of invasive species and fish 'stock enhancement'. Risks can be reduced by measures that include phasing in the use of biodegradable hooks and fishing lines, requiring all stock enhancement proposals to be subject to risk assessment and public environmental impact assessment and prohibiting the transport of live invasive species (such as European green shore crabs) as bait.

Licence sales

Several million dollars ($5.9 million in 2010-11) are collected annually from sales of recreational fishing licences. A small proportion is spent on habitat management, about one-quarter is spent on compliance, and most of it goes to promote recreational fishing opportunities, including stocking invasive fish species. A much more substantial proportion should go to habitat management.

2.7 Future directions

Australia's southern seas are a natural treasure trove, with dazzling diversity and uniqueness unmatched globally for seaweeds, sea mosses and several other groups. The level of endemicity in many groups is close to 90%. But Victoria's marine habitats are under-studied, under-appreciated and under-protected, for the land lubber bias applies in Victoria as elsewhere. Little more than 5% of state waters are protected in the national park estate.

As the interface between land and sea, where many different landforms and oceanic influences meet, Victoria's coast is naturally a dynamic and diverse environment. As the most popular zone for living and recreating, Victoria's coast is certainly appreciated but is under much pressure from development, harmful catchment changes and invasive species.

Marine and coastal habitats are among the most vulnerable to climate change. Strengthening protection is essential not only to protect biodiversity from multiple existing current threats but to foster their resilience and adaptation to future changes.

Knowledge of biodiversity and ecology is essential for management of any environment but is particularly lacking for Victoria's marine habitats. Even for the national park estate, one of the serious threats highlighted in government assessments is 'limited ecological knowledge of important processes'.[191] Knowledge gaps need to be addressed systematically with long-term research and monitoring and detailed mapping of ecological communities.

It is more than a decade since a network of highly protected areas was established in 5.3% of Victorian waters. A gap analysis (summarised in section 2.4) shows they are inadequate to protect the values they were established for and to achieve a comprehensive, adequate and representative network. The past decade has also brought compelling evidence that a substantially larger network is needed to protect biodiversity and ecological processes and to foster ecosystem resilience.

Although more than a third of the coast (to 500 metres inland) is in the national park and conservation system, many endangered coastal vegetation communities are scantly protected and coastal habitats are at great risk from development and poor management. Bioregional priorities for increased protection have been identified in section 2.5, which can be achieved by upgrading protection for public lands and buying, leasing or covenanting private land.

As a high priority, Victoria needs a comprehensive independent inquiry into marine and coastal biodiversity to recommend new areas for protection based on targets that will foster resilience to climate change and multiple other threats.

With very high values and threats, Victoria's bays, inlets and estuaries warrant a special conservation focus – an independent authority to manage the two largest, the internationally significant Port Phillip Bay and Western Port, and a program with clear measurable improvement targets, monitoring and public reporting.

The complex interconnectedness of marine and coastal environments requires a holistic management focus on ecosystems. But current governance arrangements, laws and policies lack integration and perpetuate sector-, site- or species-focused management. An essential basis for ecosystem-based management is a new overarching legal and policy framework and a marine and coastal authority with the mandate to achieve this outcome.

To restore ecological health to many marine and coastal habitats will also require better management of fisheries, invasive species, coastal vegetation and water quality.

Following is a summary of reforms recommended as high priorities over the next decade to make substantial progress on the protection and restoration of Victoria's marine and coastal ecosystems.

Research and information sharing

M1 Prepare and implement a marine and coastal research strategy and action plan, and establish a website to provide public access to all information relevant to marine and coastal protection, planning and management.

M2 Establish a long-term scientific research and monitoring program for marine national parks and sanctuaries and other coastal and marine environments, which includes:

- completion of a systematic biodiversity assessment program across Victorian waters to map all marine and intertidal habitats at a fine scale
- a state-wide 1:10,000 scale map showing predominant community types for reef and sediment areas and locations for seagrass beds, produced within two years.

M3 Establish a marine and coastal research and information service to address high priority knowledge gaps, promote the value of research, and function as a clearing house for information and advice.

National park and conservation system

M4 Commission the Victorian Environmental Assessment Council (or other independent credible body) to conduct an inquiry into biodiversity across all Victorian marine and coastal ecosystems with the purpose of recommending new targets and new protected areas to achieve a comprehensive, adequate and representative national park and conservation system and to foster resilience to climate change. The latest science and expert opinions, taking into account the threats to Victorian ecosystems, suggest the following targets are warranted:

- protection for at least 30% of each habitat type in each marine bioregion
- protection of 100% of remnant coastal vegetation
- protection of additional areas that will assist in protecting biodiversity from the future impacts of climate change
- greater levels of protection for the habitat of threatened species and special features, including Ramsar wetlands and sites identified in the nature conservation review gap analyses (in sections 2.4 and 2.5)
- configuration to provide connectivity and secure movement pathways.

M5 Implement all outstanding recommendations from the 2011 inquiry by the Victorian auditor general into the environmental management of marine protected areas.

M6 Prohibit mining exploration in the marine national park estate.

M7 Establish a coastal private land conservation program with a fund to buy, lease or covenant private land abutting coastal conservation reserves, coastal crown land reserves or the high water mark for restoration and inclusion in reserves or, in the case of leases and covenants, to be managed consistently with such reserves.

M8 Strengthen protection of coastal crown land reserves for conservation and public purposes by:

- developing regulations and coastal management plans specific to their purpose
- applying a zoning scheme to coastal reserves consistent with the recommendations of the Land Conservation Council (1978), with the location of the zones to be identified by the Victorian Coastal Council through a project similar to the Coastal Spaces Initiative
- progressively removing from coastal reserves infrastructure that is not dependent on a coastal location, and restoring the land with indigenous vegetation.

M9 Improve protection for lighthouse reserves by incorporating them within adjoining national or state parks.

Iconic bays and inlets

M10 Establish a Two Bays Board for strategic oversight of the health of Port Phillip and Western Port and their catchments. The board should be an independent authority and amalgamate the catchment management functions of Melbourne Water, Central Coastal Board and the Port Phillip Westernport Catchment Management Authority.

M11 Produce standalone 5-yearly *State of the Bays* reports covering the four main bays and inlets (Port Phillip, Western Port, Corner Inlet and Gippsland Lakes) and the smaller bays. The first report should include a detailed condition study, comprehensively review all pressures and describe existing and planned responses.

M12 Develop improvement targets for bays and inlets with water quality, ecosystem health and open space and recreation criteria that are easy to measure and include some highly visible outcomes (for example the return of whales and other flagship species to the bays and the recovery of threatened terrestrial fauna). Link the improvement targets to statutory planning instruments and controls on future development through local environmental improvement plans or similar instruments.

M13 Set up a scientific monitoring program to assess and publicly report every two years on progress made towards meeting the bays and inlets improvement targets.

M14 Establish an ongoing educational program to build awareness of and support for conservation measures proposed for the iconic bays and inlets.

M15 Prepare and implement a state environment protection policy for estuaries.

M16 Determine the boat carrying capacity of Port Phillip Bay, Western Port and other bays and estuaries in Victoria, and set limits on boat numbers consistent with carrying capacity.

M17 Develop a shorebird protection strategy.

Marine and coastal management

Legislation and institutions

M18 Develop a Victorian Marine and Coastal Planning and Management Act with objectives and strategies to implement ecosystem-based and ecologically sustainable management of all marine and coastal waters.

M19 Establish a Victorian Marine and Coastal Authority (absorbing and expanding the functions of the existing Victorian Coastal Council) and regional marine and coastal boards (replacing the existing coastal boards).

M20 Mandate processes that guarantee transparency and community participation in marine and coastal planning and decision-making.

M21 Require that all coastal catchment management authorities have at least one-third of their board members with coastal or marine expertise.

M22 Merge the many small committees of management along the following sections of coast into combined community committees of management:

- Narrawong to Port Fairy
- Breamlea to Clifton Springs (Barwon Coast and Bellarine Bayside committees)
- Mt Eliza to Mt Martha
- Safety Beach to Portsea
- Flinders to Hastings
- Cannons Creek to Tooradin
- Lang Lang to Coronet Bay
- Seaspray to Loch Sport
- San Remo to Inverloch
- Walkerville to Sandy Point
- Port Franklin to Woodside Beach
- Gippsland Lakes.

Strategies and plans

M23 Develop a Victorian marine and coastal strategy, coordinated by the proposed Victorian Marine and Coastal Authority, to provide an over-arching framework for ecologically sustainable, ecosystem-based management of all human

uses and impacts affecting Victoria's oceans and coast. This strategy should take precedence over and inform regional catchment strategies and local planning policies for coastal areas.

M24 In the longer-term, seek inter-governmental agreement for an over-arching national framework consisting of an Australian Oceans Act and National Oceans Commission established through a joint agreement between the federal government and state and territory governments. The commission would develop and coordinate a strong regional plan for Victorian oceans that incorporates the Victorian marine and coastal strategy.

M25 Prepare and implement regional marine and coastal plans (which encompass the current multiple coastal action, estuary and boating action plans). Include strategies to prepare for the impacts of climate change on coastal and marine ecosystems by identifying areas at risk and measures to limit damage and promote adaptation.

M26 Better integrate marine, coastal and catchment management by aligning the boundaries of coastal regions with those for catchment management authorities (splitting the three coastal regions into five regions) and by establishing close links between policies and plans for marine, coastal and terrestrial environments.

M27 Develop ecosystem-based management plans for marine and coastal invasive species threats, including a strong focus on prevention and rapid responses to new incursions, and integration with management of other processes and threats (fire, nutrient enrichment, fishing, disturbance, hydrology included).

M28 Ensure that protection of the environment and the marine and coastal national park estate are high priorities in oil spill prevention and response plans.

Coastal protection and restoration

Stewardship programs

M29 Expand and strengthen the BushBroker, CoastalTender and saltmarsh protection projects, with an emphasis on protection and restoration of vegetation on private land abutting the high water mark and coastal conservation and crown land reserves.

Coastal infrastructure

M30 Commission an independent review of infrastructure (including access tracks, car parks, roads, buildings and utilities) within and adjacent to the coastal national park estate and crown land reserves with the aim of relocating or removing infrastructure or better managing it to minimise impacts on natural values.

M31 Amend the National Parks Act to rule out 99 year leases that allow commercial tourism development within national, state and coastal parks along the Victorian coast.

M32 Establish a coastal infrastructure unit with an objective of ensuring that coastal infrastructure is assessed, designed, constructed and maintained within the principles of ecologically sustainable development and ecosystem-based management. The unit would carry out works, assess and manage boating infrastructure, coastal defensive/protection works, artificial reefs and the planned retreat of coastal infrastructure for all coastal locations except for the major ports of Portland, Geelong, Melbourne and Hastings.

M33 Require rigorous environmental impact assessments of proposed development or upgrade of boat ramps, including the impacts of any recreational fishing enabled by the infrastructure.

Climate change adaptation

M34 Foster the capacity of coastal nature to adapt to sea level rise and other impacts of climate change by:

- mapping current settlements, priority areas for coastal nature protection and enhancement, and predicted sea level rises
- identifying where coastal settlements and nature can move to as a result of sea level rise
- reviewing the zoning and conservation status of all identified priority areas for coastal nature protection and enhancement to determine whether they will adequately protect coastal nature.

M35 Include in the Victorian planning provisions and the state planning framework an objective to protect coastal nature to help adaptation and retreat in response to sea level rise and other climate change impacts. Amend coastal statutory zoning and overlays to aim for in situ protection of coastal nature for as long as possible and assist inland retreat as sea levels rise.

Vegetation

M36 Introduce a vegetation restoration overlay to the Victorian planning provisions, to protect a 100-200 metre buffer around vegetated coastal public land, including estuaries and wetlands. Within that buffer:

- prohibit development
- require management of harmful invasive species and encourage vegetation maintenance and restoration
- identify and progressively remove infrastructure at risk of erosion and inundation from sea level rises (rather than build defensive structures)
- encourage fencing of buffers and boundaries between private and public land to encourage vegetation restoration.

M37 Amend the Planning and Environment Act to require the planning minister to refer any changes in land use zones for coastal lands to the environment minister.

Fishing

M38 Implement ecosystem-based management of commercial and recreational fisheries by:

- establishing a program to identify and declare 'key fishery habitat' to become part of marine and coastal planning and protection
- implementing whole-of-catchment plans to maintain coastal habitat and water quality
- establishing criteria to assess the ecological sustainability of individual commercial and recreational fisheries
- conducting location-specific ecological risk assessments of recreational and commercial fisheries, mitigating identified risks and taking a precautionary approach where information is lacking
- developing a policy framework to follow up and manage important risks uncovered in environmental risk assessments
- monitoring the community ecology of important benthic and pelagic ecosystems.

M39 Assess the recreational fishing catch and impacts by:

- conducting large-scale surveys of participation and catch every 3 to 5 years
- requiring all recreational fishers to be licenced, with no licence fees for current exempt groups, and with licences endorsed for particular coastal regions (to enable measurement of participation and catch levels)
- conducting onsite surveys at all major boat ramps
- expanding the angler diary program to focus on key species and major recreational estuaries
- implementing fisheries-independent monitoring for key recreational species
- re-establishing annual trawl surveys of Port Phillip Bay
- investigating the impacts of fishing discards on declining target species (eg sand flathead, dusky flathead) and non-target species of low abundance (eg rare rays and sharks).

M40 Improve enforcement of fishing laws, with a strong focus on protecting marine national parks and sanctuaries from illegal fishing.

M41 Reduce risks associated with stocking, movement of invasive species and fishing gear by:

- requiring all stock enhancement proposals to be subject to a public environmental impact assessment supported by a comprehensive, independent risk assessment
- prohibiting the transport of live invasive species (eg European green shore crabs) as bait
- phasing in over five years the use of biodegradable hooks and fishing lines.

M42 Allocate a substantial proportion of fishing licensing fees to support long-term fish habitat recovery projects.

2.8 Sources

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