

MAY 2019

Assessment of the Values of Victoria's Marine Environment

Report


VICTORIA

VEAC

Victorian Environmental Assessment Council

Victorian Environmental Assessment Council

The Victorian Environmental Assessment Council (VEAC) was established in 2001 under the *Victorian Environmental Assessment Council Act 2001*. It provides the State Government of Victoria with independent advice on protection and management of the environment and natural resources of public land.

The five Council members are:

Contact details

Victorian Environmental Assessment Council
Level 39, 2 Lonsdale Street
GPO Box 527
Melbourne, Victoria 3001

Phone (03) 9637 9902
or 1800 134 803 (toll free from landline)
Email veac@delwp.vic.gov.au

www.veac.vic.gov.au

MAY 2019

Assessment of the Values of Victoria's Marine Environment

Report

Published by the Victorian Environmental Assessment Council
2 Lonsdale Street, Melbourne, Victoria, 3000
May 2019

Also published on www.veac.vic.gov.au

Printed by Finsbury Green
The report is printed on Ecostar Laser

Design by Kate Mansell Design Studio

Citation
Victorian Environmental Assessment Council (VEAC) (2019) Assessment of the Values of Victoria's Marine Environment – Report. Victorian Environmental Assessment Council, Melbourne

ISBN 978-1-76077-561-2 (Print)
ISBN 978-1-76077-562-9 (pdf)

Foreword

Victoria has a distinctive marine environment, rich in biodiversity and steeped in history. Our marine waters are positioned on Australia's unique southern coastline, and support a diverse assemblage of environments, habitats and species.

The Aboriginal peoples of south-eastern Australia have long inhabited coastal and marine environments. The peoples of the area that is modern-day Victoria have, with some of humanity's most enduring socio-cultural structures, lived here for many, many thousands of years. The cultural, social and spiritual meaning of Sea Country to Aboriginal Victorians is demonstrated in historical and contemporary accounts of Aboriginal dreaming stories.

Today, our inshore marine areas are well known and loved by millions of Victorians and visitors, with environments as diverse as the many sheltered bays and inlets to the Twelve Apostles in western Victoria and the wilderness coast of far east Gippsland. Both inshore and offshore marine areas also host the activities of several important sectors such as fisheries, ports and shipping, and energy.

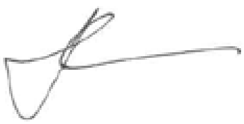
VEAC was requested to undertake the Assessment of the Values of Victoria's Marine Environment in March 2018 to inform and support the development of Victoria's marine and coastal policy and strategy including the proposed marine spatial planning framework.

A major focus of the assessment was identification of environmental, economic, social and cultural values and current and likely future threats to those values. The term 'values' is understood in different ways, and VEAC has explored various concepts of 'value' from biophysical attributes of the environment to the values held by people about the environment and natural resources, and the value of natural resources to the economy. Threats to values have been organised thematically into six categories: climate change, physical change, biological change, catchment processes, pollution and community or industry demand.

This report of the assessment together with a companion atlas is based on evidence from data and analysis, supported by expert judgement and review. It provides a basis from which more detailed descriptions can be made at different scales and for different purposes.

This assessment has shown us that there is much that we know about the marine environment and more that we still need to know to allow us to manage it for generations to come. There are parts of these complex environments that are under pressure from the impacts of climate change which, along with population growth and increased commitments for stewardship, drive a need for improved knowledge and understanding.

On behalf of the council I want to thank all those individuals and organisations who have so generously supported the preparation of this assessment. We believe that it brings together the key issues and sources of information needed to inform development of marine and coastal policy and the strategies and plans to implement that policy.



Janine Haddow, Chairperson

Council members (left to right): Joanne Duncan, Anna Kilborn, Janine Haddow (Chairperson), Charles Meredith, Geoffrey Wescott

Acknowledgement of Aboriginal Victorians

The Victorian Environmental Assessment Council pays its respects to Victoria's Aboriginal peoples, Native Title Holders and Traditional Owners and acknowledges their rich cultural and intrinsic connections to Country. Council recognises that the land and sea is of spiritual, cultural, environmental and economic importance to Aboriginal people and values their contribution and interest in the management of land and sea.

Council is pleased to have been able to consult with Traditional Owner groups, Elders and other knowledge holders through engagement of the Federation of Victorian Traditional Owner Corporations. Collectively they were able to prepare a paper that identified and discussed Aboriginal cultural values, uses, interests and knowledge associated with marine and estuarine waters in Victoria. This paper has been reproduced as chapter 7 in this report.

Contributors

VEAC thanks the following organisations that provided information for the assessment.

Department of Environment, Land, Water and Planning (DELWP)

Department of Jobs, Precincts and Regions (DJPR)

Earth Resources Regulation, DJPR

Victorian Fisheries Authority

Parks Victoria

Environment Protection Authority (EPA)

Office of the Commissioner for Environmental Sustainability

Victorian Marine and Coastal Council

Game Management Authority

Victorian Desalination Project, DELWP

Victorian Ports Corporation (Melbourne)

Port of Melbourne

Bureau of Meteorology

Deakin University

University of Melbourne, National Centre for Coasts and Climate

Swinburne University

Phillip Island Nature Parks

Federation of Victorian Traditional Owner Corporations

Victorian National Parks Association (VNPA)

The Nature Conservancy

Marine Mammal Foundation

Dolphin Research Institute

Victorian Ornithological Research Group

Sailing Australia (Victoria)

Seafood Industry Victoria

EcoTourism Australia

Water Technology

CEE Consulting Environmental Engineers

Marsden Jacob Associates

Australian Marine Ecology

Fathom Pacific

Science into Action

Water Science

Contents

Executive Summary

Victoria’s marine environment is part of Australia’s unique southern coast. Isolated for some 65 million years, the high species richness and diversity of Australia’s southern coast is influenced by the resulting endemic element as well as temperate, tropical and cold-water elements. Victoria’s marine environment is important for its diverse range of environmental, economic, social and cultural values. Understanding this special environment is a key step towards ensuring appropriate management for current and future generations.

Scope of the investigation

In March 2018 the Victorian government asked VEAC to assess the values of Victoria’s marine environment. The assessment will inform a statewide marine and coastal policy and support development of the proposed marine spatial planning framework. The assessment encompasses all State coastal waters, bays and estuaries including the Gippsland Lakes.

The purpose of the assessment is to:

- identify current environmental, economic, social and cultural values of Victoria's marine environment, including their spatial distribution where relevant
- identify current and likely future threats to these values
- provide independent advice on future patterns, trends and direction related to existing and emerging uses
- determine a process to systematically classify data and an approach to describe social and economic values and uses of Victoria's marine waters
- provide an inventory of available knowledge and data on existing values, uses and threats and advise on any significant gaps.

Although the terms of reference did not require formal public consultation, VEAC has directly engaged with key technical and sector experts including government departments and public authorities, researchers and data custodians, Traditional Owners, industry associations, marine conservation groups and marine user groups.

Assessment process

Working within a broad framework of values, threats and emerging uses, the assessment provides a current and authoritative review of information and issues across nine themes. These include: climate and oceanography, biodiversity, Aboriginal cultural values, non-Aboriginal heritage, coastal development, tourism and recreation, fisheries, ports and shipping, and energy and earth resources. VEAC has presented the information thematically as this best reflects the complexity and overlap of environmental, economic, social and cultural values. The approach for each theme varies depending on the information available.

There is a significant variation in the amount and complexity of information that is available across each of themes. For this reason, some of the chapters are more extensive than others or have focused on species or situations that highlight a broader value or threat to values.

The first part of the report (chapters 1 to 4) establishes the context and background for the assessment. The second part (chapters 5 to 13) describes values, threats to these values, and relationships to existing and emerging uses, addressing the first three parts of the terms of reference. The third and final part (chapters 14 and 15) addresses the fourth and fifth parts of the terms of reference, discussing processes for systematically classifying data for social and economic values, and providing an inventory of available data and advice on significant knowledge gaps.

Values, threats and uses

Climate and oceanography

Climate change is affecting key climate variables and oceanographic conditions. Mean sea level will rise, sea surface temperatures and salinity will increase, and ocean pH will decrease. Sea surface temperatures have already increased by 0.1 to 0.2°C per decade since 1970. Both increasing sea levels and storm intensities will lead to coastal flooding, storm erosion and long-term shoreline recession. Loss of coastal habitat, cliff, beach and foreshore erosion, as well as increased nutrient levels, sediment and pollution will affect the coast and marine environment. Many of the threatening processes affecting marine biodiversity values will be compounded by climate change. Changes to continental currents, sea level, water temperature and frequency of storms are likely to affect a wide range of ecological processes with resulting reductions in the availability of some species, areas of suitable habitat and safe breeding/roosting sites.

Biodiversity

Australia's southern waters are unique with many of the species that occur in this region found nowhere else (endemic). For example, up to 67 per cent of polychaete worms, 70 per cent of brown algae, 74 per cent of echinoderms and decapods, and 77 per cent of red algae are endemic to southern Australia. There are 172 species and four communities in Victoria with conservation listing; however, because of the knowledge gaps in relation to marine biodiversity, this is almost certainly an underestimate of the number of threatened marine species and communities.

Marine species and communities are susceptible to a range of threats that range from local to global scales. Species or communities with very restricted habitat requirements, small home ranges and limited mobility are likely to be most severely affected by what may appear to be fine-scale disturbances. Seagrass beds, tidal mudflats and mangroves are amongst the most vulnerable habitat types as they are at increased risk of erosion from storms and high seas, and from catchment runoff and pollution. These specialised habitats are critical for all or some life cycle stages of many marine species.

Aboriginal cultural values for sea country

Aboriginal peoples of the coastal and marine areas of Victoria identify today as Monero/Ngarigo, Bidwell, Yuin, Gunaikurnai, Boon Wurrung, Bunurong, Wurundjeri, Wathaurung/Wadawurrung, Eastern Maar and Gunditjmara. Cultural, social and spiritual meaning of Sea Country to Aboriginal Victorians is demonstrated in historical and contemporary accounts of Aboriginal dreaming stories. These stories are integral to understanding the importance of Sea Country and informing the development of frameworks that facilitate the cultural application of Sea Country management in the contemporary Victorian landscape.

Contemporary Aboriginal Victorians continue to use and harvest the resources of their Country as they have done for countless years. They and their extended families maintain regular camping sites along the coast in which they pass knowledge of the coastal and marine environment from generation to generation. This interaction with the coast has always been a crucial source of physical and spiritual sustenance and vital to their identity as coastal people.

The nature of Aboriginal culture and knowledge means that there is not a well-documented inventory of information available to decision makers. If Aboriginal cultural values and threats to those values are to be more effectively addressed in marine planning and management, Traditional Owners need to be able to mobilise their knowledge and fulfil their rights and obligations to care for Country. The second part of chapter 7 sets out a strategic framework that articulates the measures that Traditional Owners say are needed to fill knowledge gaps and avoid threats to natural and cultural values.

Non-Aboriginal heritage

The early economic, social and physical development of Victoria by Europeans was shaped by the sea. Physical evidence of past dependence on the sea for transport remains in numerous historic places and objects, although many heritage sites are not well documented. For example, fewer than half of the 780 shipwrecks along the Victorian coast have been located. Many sites in Victoria share non-Aboriginal and Aboriginal heritage – both pre- and post-contact with Europeans – although these are generally poorly known.

Threats to non-Aboriginal maritime heritage include theft (looting) and degradation by natural forces, some of which will worsen with climate change (e.g. storm surges). Increasing pressure for coastal development is likely to lead to disturbance of undiscovered or undocumented heritage sites and objects.

Coastal development

Early coastal settlement was driven by access to safe harbours. More recently it has been influenced by Victoria's increasing population and lifestyle factors such as 'sea change'. Growing urban populations lead to increased volumes of wastewater and stormwater, more intensive use and crowding at coastal facilities, and increased reliance on coastal protection structures.

Coastal protection structures (e.g. seawalls) are an important part of coastal development but can have significant environmental impacts. Rehabilitating habitats that provide natural coastal protection, such as shellfish reefs and mangroves, is of emerging interest for affected local communities. Climate change will also put pressure on ageing coastal infrastructure and ultimately impact on feasibility of living in or developing some coastal locations.

Victoria has more than 400 boat launching sites and yacht clubs providing access to the marine environment. Demands for coastal access are increasing leading to conflict between users (e.g. boats and swimmers) and greater impacts on the environment.

Tourism and recreation

Marine tourism is a large and growing part of Victoria's tourism sector and includes boating, visiting the beach, surfing, fishing, sightseeing and bushwalking. Victoria's most popular marine destinations are the Twelve Apostles on the Great Ocean Road and the Penguin Parade on Phillip Island. Aboriginal cultural experience, nature-based and adventure tourism are an emerging and important part of the state's tourism sector, which continues to have steady growth in both international and domestic markets.

There are significant health benefits associated with marine recreation. There are over 400,000 licensed boat operators and over 200,000 licensed vessels. Swimming, surfing, diving and snorkelling are popular in-water recreational activities. Artificial reefs, including sunken ships, are growing in popularity for diving. Citizen science and community-based projects are important recreational activities that raise the awareness of environmental values and marine stewardship.

A combination of urban population growth and climate change generates a complex mix of threats to tourism and recreation, including overcrowding, conflict between users, loss of beaches and degradation of built assets (e.g. piers and jetties) and decreased water quality.

Fisheries

The commercial wild catch fisheries sector targets a diversity of species (finfish, molluscs, echinoderms, crustaceans and sharks) across various environments (bays, inlets and open ocean). Nearly 5000 live weight tonnes of seafood were commercially harvested in Victorian waters in 2016-17; this represents approximately half of the commercial wild catch in 1986-87. Assessing fish stocks and the impacts of harvesting is difficult and more data is needed for some target species and most non-target species. Aquaculture is currently limited to a few mollusc species (abalone and mussels) and is growing in value.

About 10 per cent of Victorians fish recreationally in marine and estuarine waters, particularly Port Phillip Bay, Western Port, Corner Inlet and the Gippsland Lakes. Current government policy aims to increase recreational fishing participation. Monitoring of recreational fishers (e.g. number of fishers, total catch) is logistically challenging and expensive, so there are large knowledge gaps for this sector.

The Victorian Aboriginal Fishing Strategy aims to incorporate the rights, interests, aspirations and culture of Aboriginal people into fisheries management. Customary use and access rights are only available to some Traditional Owners under native title or settlement agreements. Harvests of pipis and short-finned eels have received most attention, but there is little information about this sector which overlaps with the commercial, recreational and aquaculture sectors.

Threats to fisheries includes habitat loss, poor water quality, invasive species and diseases. Certain traits render species more vulnerable to overexploitation; these include being long lived, slow to mature, producing few young and having narrow habitat requirements. Several species have been overexploited in the past, most recently scallops in the 2000s.

Ports and shipping

Victoria has four commercial ports that are part of complex supply chains linking road, rail and sea transport. To accommodate increasing volumes of trade, ships are becoming longer and wider, although not deeper. Increasing draught would impact on ships' abilities to use existing port infrastructure, including channels and berths.

The initial construction of port facilities involved substantial impacts on sensitive environments. Present day maintenance (such as dredging) and upgrading of port facilities is conducted with more attention on mitigating these environmental impacts. Concerns remain about the impact of anchors on sensitive benthic environments, particularly within marine protected areas, and risks associated with the transfer of marine pests.

More than 4000 ships visit Victorian ports annually, with about 3200 visiting the Port of Melbourne.

Energy and earth resources

Three oil and gas basins straddle Victorian and Commonwealth waters: the Otway, Bass and Gippsland basins. Production in Victorian waters only occurs within the Otway Basin, with most of the gas Victoria consumes coming from fields in Commonwealth waters. A shortfall in gas supply has been predicted from 2022.

Victorian waters have substantial potential for wave and tidal energy generation, which have been demonstrated by pilot projects.. An exploration licence has recently been granted to investigate an offshore wind proposal in Commonwealth waters offshore from Gippsland. Other sources of marine renewable energy, including geothermal or biofuels have minimal potential for development in Victoria.

No mineral resources are mined in Victorian marine waters. Where valuable minerals occur, it is currently not economically viable to extract them in commercial quantities. In some locations offshore sand deposits are dredged for beach renourishment.

Classifying social and economic values

While systems to classify environmental data are relatively well-developed, social and economic values are more challenging to capture, particularly as they relate to the environment. One approach is to link these values through the concept of ecosystem services. Ecosystem services are the contribution of ecosystem components to people's wellbeing. However, measurement is not straightforward and only a limited number of services have been assessed in the marine environment. The importance of ecosystem services is recognised in the United Nations' 17 sustainable development goals.

Economic evaluation approaches include cost benefit analysis and total economic value (use and non-use values) frameworks. In Victoria, the role of environmental-economic accounting is increasingly recognised. Environmental accounting and economic valuation, while linked, are generally used for different purposes. The purpose of environmental accounting is to provide consistent and comparable information on ecosystem assets and the services they provide, along with performance measures of resource use and emissions in the economy (e.g. water, energy, carbon). Environmental valuation is used to assess the benefits provided by environmental assets and places a value in monetary terms, which enables appraisal of competing use of resources, alternative policies or investments.

Given the ecological complexity of the marine environment, the diversity of benefits, and the numerous stakeholders, a combination of processes and tools are required to bring together social and economic values targeted to the purpose and scale of the specific task.

Adoption of evaluation methods that align with international standards, seeking bottom-up approaches for engagement of stakeholders, and collating knowledge from a diverse range of sciences provides the best approach to describing social and economic values and uses of Victoria's marine waters.

Data inventory and knowledge gaps

Knowledge of how marine ecosystems operate and how they respond to changing conditions is critical for informing management decisions. To improve knowledge there is a need to have in place processes for data collection, data management, data analysis and decision support systems to support planning and management. Current systems for collecting and managing knowledge about the marine environment include DELWP’s marine knowledge framework and Australia’s Integrated Marine Observing System.

Government investment in a range of research and monitoring is required to inform operational and planning requirements. Better understanding of ecosystem linkages and processes, particularly for subtidal environments, is essential for assigning value and significance, identifying hotspots and predicting consequences of change and response to threats.

The nature of Aboriginal culture and knowledge means that there is not a well-documented inventory of information on cultural values available to decision makers and investment is required to support Traditional Owners in mobilising this knowledge.

Assessment

This assessment has identified current environmental, economic, social and cultural values of Victoria’s marine environment, together with threats to these values and advice on future patterns, trends and direction related to existing and emerging uses. Collectively, the information presented in this assessment can be used in the development of a marine and coastal policy, marine and coastal strategy, marine spatial planning framework and the upcoming State of the Marine and Coastal Environment report, all of which are requirements of the *Marine and Coastal Act 2018*.

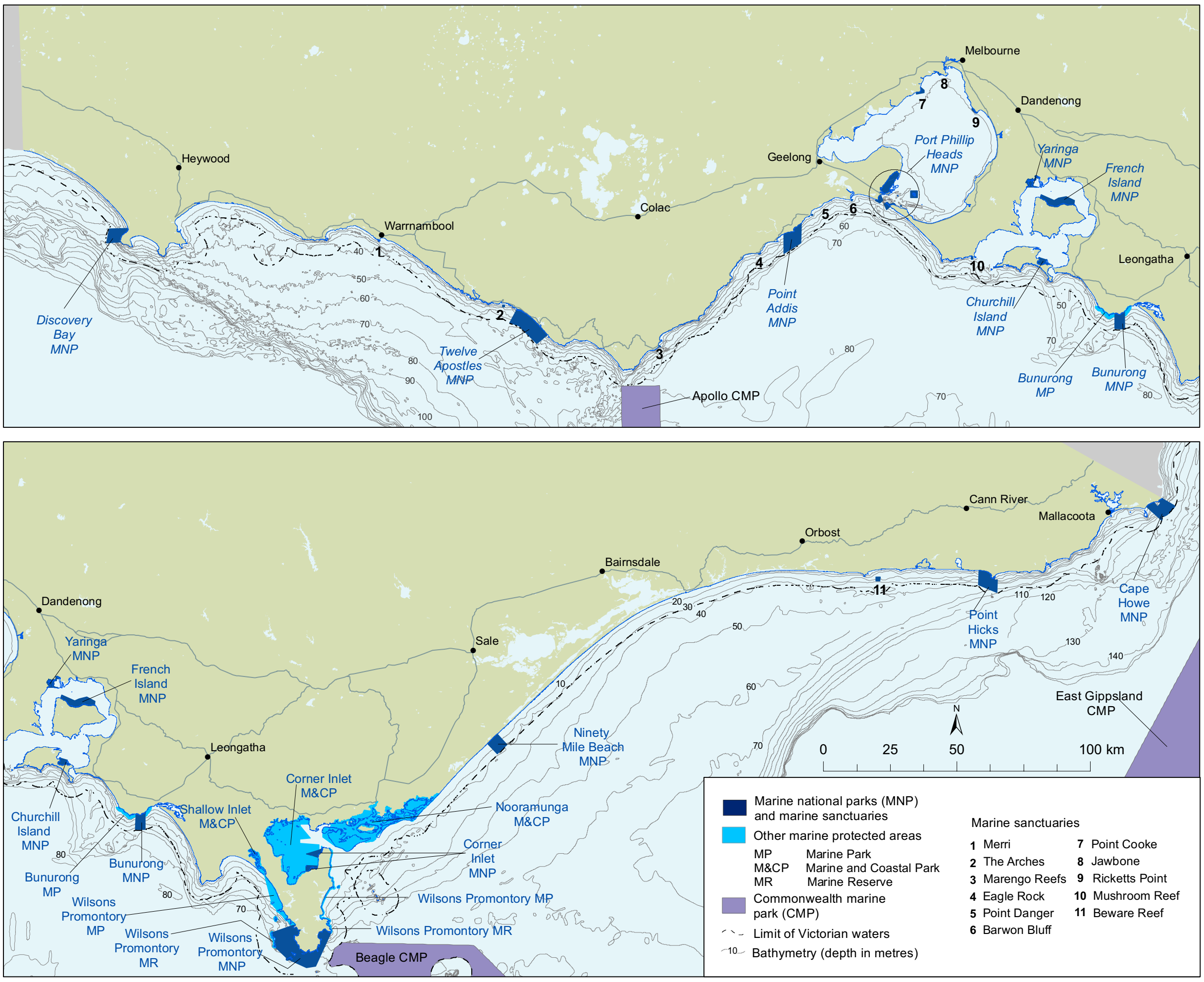
1 Introduction

Victoria's coastal waters stretch from South Australia in the west to New South Wales in the east, and south into Commonwealth waters and towards Tasmania (see figure 1.1). Victoria's location on the southeastern coast of mainland Australia and at the interchange of the Southern and Pacific oceans has created a distinctive and diverse marine environment.

Understanding how Victoria's marine environment is used and having sufficient information on its environmental, economic, social and cultural values is a key step in managing this natural asset for current and future generations.

Improved understanding of marine values, the threats to those values and emerging uses can inform development of a new marine and coastal policy, a marine and coastal strategy and the design of a marine and spatial planning framework.

Figure 1.1 Victoria's marine waters



1.1 Terms of reference

In March 2018, the Victorian Environmental Assessment Council (VEAC) was requested by the Minister for Energy, Environment and Climate Change, the Hon Lily D'Ambrosio MP, to carry out an assessment of the values of Victoria's marine environment. The terms of reference are presented in box 1.1.

Box 1.1 Terms of reference

Pursuant to section 26B of the Victorian Environmental Assessment Council Act 2001, the Minister for Energy, Environment and Climate Change hereby requests the Council to carry out an assessment of the values of Victoria's marine environment.[1]

The assessment will inform the development of a statewide marine and coastal strategy and support the development of the proposed marine spatial planning framework.

The purpose of the assessment is to:

a) identify current environmental, economic, social and cultural values of Victoria's marine environment, including their spatial distribution where relevant

b) identify current and likely future threats to these values

c) provide independent advice on future patterns, trends and direction related to existing and emerging uses

d) determine a process to systematically classify data and an approach to describe social and economic values and uses of Victoria's marine waters

e) provide an inventory of available knowledge and data on existing values, uses and threats and advise on any significant gaps.

The assessment will encompass all State coastal waters, bays and estuaries (including the Gippsland Lakes), and must have due regard to the interaction of processes and values of the coastal zone.

The Council must take into account the following matters:

a) relevant agreements under the Traditional Owners Settlement Act 2010

b) relevant Victorian government policies, strategies and reports

c) relevant national and international agreements, policies and strategies.

VEAC is required to consult with technical and sector experts to gather and confirm source data, and to document any relevant caveats to these data. In addition, as specified in section 26D of the Victorian Environmental Assessment Council Act 2001, the Council must confer with any Department or public authority which may be affected by the provision of the assessment including the Department of Environment, Land, Water and Planning; the Department of Jobs, Precincts and Regions; Department of Transport; and the Victorian Fisheries Authority.

The Council must report on the completed assessment by 29 March 2019.[2]

---

[1] For the purposes of the assessment, Victoria's marine environment means the following between the outer limit of Victorian coastal waters and the high-water mark of the sea—

a) the land (whether or not covered by water) to a depth of 200 metres below the surface of that land;

b) any water covering the land referred to in paragraph (a) from time to time

c) the biodiversity associated with the land and water referred to in paragraphs (a) and (b).

[2] extended to 21 May 2019.

1.2 Policy context

The Final Transition Plan for Victoria's Marine and Coastal Reforms (2018) outlines policy, actions and other measures to strengthen management of the marine and coastal environment.

These include the following key actions for the marine environment:

- development of a marine spatial planning framework as a component of the statewide marine and coastal policy by the end of 2019
- preparation of a statewide strategy for the marine and coastal environment by the end of 2020
- development of a marine knowledge framework by the end of 2019
- preparation of a state of the marine and coastal environment report by 2021-22
- partnering with Traditional Owners to increase their involvement in coastal and marine management.

1.3 About VEAC

The *Victorian Environmental Assessment Council Act 2001* (VEAC Act) established the Victorian Environmental Assessment Council (VEAC) to conduct investigations and make recommendations relating to the protection and ecologically sustainable management of the environment and natural resources of public land. VEAC is a successor organisation to the Land Conservation Council (LCC), established in 1971, and the Environment Conservation Council (ECC), which replaced the LCC in 1997.

Amendments to the VEAC Act that came into operation in 2016 established a process by which VEAC is able to provide advice to and assessments for the Minister, in addition to being able to undertake investigations. The amended Act allows for VEAC to provide advice or carry out assessments on matters that, because of their limited scale or scope or their technical nature, might not require an investigation. Assessments do not require formal public consultation unless specified by the Minister in the terms of reference.

The VEAC Act requires the Council to consult with government departments and public authorities, and requires departments and public authorities to give practicable assistance to the Council in carrying out investigations and assessments. VEAC papers and reports are prepared independently.

The current five members appointed to VEAC are Ms Janine Haddow (Chairperson), Ms Joanne Duncan, Ms Anna Kilborn, Dr Charles Meredith and Dr Geoffrey Wescott. A brief biography of each of the Council members can be found on VEAC's website at http://www.veac.vic.gov.au. The Council is supported by a small research and policy team and an administrative secretariat.

1.4 Outputs of the assessment

The assessment outputs include a technical report and a data inventory (list) – this report – and an atlas covering discrete spatial units along the coast.

The first part of the technical report (chapters 1 to 4) establishes the context and background for the assessment and how it has been undertaken.

The second part (chapters 5 to 13) covers the assessment of values, threats to these values, and discusses how the values and threats relate to existing and emerging uses. These requirements are integrated through nine themes, each presented as a chapter in this report.

The third part of the report includes, in chapter 14, discussion of processes for systematically classifying data for social and economic values and uses, and in chapter 15 there is an inventory of available data on values, threats and uses, and advice on significant knowledge gaps.

The atlas, which is a separate document, brings together local information on the values, threats and uses for the 26 bioregional units along Victoria's coastline. The boundaries of these biounits, have been derived from marine habitat mapping undertaken for the Department of Environment, Land, Water and Planning (DELWP). The 26 marine biounits are a finer-scale breakdown of the marine bioregions established through the national Integrated Marine and Coastal Regionalisation of Australia (IMCRA) program.

Collectively, the information presented in the assessment report and atlas can be used in the development of a marine and coastal policy, marine and coastal strategy, marine spatial planning framework and the upcoming State of the Marine and Coastal Environment report, all of which are requirements of the *Marine and Coastal Act 2018*.

1.5 Consultation

The terms of reference did not require VEAC to carry out a formal public consultation process for the assessment. VEAC has directly consulted with key stakeholders including departments and public authorities, researchers and custodians of data.

Agencies consulted included:

- Department of Environment, Land, Water and Planning (DELWP)
- Department of Jobs, Precincts and Regions (DJPR)
- Environment Protection Authority (EPA)
- Office of Commissioner for Environmental Sustainability
- Parks Victoria
- Victorian Fisheries Authority.

Other stakeholders engaged or consulted included:

- Traditional Owners
- research organisations and universities
- marine conservation groups and user groups
- industry associations.

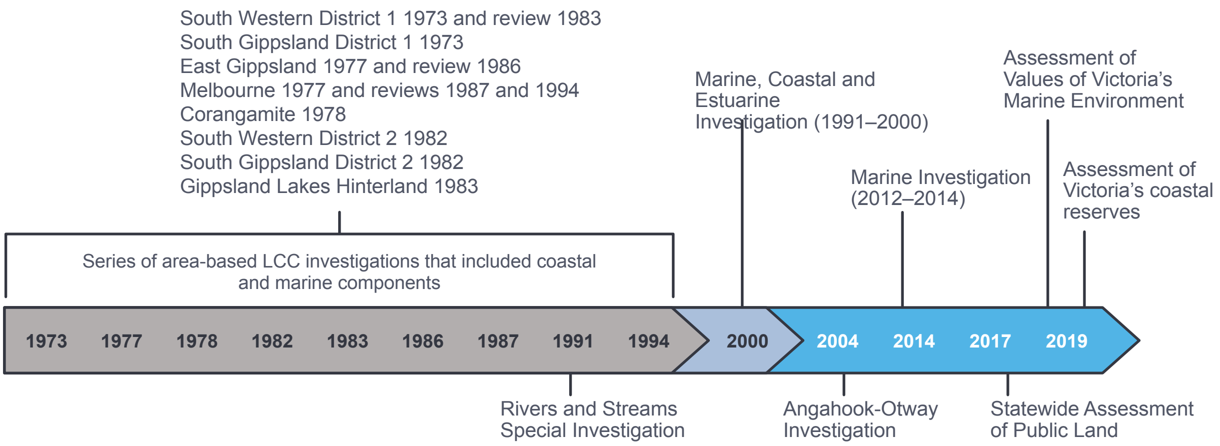
Notice of the assessment was advertised on VEAC's website, and visitors were provided with the opportunity to register their interest.

To assist with the assessment, VEAC engaged the services of several consulting companies to contribute to preparation of material for the report in relation to climate and oceanography, biodiversity and the Aboriginal cultural values.

1.6 Previous investigations by VEAC, ECC and LCC

VEAC and the former ECC and LCC have completed 44 land use investigations and two assessments over more than 45 years, including 27 regional investigations or reviews. Previous investigations of relevance to the coast highlighted in figure 1.2 have been reviewed as background to the current assessment.

Figure 1.2 Timeline for previous VEAC, ECC and LCC investigations of relevance to the marine and coastal environment



2 Assessment Framework

The terms of reference for this assessment require VEAC, amongst other things, to identify 'current environmental, economic, social and cultural values of Victoria's marine environment', identify 'current and likely future threats to these values' and provide advice on 'future patterns, trends and direction related to existing and emerging uses'.

Many of these terms overlap: for example, uses are also economic, social and cultural values; and the environment can be valued in economic terms. The term 'values' is also understood in different ways depending on the context. In contemporary land and resource management, for example, environmental values are mostly conceptualised as biophysical attributes of the environment, such as landscape features and formations, and sites, processes and properties such as endangered species and biodiversity. More broadly however, 'values' may also refer to the values held by people about the environment and natural resources, or the value of extracted natural resources to the Victorian economy.

The following sections provide context for the assessment of values, threats to values, and how values and threats relate to existing and emerging uses.

KEY POINTS AT A GLANCE

Values

- *Held values* inform peoples' judgements and preferences about the world (e.g. stewardship for nature).
- *Relational values* arise out of the interaction between a person (with certain held values) and a valued object (e.g. fish).
- *Assigned values* articulate the value of an object (e.g. market price).
- Environmental values tend to be defined as things in the environment (valued objects) and include physical entities (e.g. species) and ecosystem processes.
- Ecosystem services are increasingly described as environmental values, incorporating relational and assigned values.
- Economic values of the environment are primarily assigned values, often expressed in monetary terms. However, these measures depend on the valued object and relationship with place where the resource is extracted.
- Aboriginal cultural values are primarily relational. Aboriginal people belong to Country and there is a reciprocal relationship between people and Country. Cultural values are intertwined around traditional uses, spiritual connection, ancestral ties and respect for the land and sea and the resources they provide.
- Non-Aboriginal social and cultural values of the environment rarely correspond to valued objects, except for sites like shipwrecks. These values are more likely to be relational.

Threats

- Threats to values have been organised into six categories: climate change, physical processes, biological processes, catchment processes, pollution and community or industry demand.
- Instead of a risk assessment of threats against values, this report describes the threats to values. Where there is insufficient data to describe a threat, this is included as a knowledge gap.

Future uses

- In identifying future uses, this assessment has generally used a 30-year outlook. For some sectors it was more realistic to use a period that coincided with a physical change in conditions (e.g. one-metre sea level rise). For other sectors, the future was assessed with reference to the life cycle of an industry.

2.1 What are values?

There is a well-articulated body of theory surrounding the concept of value in environmental management, which draws on philosophy, sociology, psychology, anthropology, economics, geography, cultural studies, applied ecology and conservation biology, among others. Behind any valuation are things in the world that are valued by people, referred to as 'valued objects'.[1]

Some arguments about environmental value focus only on the relative importance of intrinsic value (conserving the environment for its own sake) versus instrumental value (conserving the environment for humans' sake). However, this dichotomy fails to account for the diversity of ways that people interact with, and therefore value, the environment.[2] The held/relational/assigned values framework[3,4] is a useful way to understand the range of meanings of 'value' that are relevant to this marine values assessment (see figure 2.1).

The everyday use of the term 'value' refers to the values held by people, such as integrity, freedom or happiness.[1] This understanding of values is referred to as *held values* in the values literature.[4] Peoples' held values inform their judgements and preferences about the world and include both modes of conduct (e.g. pleasure-seeking, conforming) and desirable end states of behaviour (e.g. nature conservation).[3]

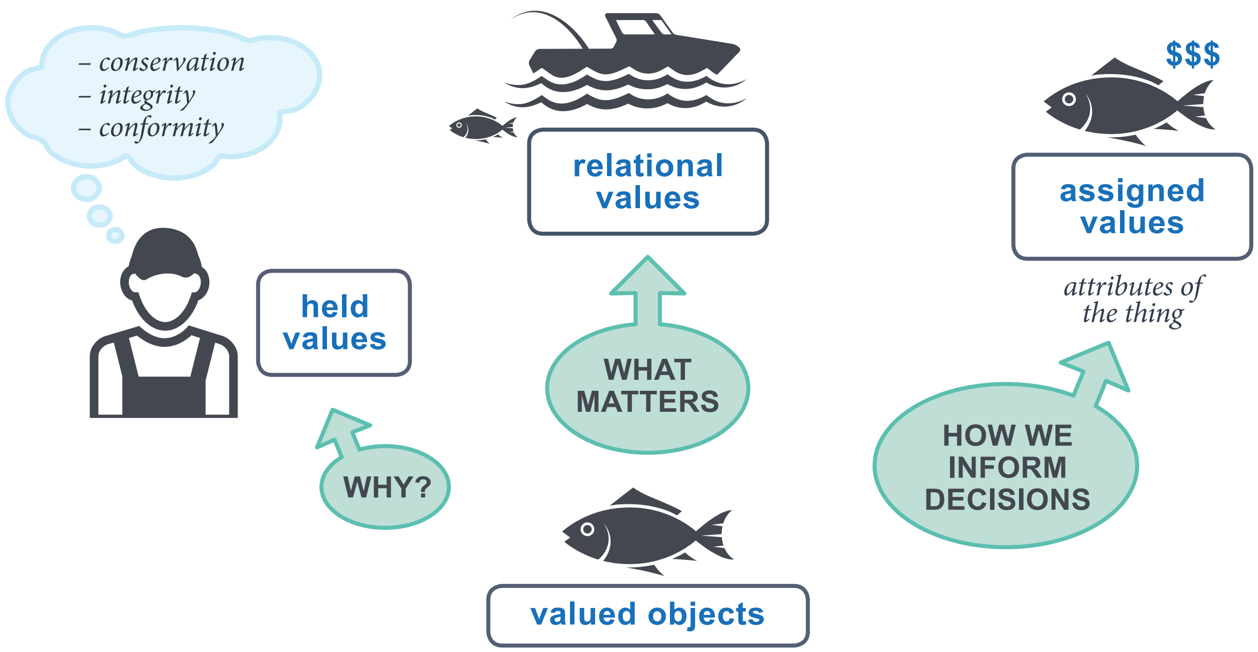
The interaction between a person (with a set of held values) and the valued object gives rise to *relational values*.[3] Relational values are not present in objects but arise out of peoples' relationships with and responsibilities to valued objects.[2] In this understanding, the value emerges from the relationship (or relationships) between the person and the valued object.[3]

Relational values express the appropriate or desired relationships between people and nature[5] and are expressed in formal or informal rules about the ways in which people can interact with the valued object.[4] Relational values in the marine environment could include the importance of a place for gas exploration, enjoying nature or passing on traditional knowledge.

The way that the value of an object is articulated is its assigned value.[4] Assigned values are the stories, measures and indicators used to describe or quantify valued objects and relational values i.e. attributes. Assigned values relative to the marine environment could include market value of commercially harvested fish, population numbers of endangered species, and the annual revenue generated by tourism at a site.

The held/relational/assigned values framework is useful to capture the relevant aspects of value for each of the environmental, economic, social and cultural values of Victoria's marine environment.

Figure 2.1 Illustration of the three core concepts of value and their relationships to the valued object (adapted from Gorddard et al. 2017)



2.1.1 Environmental values

Environmental values tend to be defined (explicitly or not) in the natural resource management literature as things in the environment that would exist whether or not there was anyone there to value them (valued objects). These values typically include physical entities (e.g. endangered species, geological and geophysical formations, species habitat) and ecosystem processes and properties (e.g. biodiversity, carbon sequestration).[6,1,7]

However, some standard natural resource values are more than objects. For example, ecosystem services are increasingly described as an environmental value. Ecosystem services rely on some aspect of the natural world to provide a service to people (otherwise described as a relationship) that is often measured in dollar values (an assigned value).[5] Ecosystem services therefore encompass the valued object, relational value and assigned value.

2.1.2 Economic values

Economic values of the environment are often expressed in monetary terms through measures like price, willingness to pay (stated preference), and consumer behaviour (revealed preference)[3] and closely align with the definition of assigned values. However, these measures are dependent on the valued object, such as the fish or other extracted resource, as well as the relationship with the physical place where the resource is extracted from.

2.1.3 Social and cultural values

The cultural, social and spiritual meaning of Sea Country to Aboriginal Victorians goes back tens of thousands of years. Aboriginal cultural values are primarily relational; Aboriginal people belong to Country and there is a reciprocal relationship between people and Country.

For Aboriginal people, cultural values are intertwined around traditional uses, spiritual connection, ancestral ties and respect for the land and sea and the resources they provide. Traditional Owners have responsibilities to care for Country – thereby healing both Country and culture. Traditional Aboriginal beliefs and a strong attachment to the marine and coastal environment are still a feature of the lives of contemporary Traditional Owners (see chapter 7).

Non-Aboriginal social and cultural values of the environment rarely correspond to physical things, or valued objects, except for sites like shipwrecks or burial sites. In general, social and cultural values of the environment are much more likely to be relational values including recreation, connecting with people in nature, a sense of identity tied to places, and caring for and attending to places.[2,7] Assigned values for social and cultural values vary widely, but could include contribution of tourism to the economy, absence of pollution (pristine sites) and visitation rates.

2.2 Threats identification process

To provide consistency, VEAC have adopted definitions for threats and stresses as used by the International Union for Conservation of Nature (IUCN)[8] for ecosystem assessment, and which were based on a standard lexicon developed by Salafsky et al.[9] for biodiversity conservation (figure 2.2 and table 2.1).

It is acknowledged that a direct threat for one value or valued object can be an indirect threat for another or pose no threat to other values. For example, unsustainable fishing will directly threaten target and bycatch species and may also have indirect effects (negative or positive) on species that prey upon, compete with or are preyed upon by targeted species. This complexity of effects requires careful consideration when planning actions to eliminate or mitigate threats.

Figure 2.2 General model developed for assessment of threats – actions can be applied to contributing factors and threats to reduce stresses on values (adapted from: Salafsky et al. 2008)[9]

Table 2.1 Definitions of threats, drivers and stresses (adapted from: Salafsky et al. 2008)[9]

Term	Definition	Synonyms
Drivers	The drivers also referred to as contributing factors, enable or otherwise add to the occurrence or persistence of proximate threats. There is typically a chain of contributing factors (includes indirect threats) behind any given threat.	Underlying factors, root causes, indirect threats, pressures
Threats	Direct threats are the proximate activities or processes that have impacted, are impacting, or may impact the status of the value being assessed. Threats can be past (historical), ongoing, and/or likely to occur in the future. Natural phenomena are also regarded as threats in some situations.	Direct threats, sources of stress, pressures, proximate pressures, stressors
Stresses	Stresses are the effects on values that are impaired directly by threats (e.g. reduced abundance of keystone species, fragmentation of habitat). A stress is not a threat in and of itself, but rather a degraded condition or symptom of the value that results from a direct threat.	Symptoms, key degraded attributes

Published research and available reports have been reviewed for each of the nine themes to identify environmental, economic, social and cultural values and a range of threats to those values.

To ensure completeness, the list of threats for each value have been checked against six categories of threats, as shown in figure 2.3. This list has incorporated those classes of threats used by the IUCN[8] for the assessments of risk to biodiversity and conservation of threatened species. The list also accommodates those threats considered in a desktop review of marine values undertaken for the review of the *State Environment Protection Policy (Waters of Victoria)*.[10]

Figure 2.3 Threat categorisation framework

Threat assessments can be used to develop management strategies and for prioritising actions to mitigate threats.[11] To achieve this a quantitative approach is used where the likelihood or exposure are scored, together with a score for the consequence of the threat occurring. However, for VEAC's more broad-ranging assessment, the approach is to describe the threats to each value and, where data are available, their spatial extent. Where there are insufficient data to describe the threat, this has been noted as a knowledge gap.

In 2013, VEAC commissioned an assessment of anthropogenic (human caused) threats to marine protected areas.[12] Threats were drawn from previously published lists (including Carey et al. 2007[13]) and workshops with stakeholders for the development of management plans for marine protected areas. Outputs from these projects and other sector-based risk assessments, such as the Victorian Marine Pollution Risk Assessment[14], have been reviewed and used to inform the descriptions of threats for VEAC's assessment.

2.3 Identifying emerging uses and trends

The terms of reference for the assessment requires VEAC to provide independent advice on future patterns, trends and direction related to existing and emerging uses of the marine environment. To do this, VEAC has relied on available literature, published research, industry reports and sector outlooks that have been reviewed across each of the nine themes.

In assessing emerging uses, VEAC has taken into consideration the differing time periods required for potential changes to occur or for new uses to emerge. For some sectors a suitable time period can be related to commonly used planning horizons, for example a 30-year outlook for urban planning. For other sectors it can be more realistic to consider a conceptual time period that coincides with a change in physical conditions. For example, a one metre sea level rise is expected to happen in the future, but the time period for this occurring has some uncertainty.

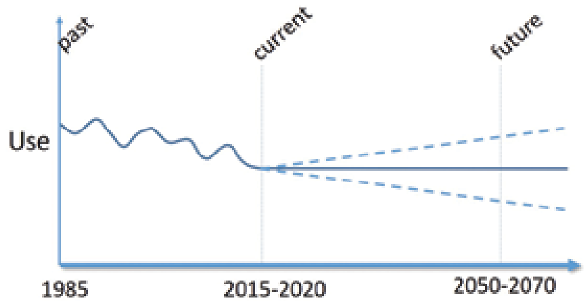
Similarly, to assess trends, there is a need to assess changes that have occurred over a past time period. Again, the time period used is dependent on the use or conditions being assessed and the nature and rate of variation that has occurred.

As a general guide, VEAC has used a 30-year outlook for emerging uses and the past 30 years for assessing trends in conditions. However, the accuracy of any predictions or assessment of patterns of change are dependent on the data available to assess the rate of change, conceptual understanding of what causes and drives change, and the time period allowed for that change to occur. Levels of use can increase, stay the same or decrease in the future (see figure 2.4).

Another consideration for predicting emerging uses is to consider the life cycle of an industry. There are many examples where past uses are transitioning or changing to meet the demands of current communities. For example, there have been regulatory changes imposed on commercial fishing in Port Phillip Bay that may increase fish stocks, which will subsequently support increased recreational fishing.

Other aspects discussed under the chapter themes are the interplays between uses that provide economic value and consequently threaten other values. For example, the increased frequency of recreational diving on shipwrecks can hasten the deterioration of the shipwreck, which leads to a loss of underwater cultural heritage value.

Figure 2.4 Conceptual understanding of change over time that levels of use can increase, stay the same or decrease in the future



2.4 Assessment approach

VEAC has adopted a flexible approach that reflects the nature and availability of information for the assessment of values and threats to those values.

Working within a broad framework of values, threats and emerging uses, VEAC has sought to identify key sources of information that provide an understanding of issues across the nine themes of the assessment. These sources of information are referenced in each chapter to allow readers to undertake additional research in areas relevant to their interests.

There is a significant variation in the amount and complexity of information available. In many cases VEAC referred to previous reviews and syntheses rather than analysing original data to expedite the assessment process. For this reason, some of the chapters are more extensive than others or have focused on species or situations that highlight a broader value or threat to values. For example, in chapter 6 on biodiversity a few selected species have been used to highlight the impact of sea level rise, although clearly many species will be affected.

An area where the assessment approach has varied is in presenting Aboriginal cultural values. Through a conversational process, tangible and intangible cultural values and threats to these values have been presented. However, the nature of Aboriginal culture and knowledge means that there is not a well-documented inventory of information relating to the Victorian coast available to decision makers. Chapter 7 includes a strategic framework that articulates the measures that Traditional Owners have told VEAC are needed to fill knowledge gaps and avoid threats to natural and cultural values.

2.5 References

1. Ives, C.D. and Kendall, D. (2014) The role of social values in the management of ecological systems. *Journal of Environmental Management* 144: 67-72.
2. Chan, K.M.A., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., Gould, R., Hannahs, N., Jax, K., Klain, S. and Luck, G.W. (2016) Why protect nature? Rethinking values and the environment. *Proceedings of the National Academy of Sciences* 113: 1462-1465.
3. Brown, T.C. (1984) The concept of value in resource allocation. *Land Economics* 60: 231-246.
4. Gorddard, R., Dunlop, M., Wise, R. and Dunstan, P. (2017) *Rethinking approaches to valuation in marine systems*. Report to the National Environmental Science Programme. Marine Biodiversity Hub. CSIRO, Hobart.
5. Tadaki, M., Sinner, J. and Chan, K.M.A. (2017) Making sense of environmental values: A typology of concepts. *Ecology and Society* 22: 7-18.
6. Bentrupperbäumer, J.M., Day, T.J. and Reser, J.P. (2006) Uses meanings and understandings of values in the environmental and protected area arena: A consideration of World Heritage values. *Society and Natural Resources* 19: 723-741.
7. Gratani, M., Sutton, S.G., Butler, J.R.A., Bohensky, E.L. and Foale, S. (2016) Indigenous environmental values as human values. *Cogent Social Sciences* 2: 1-17.
8. International Union for the Conservation of Nature (IUCN) (2015). Guidelines for the application of IUCN *Red List of Ecosystems Categories and Criteria.* Bland, L.M., Keith, D.A., Murray, N.J. and Rodríguez, J.P. (eds.). International Union for the Conservation of Nature, Gland, Switzerland. https://www.iucn.org/sites/dev/files/content/documents/rle_guidelines_draft_dec_2015.pdf
9. Salafsky, N., Salzer, D., Stattersfield, A.J., Hilton-Taylor, C., Neugarten, R., Butchart, S.H.M., Collen, B., Cox, N., Master, L.L., O'Connor, S. and Wilkie, D. (2008) A standard lexicon for biodiversity conservation: Unified classifications of threats and actions. *Conservation Biology* 22: 897–911.
10. Hale, J. and Brooks, S. (2015) *Desktop review of Victoria's marine values*. A report to the Department of Environment, Land, Water and Planning, Melbourne.
11. Robbins, W.D., Huveneers, C., Parra, G.J., Moller, L. and Gillander, B.M. (2017) Anthropogenic threat assessment of marine-associated fauna in Spencer Gulf, South Australia. *Marine Policy* 81: 392-400
12. Jenkins, G. (2013) *Assessment of anthropogenic threats to marine protected areas in Victoria.* Technical Report. Department of Zoology. University of Melbourne, Parkville.
13. Carey, J.M., Boxshall, A., Burgman, M.A., Beilin, R. and Flander, L. (2007) *State-wide synthesis of threats to natural values in Victoria's marine national parks and marine sanctuaries.* Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne. https://parkweb.vic.gov.au/park-management/environment/research-and-scientific-management/technical-series2
14. Navigatus Consulting Limited (NCL) (2011) *Victorian Marine Pollution Risk Assessment 2011 (VMRA11)*. Prepared for Department of Transport, Melbourne.

3 Legislative Arrangements

Marine waters and the underlying seabed are multi-jurisdictional and multi-use environments. They are subject to a complex and diverse range of legislative instruments deriving from state, Commonwealth and international law. While an assessment of individual pieces of legislation is beyond the scope of this assessment, some understanding of the legislation provides context for the assessment of values, threats and emerging uses.

KEY POINTS AT A GLANCE

- Victoria has jurisdiction over inland waters, those waters landwards of the territorial sea baseline (generally corresponding with the low water line along the coast). Under an agreement with the Commonwealth, the Offshore Constitutional Settlement, Victoria also has jurisdiction over coastal waters (water column and the seabed) for three nautical miles (approximately 5.5 kilometres) seaward of the territorial sea baseline.
- Much of the seabed and overlying waters is unreserved Crown land, managed under the *Land Act 1958*. A government-accepted recommendation of the Environment Conservation Council to establish a coastal waters reserve for these marine areas under the *Crown Land (Reserves) Act 1978* has not yet been implemented.
- The *Marine and Coastal Act 2018* provides a whole-of-government approach to planning and management of the marine and coastal environment while recognising the ongoing role of existing legislation that governs resource or land use. It is not a land reservation act. The act introduced objectives on climate change and acknowledgement of Traditional Owners' connections to the marine and coastal environment, two major gaps in older legislation.
- Victoria's 24 marine national parks and marine sanctuaries are established under the *National Parks Act 1975*. Terrestrial national and other parks with a coastal boundary extend to low water mark, except where they abut a marine national park.
- Victoria's six multiple-use marine protected areas are reserved under the Crown Land (Reserves) Act and included in a schedule to the National Parks Act.
- Land seaward of high water mark may be set aside for specific purposes such as protection of the coastline; and ports, quays, wharves, docks and landing places, under the Crown Land (Reserves) Act.
- The primary legislation for biodiversity protection in Victoria includes the *Flora and Fauna Guarantee Act 1988*, the *Wildlife Act 1975*, and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.
- Legislation relating to Aboriginal rights and interests in the marine environment includes the *Traditional Owner Settlement Act 2010* and the *Commonwealth Native Title Act 1993*.
- Aboriginal cultural heritage in Victorian waters is protected under the *Aboriginal Heritage Act 2006*.
- Non-Aboriginal cultural heritage, including shipwrecks, is protected under the H*eritage Act 2017* and the Commonwealth Underwater *Cultural Heritage Act 2018* (from 1 July 2019).
- The *Fisheries Act 1995* provides the legislative framework for managing Victoria's fisheries resources including commercial and recreational fishing and the aquaculture industry. The act also provides for fisheries reserves to be declared for various purposes including aquaculture.
- The *Climate Change Act 2017* includes a requirement for adaptation action plans for key systems that are vulnerable to the impacts of climate change (from 2021) e.g. natural environment.
- Other legislation controls individual sectors or uses of the marine environment including statutory planning and development, ports, shipping, maritime safety, emergency management, energy and earth resources, defence and waterway management.

3.1 Jurisdiction over marine waters

Waters under Victoria's jurisdiction include both internal waters – landward from the territorial sea baseline (normally the low water mark along the open coast). – and coastal waters. Marine waters landward of the territorial sea baseline include bays, inlets and estuaries. Islands within Bass Strait that are south of the line of latitude at 39°12' S are under the jurisdiction of Tasmania.

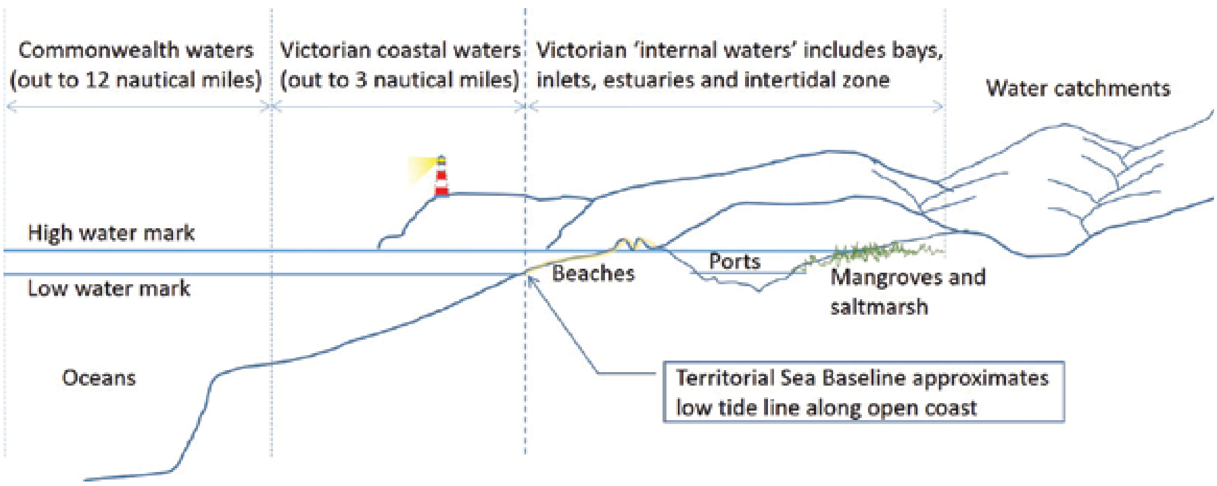
The *United Nations Convention on the Law of the Sea* gives a nation the right to regulate activities and impose its laws in the seas next to its coastline. For Australia, the Commonwealth *Seas and Submerged Lands Act 1973* legislates that all waters beyond the territorial sea baseline and outside of embayments are under the jurisdiction of the Commonwealth. The Commonwealth, the states and the Northern Territory have come to an arrangement, called the 'Offshore Constitutional Settlement' or OCS, in respect of jurisdiction in the waters to the edge of the territorial sea. The OCS, which came into effect in 1983, gives the states jurisdiction over the sea and seabed within three nautical miles of the coast. The OCS is not a single document but is found in the legislation that implements it.

The OCS recognises the need for cooperative federalism in the management of ocean resources. Commonwealth and state/territory governments may agree to arrangements for managing resources such as oil, gas and other seabed minerals and marine living resources. Such arrangements may allow for the management of the resources by state authorities even in waters outside the state three-mile limit, and vice versa.

The majority of Victoria's seabed and overlying waters are unreserved Crown land under the *Land Act 1958*; the Department of Environment, Land, Water and Planning (DELWP) is the designated land manager for these areas, unless otherwise specified. The major focus of the Land Act is on the sale, leasing and licensing of Crown land and the prevention of unauthorised occupations. Its provisions date back to the 1800s. Over time, land moved from being administered under the Land Act to other acts. However, for unreserved Crown land, the provisions of the Land Act apply.

In 2001, the government accepted the recommendation of VEAC's predecessor the Environment Conservation Council, in its final report for the Marine, Coastal and Estuarine Investigation (2000), that a coastal waters reserve be established for the major portion of Victoria's marine waters that are not otherwise designated for a specific purpose. The primary objectives for the reserve were to provide for a diverse range of activities that are compatible with long-term sustainable use and provide for the integrated management of Victoria's marine, estuarine and coastal area. This government-accepted recommendation has not yet been implemented.

Figure 3.1 Extent of coastal waters and the marine and coastal environment



The definition of 'marine and coastal Crown land' in the *Marine and Coastal Act 2018* is similar to but not the same as the sea and seabed within Victoria's jurisdiction (see figure 3.1). For example, marine and coastal Crown land for the purposes of the act has a depth limit of 200 metres beneath the surface, while the seabed within Victoria's jurisdiction extends 'to the centre of the earth'. Other differences are that marine and coastal Crown land under the act extends 200 metres inland of the high-water mark. The 'marine and coastal environment' defined under the act extends further inland: five kilometres from high-water mark.

3.2 Integrating legislation

3.2.1 Marine and Coastal Act

The *Marine and Coastal Act 2018* provides for a whole-of-government approach to planning and management of the marine and coastal environment while recognising the ongoing role of existing legislation that governs resource or land use. It is not a land reservation act.

The act establishes a coordination framework that aims to integrate the planning and management of the marine and coastal environment at statewide, regional and local levels. The act also aims to address contemporary challenges such as climate change, population growth and ageing coastal infrastructure.

The Marine and Coastal Act, which replaced the *Coastal Management Act 1995*, came into operation in August 2018. The act is supported by the *Victoria's Marine and Coastal Reforms – Final Transition Plan*, which outlines a series of actions needed to establish an integrated and co-ordinated whole-of-government approach to protect and manage Victoria's marine and coastal environment. This assessment by VEAC is listed as action 1.1 in the transition plan. The new act introduced objectives on climate change and acknowledgement of Traditional Owners' connections to the marine and coastal environment, two major gaps in the older legislation.

The act requires the development of a marine and coastal policy, which includes a marine spatial planning framework, and a marine and coastal strategy. The act also provides a 'consents process' to use, develop or undertake works on marine and coastal Crown land.

3.2.2 Climate Change Act

The *Climate Change Act 2017* is another piece of Victorian legislation that establishes a framework for an integrated and coordinated approach to an aspect of environmental management.

The act provides Victoria with a legislative foundation to manage climate change risks, maximise the opportunities that arise from decisive action, and drive transition to a climate resilient community and economy with net zero emissions by 2050. The act sits alongside other key Victorian government energy and climate change initiatives including *Victoria's Climate Change Framework, Victoria's Climate Change Adaptation Plan 2017-2020* and *Victoria's Renewable Energy Action Plan.*

Of relevance to marine and coastal waters is that the act requires the government to develop a climate change strategy setting out how Victoria will meet its targets and adapt to the impacts of climate change (from 2020). It also requires preparation of adaptation action plans from 2021 for key systems (including plans for natural environment systems, which includes coastal waters) and a process for use of Crown land for carbon sequestration.

3.3 Managing and protecting marine environments

3.3.1 Land legislation

There are four primary land acts in Victoria which govern the use of Crown land in Victoria and determine the legal basis for its use and management: the *Land Act 1958, Crown Land (Reserves) Act 1978, National Parks Act 1975* and the *Forests Act 1958*. All but the Forests Act are relevant to managing and protecting marine environments.

Victorian legislation relevant to the declaration of protected areas include: the *National Parks Act 1975*, pursuant to which marine national parks and marine sanctuaries and other protected areas are declared; the *Crown Land (Reserves) Act 1978* through which lands may be reserved for a variety of public purposes including nature conservation; the *Wildlife Act 1975*, through which reserves including wildlife and nature reserves may be declared; and the *Fisheries Act 1995*, which allows for the declaration of fisheries reserves, including for biodiversity protection purposes.

The National Parks Act was established with the purpose of preserving and permanently protecting unspoilt landscape and its flora and fauna for the benefit of the public. Victoria’s 13 marine national parks and 11 marine sanctuaries, which have been established to protect representative examples of marine biodiversity, are protected under the National Parks Act. National, state, coastal and other parks with a coastal boundary established under the National Parks Act extend to low water mark except where they abut a marine national park.

Commonwealth legislation relevant to the protection and management of Victoria’s marine environment includes the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Australia also has obligations under international conventions that relate to the protection of the marine environment. These include the *Convention on Wetlands of International Importance* (the Ramsar Convention) and the International Convention of the Regulation of Whales. These obligations are implemented through the Commonwealth EPBC Act.

The *Wildlife Act 1975* and *Fisheries Act 1995* are also relevant to the establishment and management of some reserves, with wildlife reserves and wildlife management cooperative areas able to be declared pursuant to the Wildlife Act. Fisheries reserves for biodiversity protection may be declared through the Fisheries Act, including for spawning, hatchery or nursing grounds.

The *Crown Land (Reserves) Act 1978* provides for the reservation and management of Crown lands for public purposes. Those purposes as listed in the Act that are relevant to marine and coastal environments include:

- ports, quays, wharves, docks and landing places
- protection of the beds or channels and the banks of waterways
- preservation of areas of ecological significance
- conservation of areas of natural interest or beauty or of scientific, historical or archaeological interest
- carbon sequestration in vegetation and soil
- preservation of species of native plants
- propagation or management of wildlife or the preservation of wildlife habitat
- public recreation
- facilities and services for tourists or for the promotion of tourism
- protection of the coastline.

The *Conservation Forests and Lands Act 1987* sets up a legislative framework that enables the minister to be an effective conserver of the State's lands, waters, flora and fauna; and to make provision for the productive, educational and recreational use of the State's lands, waters, flora and fauna in ways which are environmentally sound, socially just and economically efficient.

The *Parks Victoria Act 2018* (which replaced the *Parks Victoria Act 1998*) established Parks Victoria as an independent statutory authority with the aim of protecting, conserving and enhancing Parks Victoria managed land, which includes Victoria’s system of marine protected areas and selected local ports and waterways.

3.3.2 Biodiversity legislation

The *Flora and Fauna Guarantee Act 1988* enables and promotes the conservation of Victoria's native flora and fauna and provides a choice of procedures that can be used for the conservation, management or control of flora and fauna and the management of potentially threatening processes. Mechanisms include listing of threatened species and communities and threatening processes, the preparation of a strategies and action statements, identification of critical habitat and controls over protected flora and fauna. The act also empowers the secretary to require a public authority to consult with him or her prior to taking action that is likely to threaten the survival of a listed taxon or community of flora or fauna or a critical habitat.

The Wildlife Act was established to promote the protection and conservation of wildlife, promote prevention of taxa of wildlife from becoming extinct, promote sustainable use of and access to wildlife, and prohibit and regulate the conduct of persons engaged in activities concerning or related to wildlife. For the purposes of the act, wildlife is defined broadly as any animal of a vertebrate taxon other than mankind that is indigenous to Australia although it also includes deer and some other taxa.

The Wildlife Act creates various offences relating to the acquiring, hunting, taking or destruction of protected wildlife and offences relating to game. The act also enables the government to make regulations for the management, control, conservation and propagation of wildlife, for the preservation and maintenance of wildlife habitat and for the effective management of hunting. Particularly relevant to the marine environment, the act provides for the establishment of regulations for the protection of whales, seals and dolphins, including rules and offences relating to conducting whale sightseeing tours and dolphin swim tours.

Victoria's *Environment Protection Act 1970* and the Commonwealth EPBC Act provide overarching legislation that defines core conservation and management principles for the marine environment.

The long-term strategy for the management of biodiversity, which includes the marine environment, is outlined in Victoria's biodiversity plan Protecting Victoria's Environment – Biodiversity 2037.

3.3.3 Environmental regulation

The Environment Protection Authority (EPA) established under the Environment Protection Act 2017 is the environmental regulator and has responsibility for independent assessment, licensing, reporting and advice regarding environmental health issues relating to pollution and waste affecting coastal waters. The EPA is responsible for administering and enforcing the *Environment Protection Act 1970* and *State Environment Protection Policy (Waters) 2018*, which provides a framework to protect and improve the quality of Victoria's waters.

3.4 Statutory planning and development

The *Planning and Environment Act 1987* establishes a framework for planning the use, development and protection of land in Victoria in the present and long-term interests of all Victorians. The focus of the act is on land, although 'land' is defined in the act to include land covered with water. The act provides for establishment of planning schemes and the Victoria Planning Provisions.

The Planning and Environment Act allows for some flexibility in how boundaries of planning schemes may be drawn, however they generally extend 600 metres seaward from the municipal boundary, which coincides with the low water mark. Most impacts of planning on the marine environment are thus indirect, resulting from the effects of adjacent catchment and coastal planning practices.

The Planning and Environment Act was amended in 2018 to provide for the declaration by the minister of distinctive areas and landscapes, and subsequent preparation and implementation of a 'Statement of Planning Policy'. The purpose of the statement being to provide state level protection against inappropriate development in declared distinctive areas and landscapes. Declarations are being considered for the Bass Coast, Bellarine Peninsula and Surf Coast to protect seaside townships and coastal landscapes from excessive urban development.

When a proposed development or project could potentially have significant environmental effects, a written referral is sent to the minister administering the *Environment Effects Act 1978* (currently the Minister for Planning) by the proponent or decision-maker. The process under the act is not an approvals process itself; it enables statutory decision-makers to make decisions about whether a project with potentially significant environmental effects should proceed. Commonwealth legislation may also be relevant in that certain developments subject to planning permission in Victoria may be determined a 'controlled action', likely to have a significant impact on environmental significance, under the Commonwealth EPBC Act. Under the bilateral agreement between the Commonwealth and Victoria for environmental assessment made in 2014, Victoria can assess these proposals using accredited assessment processes to avoid duplication and provide the assessment to the Commonwealth minister to inform the EPBC approval decision.

3.5 Interests of Aboriginal Peoples

Recognition of the rights and interests of Aboriginal peoples in Victoria's marine environment can derive from native title determinations under the Commonwealth *Native Title Act 1993* as well as through agreements made pursuant to the *Traditional Owner Settlement Act 2010*. Aboriginal rights to land and resources may be implemented through joint management plans in the case of certain types of protected areas, through indigenous land use agreements made pursuant to native title determinations or through agreements pursuant to the Traditional Owner Settlement Act.

The Traditional Owner Settlement Act offers an alternative to court-determined native title determinations. It enables the Victorian government to make agreements with Traditional Owners to recognise their relationship to land and provide for certain rights on Crown land and other benefits. In entering into a settlement, Traditional Owners must agree to withdraw any native title claim they have and agree not to make a claim into the future.

The first settlement under the Traditional Owner Settlement Act was the Gunaikurnai agreement. The settlement area, which extends from West Gippsland east to the Snowy River, includes the area up to 200 metres seawards of the territorial sea baseline. A land use activity agreement has been developed and will result in recognition of certain natural resource rights held by the Traditional Owners. The agreement also provides for joint management of some parks and reserves. These include, on the coast, the Lakes National Park, the Gippsland Lakes Coastal Park, the Gippsland Lakes Reserve at Raymond Island and the Corringle Foreshore Reserve. In this particular case the Gunaikurnai people, under separate orders, also have native title recognised under the *Native Title Act 1993*.

The *Aboriginal Heritage Act 2006* recognises Aboriginal people as the primary guardians, keepers and knowledge holders of Aboriginal cultural heritage. An 'Aboriginal Place' under the act may be in the coastal waters of Victoria. Land and sea managers must manage lands in accordance with the provisions of the act. Those responsibilities include, for example, reporting discovery of Aboriginal places and objects.

3.6 Cultural heritage

The *Heritage Act 2017* provides for the protection and conservation of places and objects of cultural heritage significance and the registration of such places and objects. Part 4 of the Act and the Heritage (Underwater Cultural Heritage) Regulations 2017 protect underwater cultural heritage including shipwrecks, shipwreck artefacts and sunken aircraft in Victorian state waters.

The Commonwealth *Underwater Cultural Heritage Act 2018* provides complementary protections in Commonwealth waters to the edge of the continental shelf. The act will come into effect on 1 July 2019, replacing the *Historic Shipwrecks Act 1976*.

The Heritage Act establishes the Heritage Council, the Victorian Heritage Register and a Heritage Fund. It also clarifies the role for local government in permit processes, including a clear opportunity to comment on permit applications and allows local government to be heard in any permit review before the Heritage Council.

3.7 Fisheries

The Fisheries Act 1995 provides the legislative framework for managing Victoria's fisheries resources and sets out the general provisions applicable to all recreational fishing activities, commercial access licences and aquaculture industries. The Department of Jobs, Precincts and Regions (DJPR) sets policy for the management and regulation of commercial and recreational fishing and aquaculture under the act.

The Victorian Fisheries Authority (VFA) is an independent statutory authority established under the *Victorian Fisheries Authority Act 2016* to effectively manage Victoria's fisheries resources and enforce the provisions of the Fisheries Act. The VFA prepares and reviews management plans for the ecologically sustainable management of Victoria's fisheries across the recreational, commercial and aquaculture sectors.

The Fisheries Act contains several tools for protection of the marine environment. These include declaration of fisheries reserves, setting requirements for the development and content of fisheries management plans, declaration of protected aquatic biota and noxious aquatic species and use of fisheries restrictions, closures and quota notices.

The Fisheries Act is supported by regulations. There are provisions within the Fisheries Regulations 2009 specific to the intertidal zone (defined from the maximum high-water mark to where the water is two metres deep). For example, it is an offence under the regulations for a person to use a scoop, dredge, fork, spade, shovel or other hand-held digging implement for taking or attempting to take molluscs or other marine invertebrates from the intertidal zone.

Commonwealth legislation relevant to fisheries includes the *Fisheries Management Act 1991*, *Fisheries Administration Act 1991*, *Environment Protection and Biodiversity Conservation Act 1999* and all associated regulations. While the Commonwealth legislative framework focuses on Commonwealth-managed fisheries and waters from the limit of the state coastal waters seawards to the limits of the Australian Exclusive Economic Zone, the Victorian legislation focuses on Victorian internal waters and coastal waters (to the three-nautical mile limit).

Given many fish stocks cross jurisdictional boundaries, a suite of cross-jurisdictional arrangements has been established across the boundaries of Victorian, Tasmanian and

Commonwealth waters for fisheries such as scallops and southern rock lobster. Most Australian fisheries that span the waters of the Commonwealth and a state (or states) are managed according to agreements made under the OCS. These OCS fisheries arrangements envisaged the allocation of the management of a fishery to a single jurisdiction under a single set of regulations, although this model has not always been followed. These arrangements (of which there are 59 nationally) are typically supported by Memoranda of Understanding (MoU) between the parties (e.g. Victoria, Tasmania and South Australia each have an MoU with the Australian Government).

Under the EPBC Act, all export fisheries must be assessed against the *Commonwealth Guidelines for the Ecologically Sustainable Management of Fisheries* (2nd ed.).

3.8 Ports and harbours and marine safety

The *Port Management Act 1995* (formerly named the *Port Services Act 1995*) establishes a regulatory system for the management of Victoria's commercial trading ports and local ports. The act provides for economic regulation of port services and development of port strategies and management plans. The act also sets out requirements for harbour masters. Under the act, the government can declare any lands or waters for use as a commercial trading port or local port.

The act establishes port managers as the responsible authorities for ensuring the safety, efficiency and effectiveness of port operations. Port managers manage infrastructure including piers, jetties, aids to navigation, moorings and berths. Port managers can also restrict access to areas within the port by specific classes of vessels, at specific times or for specific activities.

Under the Port Management Act, port managers, subject to obtaining any permit, consent or other authority required under other acts, may, in carrying out their functions:

- alter, dredge, cleanse, scour, straighten and improve the bed and channel of any river or seabed in port waters
- reduce or remove any banks or shoals within any such river or seabed
- abate and remove impediments, obstructions and nuisances in, or on the banks and shores of, any such river or seabed that are injurious to the river or seabed or that obstruct, or that may tend to obstruct, navigation.

Port managers carry out the functions and powers of a local authority under the *Marine Safety Act 2010* in respect to any waters within the port. Amongst other activities this involves developing safety and environment management plans, and responsibilities associated with pollution abatement, hazardous activities and clean up.

The *Transport Integration Act 2010* establishes a framework for an integrated and sustainable transport system in Victoria. It also establishes agencies including the Victorian Ports Corporation (Melbourne), the Victorian Regional Channels Authority and the Port of Hastings Development Authority. Under the act, transport bodies, which includes the Minister for Ports, port managers and waterway managers, must consider social and economic inclusion, economic prosperity and environmental sustainability when exercising powers, performing functions or making decisions under any transport legislation.

The *Marine Act 1988* establishes a system for regulating the registration and operation of vessels. The act also provides for the minister and public authorities to take steps to prevent, mitigate and restore land in the context of prohibited discharge (i.e. oil pollution). Also relevant to protection of the marine environment is that the Marine Act establishes the roles of harbour masters and waterway managers.

The *Marine Safety Act 2010* provides a framework to ensure marine vessels are fit for purpose and those who operate them have the skills to do so safely. The act sets out clear accountabilities for all persons and parties that form the chain of responsibility for marine safety and sets testing powers for drug and alcohol impairment. The Marine Safety Regulations 2012, which accompany the act, are designed to improve compliance, reduce injuries and ensure a safe environment for recreational and commercial boating.

Maritime Safety Victoria, which is a branch of Transport Safety Victoria, regulates the safe operation of vessels (sailing, human-powered and motor craft) in coastal waters, under the Marine Safety Act.

3.9 Marine pests

The protection of Victorian waters from the introduction of marine pests is supported by several pieces of legislation and policy.

The Australian Ballast Water Management Requirements Version 7 place obligations on high-risk vessels operating within Australian waters that assist in reducing the introduction and spread of invasive marine pests via ballast water under the Commonwealth *Biosecurity Act 2015*. The requirements also align to the *International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004* (the Ballast Water Management Convention), which came into force internationally in 2017.

The *Fisheries Act 1995* includes (with some limitations) the power to declare aquatic plants, invertebrates and fish as noxious aquatic species. Unless authorised under the act, a person must not bring into Victoria or take, hatch, keep, possess, sell, transport, put into any container or release into protected waters any declared noxious aquatic species. The use of powers under the *Fisheries Act 1995* can only be used where the declared noxious aquatic species may impact on fisheries resources.

The *Emergency Management Act 1986* and *Emergency Management Act 2013* provide the legislative framework for emergency management in Victoria. Under this sits the *Emergency Management Manual Victoria* (EMMV), which contains policy and planning documents for emergency management. Marine pest incursions are listed as a declared emergency in the EMMV, as are oil spills and algal blooms.

Marine Pest Plan 2018-2023 is Australia's national strategic plan for the management of marine pest biosecurity. It outlines a coordinated approach to building Australia's capacity to manage the threat of marine pests.

The Invasive Plants and Animals Policy Framework (IPAPF) presents the overarching Victorian Government approach to the management of existing and potential invasive species. The IPAPF incorporates a biosecurity approach and ensures that Victoria maintains a comprehensive planning framework to guide the management of invasive species. A specific marine pest module under the IPAPF is under development. The *Anti-fouling and in-water cleaning guidelines 2013* describe best practice approaches for the application, maintenance, removal and disposal of anti-fouling coatings and the management of biofouling and invasive aquatic species on vessels.

The *Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria 2009* includes protocols for reducing the risk of transferring marine pests through aquaculture activities.

3.10 Mining, energy and exploration

Legislation relevant to mining and exploration in Victoria's coastal waters include the *Offshore Petroleum and Greenhouse Gas Storage Act 2010* and the *Underseas Mineral Resources Act 1963*.

The Offshore Petroleum and Greenhouse Gas Storage Act replaced the *Petroleum (Submerged Lands) Act 1982* and establishes a regulatory framework governing petroleum exploration and recovery, and the injection and permanent storage of carbon dioxide and other prescribed greenhouse gases, in Victorian offshore waters. The act sets up a system for regulating the construction and operation of facilities and construction and operation of pipelines. In the administration of the act regard is to be given to the principles of sustainable development and, in relation to making decisions, regard must be given to the public interest.

Arrangements for offshore petroleum beyond the outer limits of Victoria's coastal waters are set out in the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. The Offshore Petroleum and Greenhouse Gas Storage Act is consistent with the Offshore Constitutional Settlement and largely mirrors the Commonwealth act.

The Underseas Mineral Resources Act extends the application of the *Mineral Resources (Sustainable Development) Act 1990* to the seabed and subsoil of Victorian coastal waters. The act facilitates economically viable mining and extractive industries. The act declares that gold, silver, uranium, thorium and other minerals found in or on the seabed are deemed to be the property of the Crown. Under the act, national parks, marine national parks and marine sanctuaries are exempt from being subject to a licence or other authority for mining. The Minister may also exempt other marine and coastal areas from mining.

The *Geothermal Energy Resources Act 2005* and *Greenhouse Gas Geological Sequestration Act 2008* apply to land on the landward side of the territorial sea baseline, which includes Port Phillip Bay, Western Port, Corner Inlet and the Gippsland Lakes but not the open coast. These acts set up systems for regulating the exploration, construction and operation of associated facilities and pipelines.

3.11 Pipelines and cables

The use of the Crown land (reserved or unreserved) for the laying of pipelines (includes oil, gas and water) and cables (includes electricity and telecommunications) is generally managed through licences (which provide non-exclusive use over an area) or leases (which grant an exclusive right to occupy a defined area of land). Licences and leases are covered by legislation including the *Crown Land (Reserves) Act 1978*, *Land Act 1958*, *National Parks Act 1975* and *Pipelines Act 2005* (and occasionally by more than one of these acts).

The Pipelines Act, which applies to pipelines carrying hazardous and combustible gaseous and liquified substances, creates a system of licences for the construction of pipelines, sets out how pipelines must be operated and establishes mechanisms for enforcement. The act allows the granting of easements or licences over Crown land for the construction of pipelines. The act does not apply to a pipeline in the offshore area (Victorian coastal waters). However, a licence may be granted under the act if it is a single directional pipeline commencing on land within Victoria. Before carrying out pipeline operations, a licensee must prepare management plans including an environmental management plan.

Pipelines that lie in Commonwealth waters are administered by the National Offshore Petroleum Titles Administrator and the National Offshore Petroleum Safety and Environmental Management Authority under the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*.

Pipelines associated with scheduled premises and the discharge of waste (includes ocean outfalls for treated sewage effluent) require a works approval to be issued by the EPA under the *Environment Protection Act 1970*. Following satisfactory completion of the works, EPA issues a licence for discharge of waste. Discharge to waters must not exceed environmental quality objectives set out in the *State Environment Protection Policy (Waters) 2018*.

Pipelines and other infrastructure constructed and operated within coastal waters may require consent under the *Marine and Coastal Act 2018*.

3.12 Defence

The two principal pieces of legislation that impact on the use of coastal waters for defence purposes are the Commonwealth's *Control of Naval Waters Act 1918* and the *Defence Act 1903*.

The Control of Naval Waters Act provides for the declaration of 'naval waters'. Such waters can be proclaimed within five nautical miles of a defence installation, or within two nautical miles of any defence land upon which there is no installation. An installation includes a naval establishment, dock, slipway, dockyard, arsenal, mooring or wharf used for naval defence. Subsequently, there are restrictions placed on vessels or aircraft operating near naval waters.

The Defence Act has potential to impact upon the use of coastal waters through the establishment of defence practice areas. Such areas can be closed to shipping or other activities during exercises.

3.13 Waterways management

Under the *Water Act 1989*, the Victorian Government retains the overall right to the use, flow and control of all surface water and groundwater on behalf of all Victorians. The act also defines the Environmental Water Reserve as the amount of water set aside to meet environmental needs. The Victorian Environmental Water Holder (VEWH) was established in 2011 under the act as an independent statutory body responsible for making decisions on the most efficient and effective use of Victoria's environmental entitlements. For example, this includes the release of water from storages to support triggering of breeding cycles in species such as the Australian grayling.

The *Victorian Waterway Management Strategy* (2013) provides the framework for government, in partnership with the community, to manage rivers, wetlands and estuaries so it can support environmental, social, cultural and economic values now and into the future. The catchment management authorities – Glenelg Hopkins, Corangamite, West Gippsland and East Gippsland – and Melbourne Water are required to develop management strategies for estuaries within their areas of operation.

Catchment management authorities are established under the *Catchment and Land Protection Act 1994* and amongst other duties must prepare regional catchment strategies and coordinate and monitor their implementation. These strategies consider the cumulative impact of catchment processes on coastal waters and management actions to mitigate these impacts.

The *Heritage Rivers Act 1992* identifies heritage rivers and associated public land that have significant nature conservation, recreation, scenic or cultural heritage attributes that require protection. Natural catchment areas are also protected under the act which requires that the area is maintained in an essentially natural condition. Schedule 1 of the Act lists 18 heritage rivers, five of which include estuarine reaches – Genoa, Bemm, Snowy, Aire and Glenelg rivers. Schedule 2 of the act lists 26 natural catchment areas including the East Gippsland coastal streams catchment area containing the Red and Benedore rivers, and Shipwreck, Easby and Seal creeks.

The *Yarra River Protection (Wilip-gin Birrarung Murron) Act 2017* identifies the Yarra River and the many hundreds of parcels of public land it flows through as one living, integrated natural entity for protection and improvement and acknowledges the spiritual connection between the river and the descendants of the Woi-wurrung. Melbourne Water is the lead agency for developing a 50-year community vision for the Yarra River, which will become the foundation for an overarching Yarra Strategic Plan. The Yarra's estuarine reaches and connection to Port Phillip Bay are incorporated in the plan.

4 Boundary Definitions

This chapter provides a summary of Victoria's legislative, political and biophysical boundaries. Some boundaries are defined by features of the natural environment, some by requirements to protect biodiversity and others have been established through legislative processes.

KEY POINTS AT A GLANCE

- Victoria's coastal waters extend three nautical miles (5.56 kilometres) from the territorial sea baseline (normally the line of lowest astronomical tide along the open coast). Marine areas landward of the territorial sea baseline include intertidal areas, bays, inlets and estuaries.
- Victoria's marine waters cover 4.2 per cent of Victoria, some 1,001,400 hectares (excluding the Gippsland Lakes and other estuaries.
- Estuaries are partially enclosed waterbodies where rivers and creeks meet the sea. Depending on how frequently the estuary mouth is open to the sea, the water might be almost fresh (brackish) to very saline. There are some 114 estuaries along the Victorian coast.
- There are 23 local government areas along Victoria's coast.
- For environmental management purposes the coastline can be classified into 26 marine biounits. Biounits are based on species and habitats and align broadly with marine bioregions agreed at a national level.
- For coastal protection purposes the coastline can be classified into 23 coastal sediment compartments based on landforms and sediment movement.
- Victoria's 24 no-take marine national parks and sanctuaries are highly protected areas with no extractive uses that are managed primarily for ecosystem protection, conservation and recreation. There are also six multiple-use marine protected areas (marine reserves, marine parks and marine and coastal parks) that allow recreational and commercial fishing. Three Commonwealth multiple-use marine protected areas abut Victorian coastal waters. Some terrestrial protected areas (e.g. national parks) extend to the low water mark, protecting the intertidal zone.
- International agreements and designations to protect the natural environment or birds in particular include biosphere reserves, Ramsar sites, migratory bird agreements and key biodiversity areas.
- To help inform natural resource management, DELWP has identified some 140 tangible biophysical elements of the marine environment, known as marine assets that are valuable for their ecosystem services.

4.1 Jurisdictional boundaries

4.1.1 Coastal waters

Victoria's marine environment includes coastal waters and some 'inland' waters. Victoria's coastal waters extend some three nautical miles (5.56 kilometres) offshore from the territorial sea baseline (normally the line of low tide along the open coast). Marine waters on the landward side of the territorial sea baseline are part of Victoria's 'internal waters' and include the intertidal area, bays, inlets and estuaries.

The total area of Victoria is 23,753,750 hectares, which includes a terrestrial component of 22,752,350 hectares and a waters component of 1,001,400 hectares (approximately 4.2 per cent of total extent of Victoria) (figure 4.1). For these calculations, waters includes bays, major inlets and coastal waters within Victoria's jurisdiction, but not the Gippsland Lakes. The area of the Gippsland Lakes (estimated to be 35,400 hectares) and the estuaries of rivers and creeks are included in the calculated terrestrial area.

Waters beyond and abutting Victoria's coastal waters are under the jurisdiction of the Commonwealth, except where the seaward boundary of Victoria's coastal waters abuts coastal waters around several small islands southeast of Wilsons Promontory that are under the jurisdiction of Tasmania.

The actual position of the seaward boundary of Victoria's coastal waters has not been defined by survey positioning methods, but it is represented on a digital map product prepared by GeoScience Australia known as the Australian maritime boundaries dataset.

The *Marine and Coastal Act 2018* defines the sea as meaning the sea within the limits of Victoria and including bays, inlets, estuaries, the Gippsland Lakes and any waters within the ebb and flow of the tide. The act has definitions of marine and coastal Crown land and the marine environment that differ from formal jurisdictional boundaries. For example, the 'marine environment' is defined in the act as being the seabed and overlying waters between the outer limit of Victorian coastal waters and the high-water mark of the sea to a depth of 200 metres. Crown land making up the seabed, however, has no depth limit.

Figure 4.1 Areas of land and coastal waters in Victoria

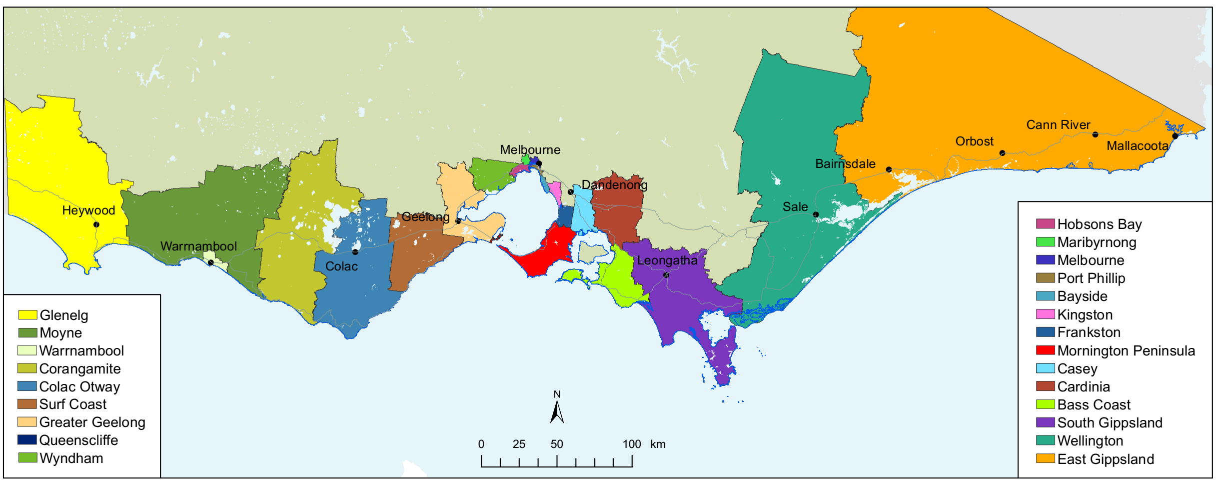
	Hectares
Mainland	22,708,200
Island	44,150
Total terrestrial component	*22,752,350*
Water*	1,001,400
Total	**23,753,750**

* 4.2%

4.1.2 Municipal boundaries

There are 23 local government areas along the Victorian coast (figure 4.2). Local councils have interests in the management of the marine and coastal environment through their roles in management of recreation and in statutory planning and management of infrastructure. Many of the councils are also the delegated local waterway managers for estuaries and coastal lakes.

Figure 4.2 Local government areas along the Victorian coast



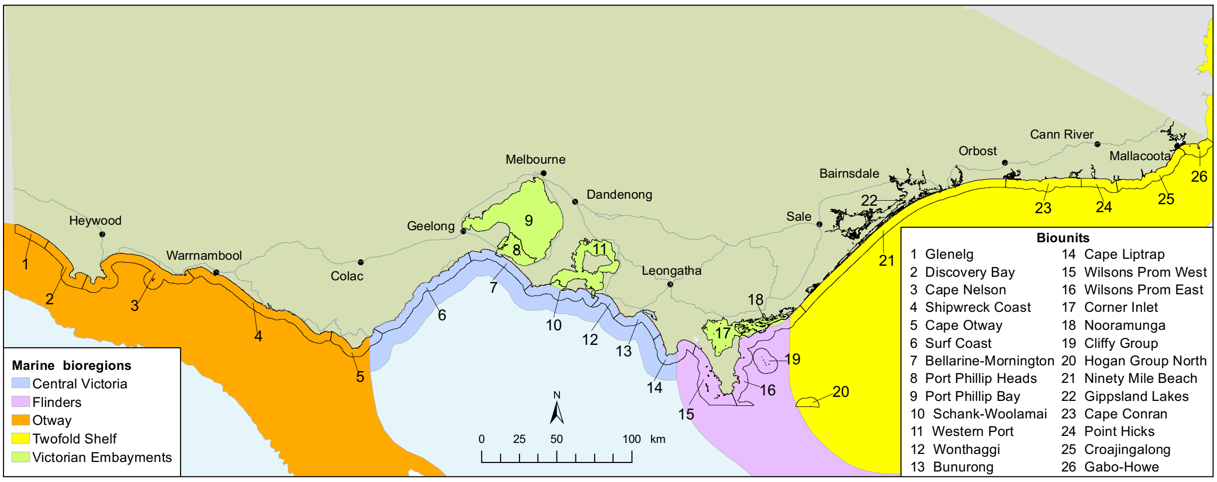
4.2 Biophysical boundaries

4.2.1 Marine biounits

DELWP has undertaken statewide marine habitat mapping and classification based on the combined biotope classification scheme (CBiCS).[1] This is a relatively new schema that provides a unified way to classify all marine habitats and biotopes and is analogous with Victoria's terrestrial system of ecological vegetation classes (EVC mapping) for classifying vegetation types and habitats. See section 6.2.2 for more detailed information on biotope mapping.

For Australia, the CBiCS levels 4 and 5 are based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) provinces and bioregions, but with modifications to their boundaries such that they match the finer scale biotopes. Regional marine biounit areas are typically separated by one or more dominant physiographical settings, such as a large embayment or cliffed coastline. Each unit consists of a complex of habitat types, often incorporating littoral (intertidal) to circalittoral (subtidal) hard and soft substrata. There are 26 regional marine biounits along the Victorian coast (figure 4.3).

Figure 4.3 IMCRA provinces with finer scale regional marine biounits based on CBiCS (adapted from Edmunds and Flynn 2018)



4.2.2 Estuaries

The *Victorian Waterway Management Strategy* [2] defines estuaries as places where rivers and creeks meet the sea and the fresh water mixes with the salt water of the ocean. They are partially enclosed waterbodies that may be permanently or periodically open to the sea and have salinities that vary from almost fresh (brackish) to very saline. Some inlets with little freshwater input may also be classified as estuaries e.g. Shallow Inlet.

A working definition used in the *Victorian Waterway Management Strategy* and the *State Environment Protection Policy (Waters) 2018* is that an estuary must be at least one kilometre long or have a lagoon length of at least 300 metres. This includes tributary estuaries that flow into Port Phillip Bay, Western Port, Corner Inlet and the Gippsland Lakes.

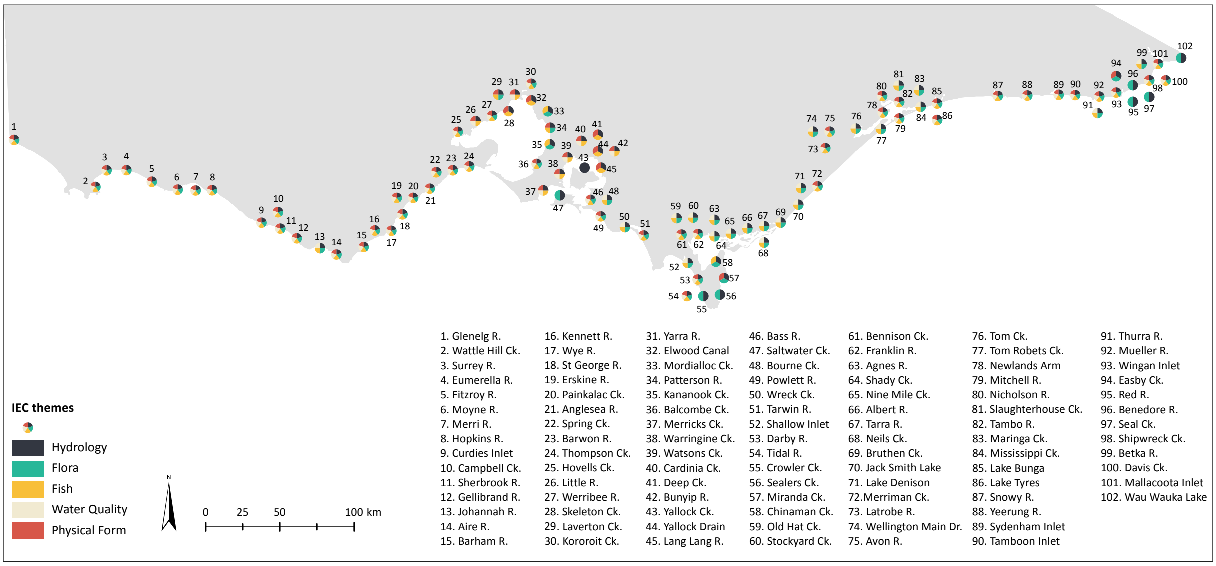
Appendix 1 provides a list of 114 estuaries along the Victorian coast. The list includes 19 estuaries that do not meet the working definition as described in the *Victorian Waterway Management Strategy*. It also includes 14 estuaries associated with rivers and creeks that terminate in the Gippsland Lakes.

Estuarine ecosystems are highly complex and dynamic environments. Their condition is influenced by activities occurring in the water catchment that drains into them. Where the condition of catchments, rivers or estuaries is poor there are likely to be additional impacts on the marine environment.

DELWP's Index of Estuary Condition (IEC) provides a consistent condition assessment method. Five themes make up the index: fauna, flora, water quality, physical form and hydrology, with multiple measures and standard methods used for their assessment. The first statewide IEC assessment, planned to be completed in

2020, will support policy and strategy revision, and facilitate reporting to government and communities. The location and list of estuaries to be assessed are shown in figure 4.4 and listed in appendix 1.

Figure 4.4 Location of estuaries considered for the Index of Estuary Condition (IEC). Numbers correspond to the estuary names listed below the map. Icons are coloured according to what themes are confirmed for assessment

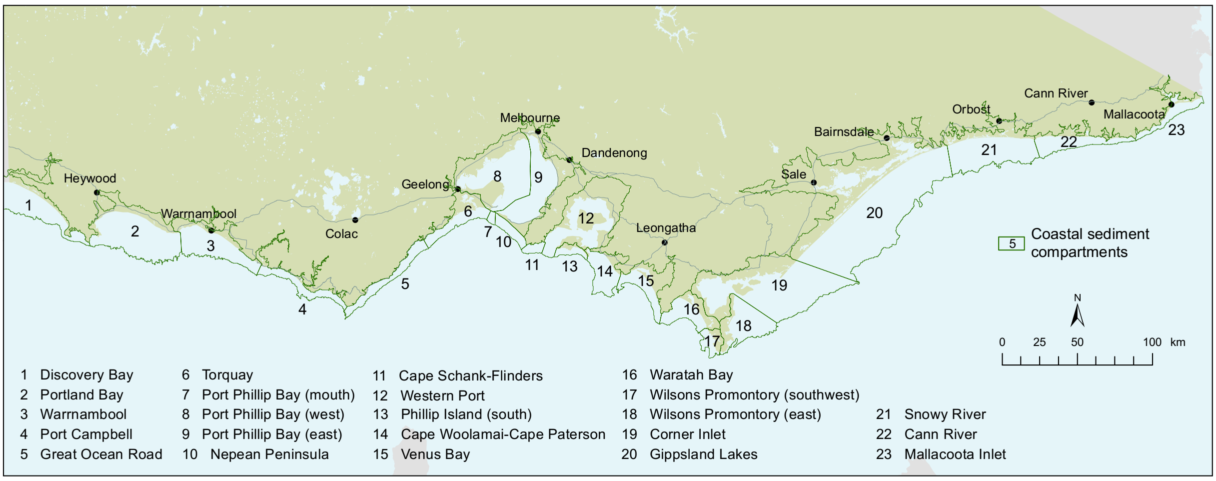


4.2.3 Sediment compartments

The National Classification of Coastal Sediment Compartments project has classified the Victorian coast into primary compartments and secondary compartments based on landforms and patterns of sediment (sand and other beach material) movement (figure 4.5).

Coastal sediment compartments are a useful framework for planning and managing coastal protection works. The compartment boundaries act as natural barriers to sediment transport, enabling each compartment to be treated as a semi-closed system with quantifiable sediment sources and sinks. The compartments also provide logical boundaries for modelling of sediment transport processes that are used to inform the design and placement of coastal infrastructure, e.g. seawalls and breakwaters.[3] Note that these compartments do not align with the boundaries of regional marine biounits discussed in section 4.2.1 because the classification serves a different purpose.

Figure 4.5 Coastal sediment compartments (secondary) along the Victorian coast



4.3 Protected areas and international designations

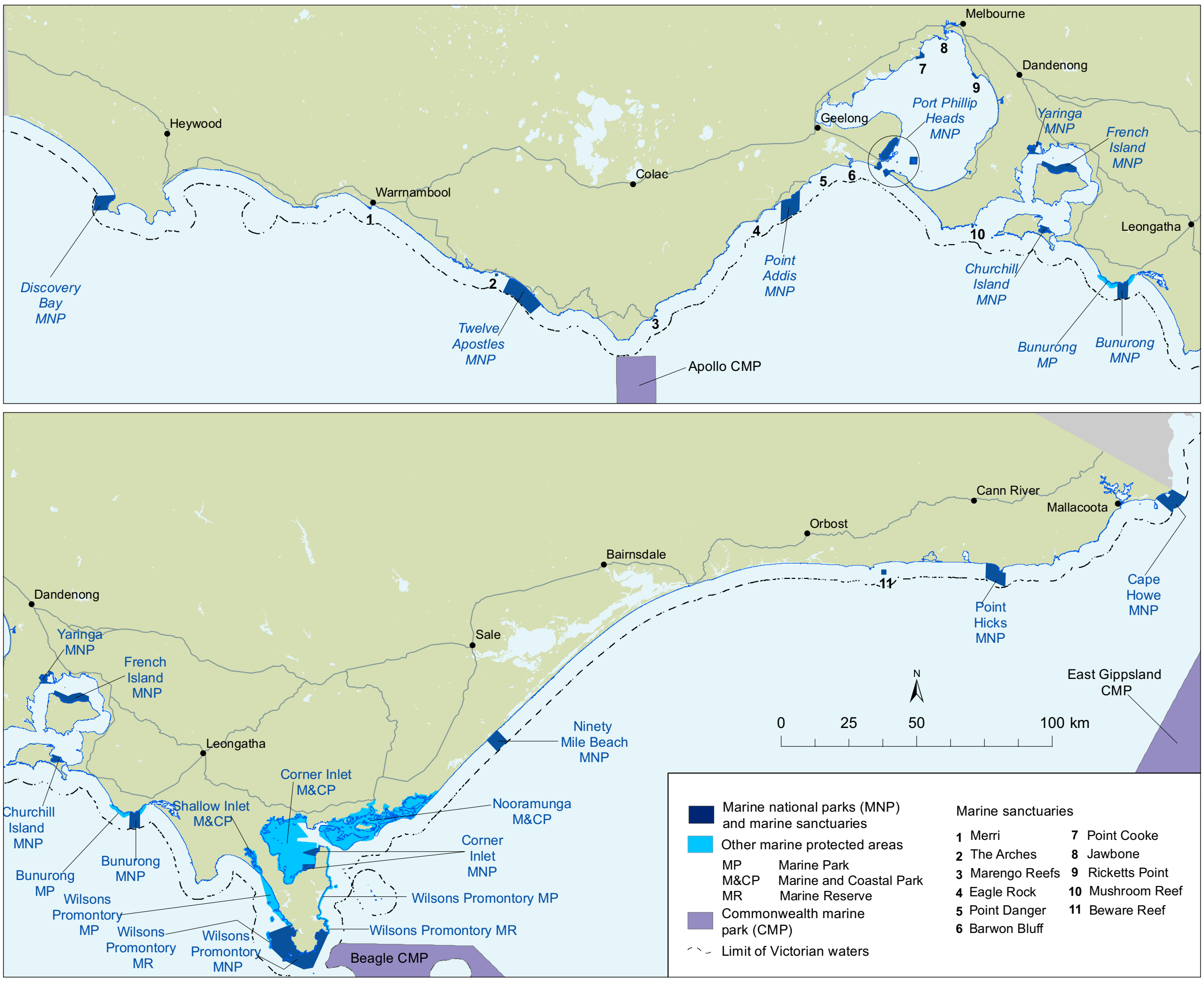
4.3.1 Marine protected areas

Victoria's marine protected areas currently consist of 24 no-take marine protected areas and six multiple-use marine protected areas. The no-take marine protected areas include 13 marine national parks and 11 marine sanctuaries that were established in 2002 following an investigation by the ECC.[4] They cover approximately 63,000 hectares or 5.3 per cent of Victorian coastal waters (figure 4.6) and extend landward to the high-water mark. They are highly protected areas with no extractive uses allowed and are managed primarily for ecosystem protection, conservation of natural features and recreation. Marine sanctuaries are smaller, between 12 and 290 hectares, and are designed to protect special features such as typical or outstanding examples of habitats, areas of special scientific significance, or areas that provide important opportunities for recreation and education.

Victoria has six multiple-use marine protected areas, includes marine parks, marine reserves and marine and coastal parks that were established between 1984 and 1991 prior to the ECC investigation and not subsumed into the no-take areas. These areas have a lower level of protection, as recreational and commercial fishing are allowed. Unlike the no-take areas, some of these multiple-use areas also include coastal land. All six multiple-use marine protected areas are reserved under the *Crown Land (Reserves) Act 1978* and included in Schedule 4 of the *National Parks Act 1975*.

The ECC also recommended 18 special management areas that highlighted special values which warranted protection through management plans or appropriate regulatory instruments e.g. the whale calving area of Logans Beach and the important fish nursery area of the Bass River delta in Western Port. These values were not intended to be protected through reservation in marine protected areas.

Figure 4.6 Marine protected areas in Victorian and adjacent Commonwealth waters



There are three Commonwealth multiple-use marine protected areas adjacent to Victorian coastal waters: East Gippsland (413,700 hectares), Beagle (293,200 hectares) and Apollo (118,500 hectares) marine parks (figure 4.6).

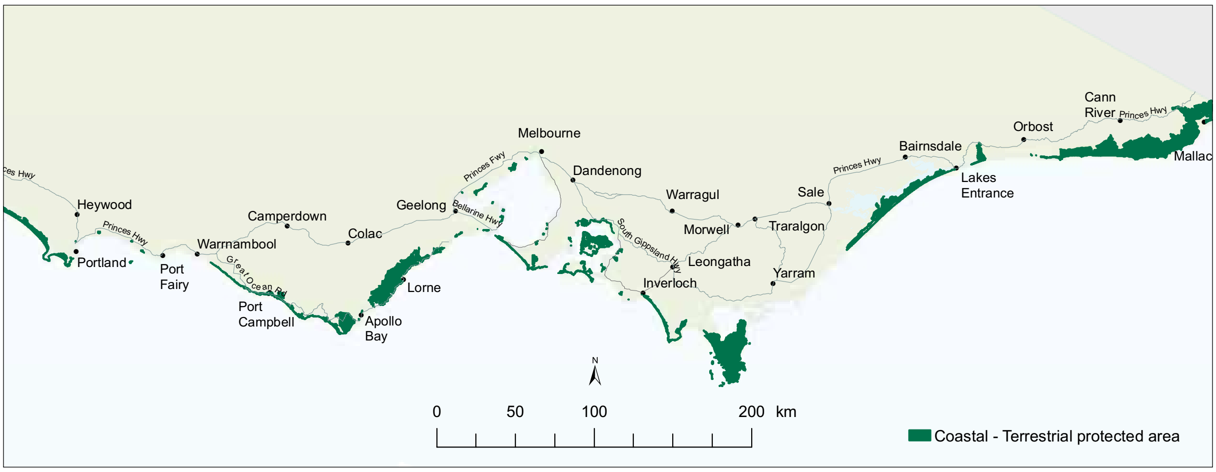
4.3.2 Terrestrial protected areas

Eight national parks (Port Campbell, Great Otway, Point Nepean, Mornington Peninsula, French Island, Wilsons Promontory (part), The Lakes, Croajingolong), two state parks (Cape Nelson, Lake Tyers) and five coastal parks (Discovery Bay, Bay of Islands, Cape Liptrap, Gippsland Lakes, Cape Conran) established under the National Parks Act extend to the mean low water mark. These parks include the intertidal zone and provide for conservation and recreation. Where a national park abuts a marine national park (e.g. Wilsons Promontory) the intertidal zone is included in the marine national park.

The Gunaikurnai people have gained Aboriginal Title to 10 parks and reserves as a result of their 2010 Recognition and Settlement Agreement with the Victorian government, including The Lakes National Park, Lake Tyers State Park and the Gippsland Lakes Coastal Park.

Other protected areas along the coast include nature reserves and bushland reserves. These areas do not usually extend seaward of high water mark.

Figure 4.7 Terrestrial protected areas along Victoria's coast



4.3.3 UNESCO Biosphere reserves

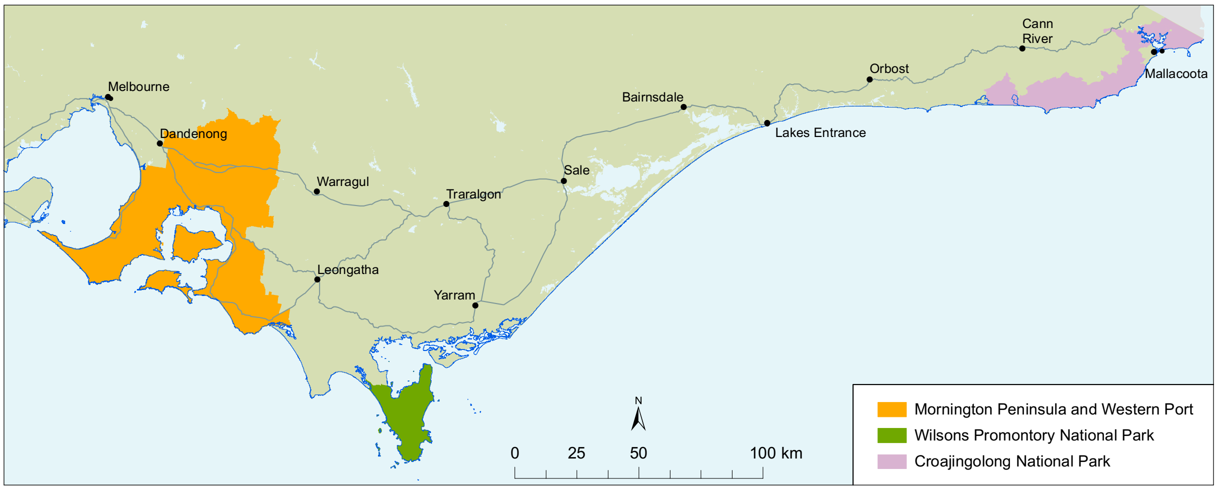
Biosphere reserve is an international designation made by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) based on nominations submitted by countries participating in the Man and the Biosphere Program. Victoria has three biosphere reserves – Croajingolong National Park (designated in 1977), Wilsons Promontory National Park (1981) and Mornington Peninsula and Western Port (2002) (figure 4.8).

The biosphere reserve concept promotes both conservation and sustainable use of natural resources. The program was launched in 1971 to stimulate a greater understanding and provision of knowledge and skills to support sustainable relationships between people and their environment. Biosphere reserves provide a global network of sites for cooperative research and to demonstrate the sustainable use goals of the World Conservation Strategy.

4.3.4 International agreements to protect migratory shorebirds and habitat

Migratory shorebirds rely on critical non-breeding habitats in Victoria every summer. Adequate protection of migratory bird habitats along migration pathways and at their destinations requires international cooperation. Accordingly, Australia is a signatory to a range of international agreements. In addition to protecting internationally important natural values, such as coastal wetlands, these agreements raise community awareness of listed sites and value for nature-based tourism.

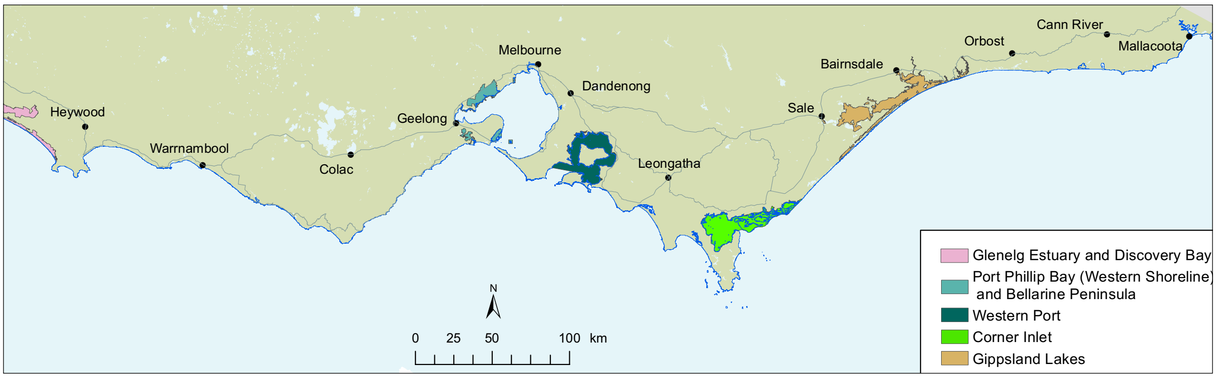
Figure 4.8 Victoria's three marine and coastal biosphere reserves



Ramsar sites

The 1971 Convention on Wetlands of International Importance especially as waterfowl habitat was signed in Ramsar, Iran. Known as the 'Ramsar Convention', this agreement aims to halt the worldwide loss of wetlands and conserve those that remain through wise use and management. There are 12 Ramsar sites in Victoria, five of which are coastal: Gippsland Lakes, Corner Inlet, Western Port, Port Phillip Bay (Western Shoreline) and Bellarine Peninsula, and Glenelg Estuary and Discovery Bay (see figure 4.9). The Commonwealth EPBC Act establishes a framework for managing Ramsar-listed wetlands through the Australian Ramsar Management Principles. Strategic management plans have been prepared for all five Victorian coastal Ramsar sites.

Figure 4.9 Victoria's five coastal Ramsar sites



The East Asian-Australasian Flyway Partnership is a regional Ramsar initiative. Launched in 2006, the partnership aims to recognise and conserve migratory shorebirds that travel south in August to November from Russia and Alaska through eastern and southern Asia to Australia and New Zealand and then return northward between March and May. There are 118 sites listed across Australia, ten of which occur in coastal Victoria: Gippsland Lakes, Corner Inlet, Shallow Inlet, Anderson Inlet, Western Port, Edithvale-Seaford, Port Phillip Bay (Western shoreline) and Bellarine Peninsula, Port Fairy to Warrnambool, and Discovery Bay.

Bilateral migratory bird agreements

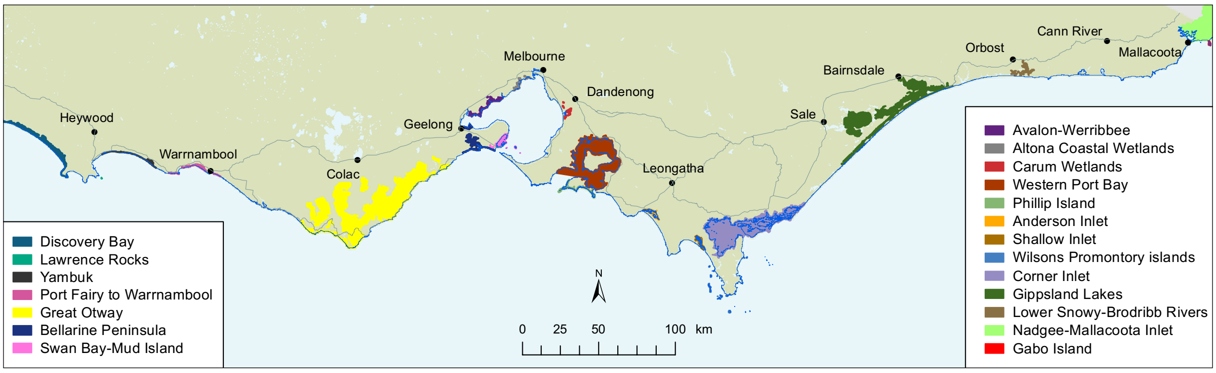
Australia has bilateral agreements to conserve and protect migratory birds with Japan (JAMBA 1974), China (CAMBA 1986) and the Republic of Korea (ROKAMBA 2007). Birds listed on the annexes to these agreements must be placed on the migratory species list under the EPBC Act.

Australia has additional international commitments to protect migratory birds under the Convention on the Conservation of Migratory Species of Wild Animals (known as the 'Bonn Convention'). Australia became a party to the convention in September 1991.

Key biodiversity areas (KBAs)

Birdlife International has identified 20 sites along the Victorian coast that are globally significant for migratory shorebirds (figure 4.10). Formerly known as Important Bird and Biodiversity Areas (IBAs), these sites were reassessed and named Key Biodiversity Areas (KBAs). Each KBA needs to either have more than half of one per cent of an endangered species population, or at least one per cent of the total population of a species at a critical stage of their life cycle e.g. migration stopover.

Figure 4.10 Key Biodiversity Areas along Victoria's coast, as identified by Birdlife International



4.4 Victorian Marine Assets database

To help inform natural resource management, DELWP developed a system for identification of marine assets. Marine assets are defined in this context as tangible biophysical elements that are valuable for their ecosystem services.[5]

Criteria considered in identifying marine assets included:

- state or bioregional importance of the asset for its biodiversity, endemism, ecological role or function
- support and contribution of the asset to the fitness of a species that is of international, state or bioregional importance for biodiversity
- performs a key ecological role or function
- representativeness of the asset in terms of marine habitats, and the naturalness and resilience of the asset.

Approximately 140 marine assets were identified, many of which were nested within larger assets. A description of the largest and most significant assets, as assessed by scientific experts, can be found in appendix 2. Each of the marine assets and threats to them are include on the relevant pages of the accompanying assessment atlas.

4.5 References

1. Edmunds, M. and Flynn, A. (2018) *Victorian marine biogeographical settings*. Australian Marine Ecology Report No. 559. Report to Department of Environment, Land, Water and Planning, Melbourne.
2. Department of Environment and Primary Industries (2013) *Improving our waterways - Victorian waterway management strategy.* Department of Environment and Primary Industries, Melbourne. https://www.water.vic.gov.au/__data/assets/pdf_file/0022/52546/VWMS_Part1.pdf
3. Thom, B. (2015) *Coastal compartments project summary for policy makers.* Report by Geoscience Australia for the Department of Environment, Canberra. http://www.environment.gov.au/system/files/resources/4f288459-423f-43bb-8c20-87f91adc3e8e/files/coastal-compartments-project.pdf
4. Environment Conservation Council (2000) *Marine, coastal and estuarine investigation.* Final Report. Environment Conservation Council, Melbourne.
6. Kent, J. and Jenkins, G.P. (2012) *Ecological descriptions of the significant marine environmental assets of Victoria: Interim Report.* Fisheries Victoria Technical Report No. 177. Department of Primary Industries, Queenscliff.

5 Climate and Oceanography

This chapter is based on a report commissioned by VEAC prepared by Water Technology Pty Ltd summarising atmospheric and ocean systems of Victoria's marine waters and the potential changes associated with climate change. Decision making in the marine and coastal environment requires information based on science and evidence. Key drivers of change in the coastal zone are climate acting on oceanography and in turn geomorphology. This chapter presents a summary of the current understanding of these drivers.

KEY POINTS AT A GLANCE

- Five main broad-scale climate processes influence Victoria's climate: the El Niño-Southern Oscillation, the Indian Ocean Dipole, East Coast (cut-off) Lows, the Southern Annular Mode and the sub-tropical ridge.
- Climate change is affecting key climate variables, including reductions in winter and spring rainfall combined with an increase in downpour intensity and frequency, warmer temperatures with an increase in mean air temperature of up to 3.2°C by 2070, and increased wind speeds of up to 19 per cent by 2100.
- Oceanographic conditions will be altered by climate change: mean sea level is predicted to rise between 0.4 to 1.0 metres by 2100; frequency and intensity of storms and magnitude of storm surges will increase; sea surface temperatures will increase between 1.9 and 3.8°C by 2090; and salinity will increase by up to 0.35 ppt by 2090.
- Ocean acidification occurs as increasing amounts of atmospheric carbon dioxide are absorbed by seawater, with ocean pH predicted to decrease by 0.07 to 0.3 by 2090.
- Increasing sea levels and storm intensities will intensify coastal hazards such as coastal flooding, storm erosion and long-term shoreline recession. Sea level rise will lead to more frequent inundation of low-lying areas, loss of coastal habitat, cliff, beach and foreshore erosion.
- The most extensive area vulnerable to erosion by 2040 is the Gippsland coast. Other coasts at risk include west of Portland, beaches in Port Phillip Bay between Mordialloc and Frankston, and the coast between Cape Paterson and Cape Liptrap in South Gippsland.
- Coastal areas most vulnerable to inundation by 2040 with a 20-centimetre sea level rise include areas around Portland, Port Fairy and Barwon Heads in the west; Queenscliff, Point Wilson, Point Cook to St Kilda and Mordialloc to Seaford around Port Phillip Bay; Tooradin and Lang Lang in Western Port; and Seaspray on Ninety Mile Beach, Gippsland.
- Sea surface temperatures have already increased by 0.1 to 0.2°C per decade since 1970. This has been linked to the East Australian Current increasing in strength and extending its path further southward.
- Victoria's coastal geomorphological features evolved through interactions between geological factors and coastal processes (e.g. ocean swell, storm surge, wind, current, changing sea levels and tidal activity). The region is broadly influenced by Tasmania and the relatively shallow waters of Bass Strait.
- The Victorian Coastal Monitoring Program aims to provide communities with information on coastal condition, change, hazards, and the expected longer-term impacts associated with climate change that will support decision making and adaptation planning.

5.1 Broad-scale climate influences

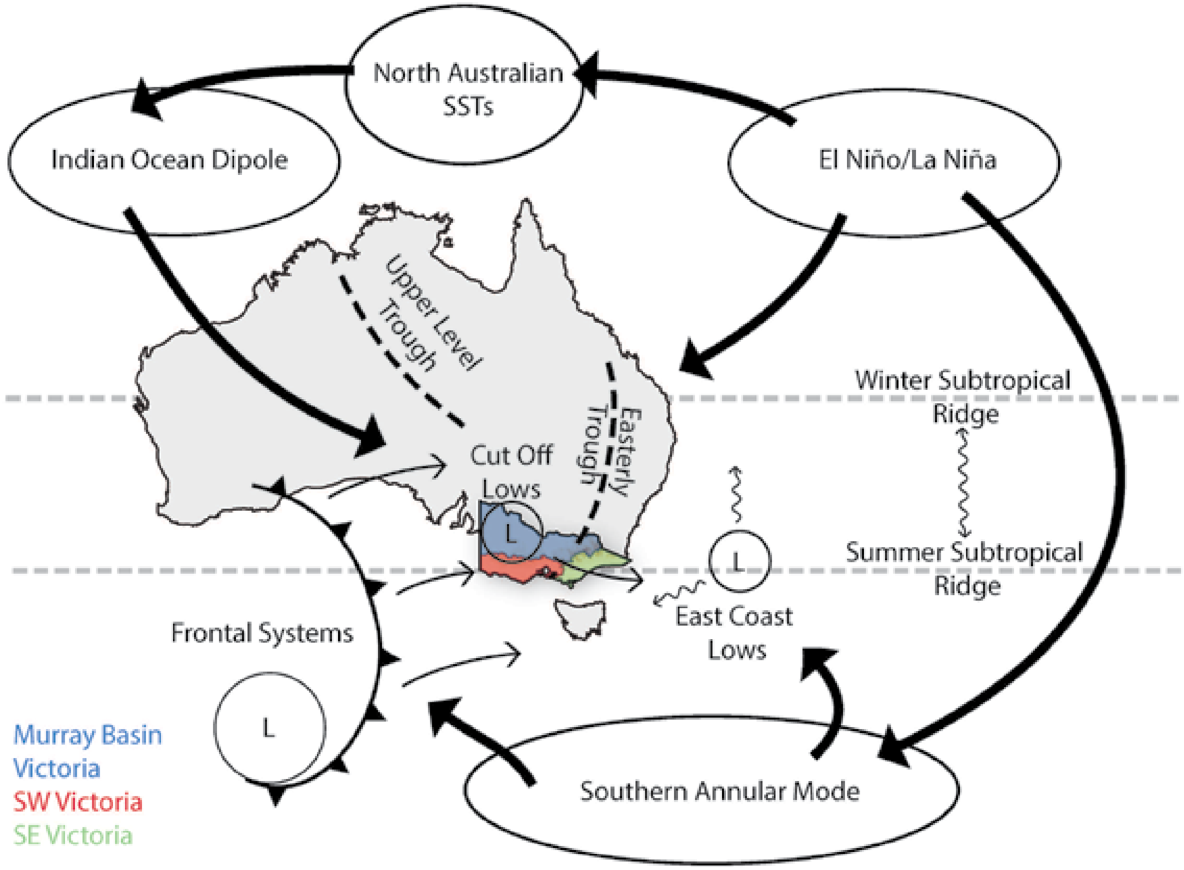
There are five main global climate processes that influence Victoria's climate: the El Niño-Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), East Coast (cut-off) Lows (ECL), the Southern Annular Mode (SAM) and the sub-tropical ridge.[1,2] These climate drivers vary over the months and years to influence seasonal and inter-annual rainfall, air temperature and wind, and correspondingly oceanographic conditions and coastal processes. They are described in more detail in table 5.1 and shown schematically in figure 5.1.

Table 5.1 Climate processes influencing Victoria's climate[2]

Process	Influence	Impact on Victorian coast
El Niño - Southern Oscillation (ENSO)	• Warming of the central and eastern tropical Pacific Ocean, leading to changing patterns of winds, atmospheric pressure and rainfall • Three phases of ENSO are: El Nino, La Nina and neutral	• Important for Victoria, particularly in winter and spring • La Nina brings strong trade winds leading to higher rainfall • El Nino brings drier winter and spring periods
Indian Ocean Dipole (IOD)	• Difference in sea temperature between western and eastern Indian Ocean leads to changes in wind, air temperature and rainfall patterns • Changes between positive, negative and neutral phases • Can be related to ENSO events	• When it connects with cold fronts IOD can produce higher rainfall • Positive and negative IOD events linked with drought in Australia • Winter and spring are more heavily influenced • El Nino combined with positive IOD results in dry periods; and vice versa
Southern Annular Mode (SAM)	• The north-south movement of westerly winds (low pressure system) that circulate around Antarctica in the Southern Ocean • Position of SAM influences strength and position of frontal activity	• SAM has the greatest influence in southern Victoria during winter • Negative SAM = expanding fronts, increases likelihood of winter rainfall in southern Victoria • Positive SAM = contracting fronts decreased winter rainfall in southern Victoria
Sub-tropical Ridge	• A belt of high pressure that encircles the southern hemisphere in the middle latitudes	• During cooler months the ridge moves northwards towards the equator bringing more rain-bearing cold fronts to southern Australia and coastal Victoria
East Coast Low (ECL)	• Can occur several times a year on the east coast of Victoria • ECLs can form rapidly overnight and are formed as a sub-tropical depression that intensifies as it propagates rapidly down the east coast of Australia	• Cause heavy and widespread rainfall in the eastern Gippsland region • Strong winds and waves approaching coastline from the southeast • Wind and wave effects can be intensified by the presence of a blocking high

Useful animations developed by Agriculture Victoria 'Climate Dogs' explaining each of these climate processes can be found via the following link: http://agriculture.vic.gov.au/agriculture/weather-and-climate/understanding-weather-and-climate/climatedogs

Figure 5.1 Large-scale climate features of relevance to Victoria's climate. Thick arrows show the influence each climate mode has upon either synoptic weather types affecting Victoria or another climate mode. Thin arrows indicate wind directions associated with certain synoptic weather types (from Hope et al. 2017).[1]



5.2 Climate variables

5.2.1 Wind

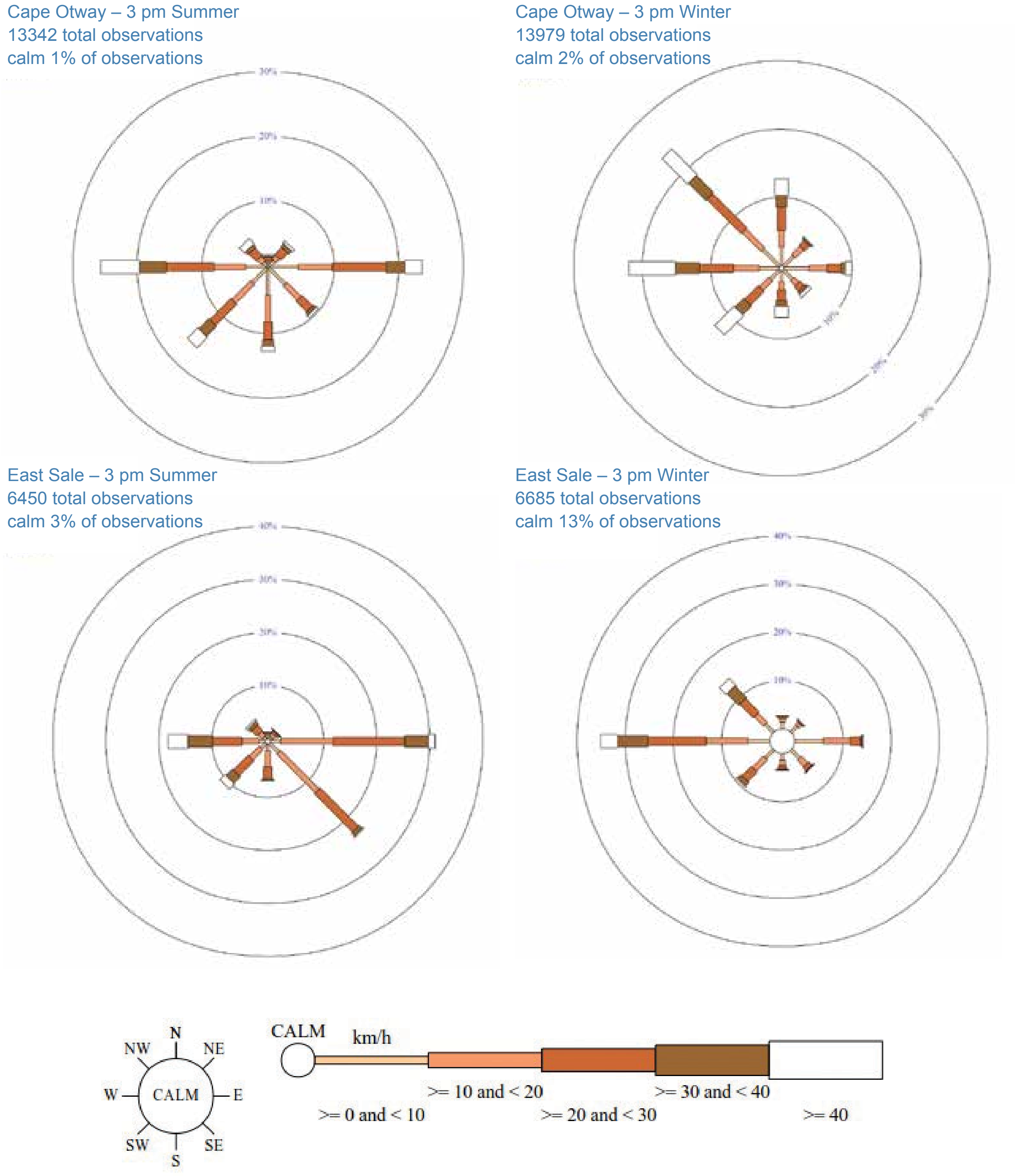
Wind speed and direction along the Victorian coast varies with the seasons. In general, the wind comes more from the northern sector during winter, and the southern sector in summer. The seasonal variations at Cape Otway and East Sale are shown in figure 5.2.

Topography can have a significant effect on local winds along the coast. For example, exposed locations such as Cape Nelson, Cape Otway, Wilsons Promontory and Gabo Island experience stronger wind speeds and greater occurrences of extreme wind speeds than areas such as Geelong or Melbourne.

5.2.2 Air temperature

Historically, the hottest month along the Victorian coast is February with mean monthly temperatures typically ranging from 18 to 20°C, whilst the coolest month is July with mean monthly temperatures ranging from 10 to 11°C. Temperatures vary dependent upon location along the coast, which is largely attributed to the degree of protection from oncoming winds. For example, temperatures at Port Phillip Bay and Western Port are higher than the more exposed locations such as Wilsons Promontory. Temperatures are also warmer along the Gippsland coast than the remainder of the state due to the presence of the Great Dividing Range which blocks the warm, moist air resulting in a warming and drying on the downwind side. Also contributing to the higher temperature is the East Australian Current which brings warmer water into this area.

Figure 5.2 Wind rose showing summer and winter wind patterns at Cape Otway (top) & East Sale (bottom) (BOM 2012)[3]



How to read a wind rose

The percentage of calm conditions is represented by the size of the centre circle; the bigger the circle, the higher is the frequency of calm conditions.

Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Eight directions are used.

The branches are divided into segments of different thickness and colour, which represent wind speed ranges from that direction. Speed ranges of 10 km/h are used in these wind roses. The length of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction.

5.2.3 Rainfall

Average annual rainfall varies widely from the east to west of Victoria. Rainfall is higher along the more mountainous Otway, South Gippsland and far-East Gippsland coasts. For example, average annual rainfall in Melbourne is about 650 millimetres, 520 millimetres in Geelong, 840 millimetres at Portland and 940 millimetres at Mallacoota. In general, rainfall is higher during the winter months, and lower during the summer months.[4]

Interannual variability in rainfall is strongly linked to the climate influences discussed in section 5.1. The three key modes that affect rainfall in Victoria are the El Niño–Southern Oscillation, the Indian Ocean Dipole and Southern Annular Mode.

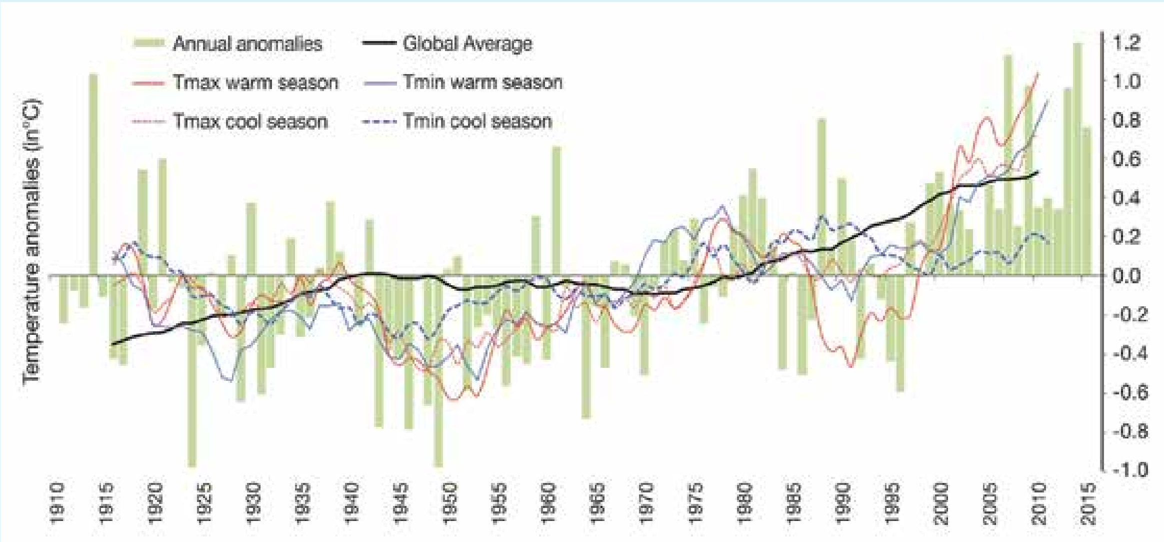
Responses to climate change

The Victorian marine and coastal environment is expected to experience the following changes in key climate variables due to increases in atmospheric greenhouse gases:

- Wind speeds to increase by up to 19 per cent by 2100[5]
- Warmer temperatures with an increase in mean air temperature of up to 3.2°C by 2070, more hot days and warm spells[6]
- Changes to wind direaction[6]
- Reductions in rainfall in winter and spring, combined with an increase in downpour intensity and frequency[6]

Figure 5.3 shows the pattern of the increase in mean air temperature. Whilst there is intra- and annual variation, the overall trend is an increase.

Figure 5.3 Annual Victorian mean air temperature anomalies (in °C) (relative to the 1911 to 2015 average). The black line shows an 11-year running mean of global average temperature anomalies (relative to the 1961–1990 average) (Source: Hope et al. 2017)[1]

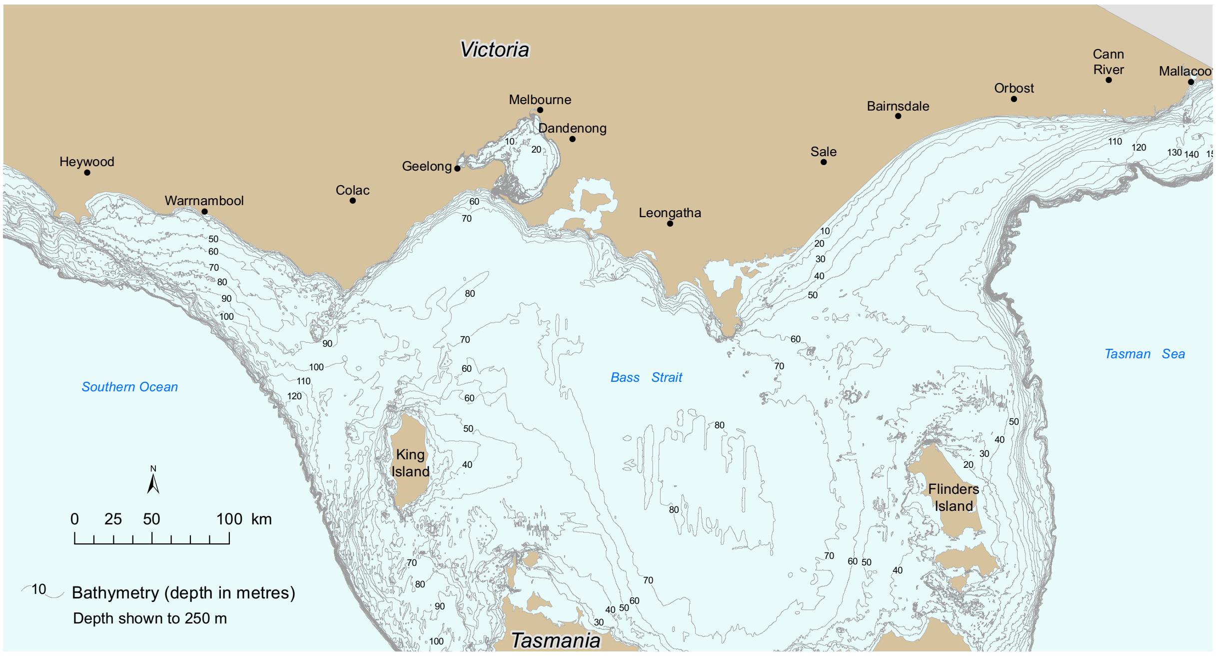


5.3 Ocean systems

5.3.1 Bathymetry

The bathymetry offshore from the Victorian coastline is presented in figure 5.4. The central part of the Victorian coast forms the northern boundary of Bass Strait. Here the water depths typically range from 50 to 80 metres. To the east and west, the continental shelf is much narrower and extends only 50 to 100 kilometres offshore.

Figure 5.4 Generalised bathymetry offshore from the Victorian coast



5.3.2 Waves

Wave heights and directions are strongly dependent upon the wind speed and direction, and the 'fetch' (the distance over which the wind blows). Waves that are still under the influence of the wind that is generating them are generally termed wind-waves, while waves that are away from their generation area are termed swell. At the latitude of Bass Strait (approximately 40° South), the west to east passage of successive low-pressure systems generate the prevailing westerly winds – the so-called 'Roaring Forties'. With long fetches to the west, these generate high west and southwest wind-waves and swells that dominate the wave conditions along much of the Victorian coast.

The median significant wave heights along the Victorian coast (where the significant wave height is the average of the highest one-third of waves) are shown in figure 5.5.[7] From a wave perspective, the coast can be divided into three main regions as follows:

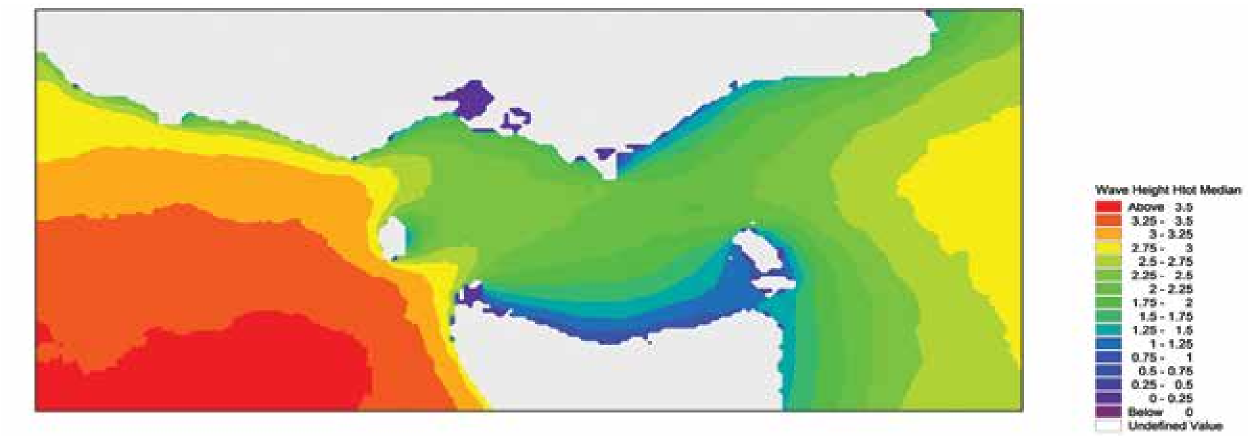
- **West:** west of Cape Otway the wave climate is dominated by high west to southwest wind-waves and swells. Median significant wave heights along this section of coast are typically 2.5 to 2.75 metres.
- **Central:** between Cape Otway and Wilsons Promontory. Cape Otway provides some protection from the prevailing westerly waves, and locally generated wind-waves contribute to the overall wave climate. Median significant wave heights are typically in the range of 1.5 to 2.0 metres, with the higher waves occurring along the more exposed coast between Cape Schanck and Wilson Promontory.

  Port Phillip Bay and Western Port are located within the Central region. The wave climate within these bays is dominated by locally generated wind-waves. Median wave heights are around 0.5 metres from the southwest to west through to the northwest directions.

- **Eastern:** east of Wilsons Promontory the wave climate comprises locally generated south to southwest wind-waves, and east to southeast wind-waves and swells propagating in from the Tasman Sea. Median significant wave heights are typically in the range of 1.25 to 1.5 metres, increasing to around 2.0 metres in the east. The highest waves are generated by extreme east to southeast winds associated with East Coast Lows.

Whilst median wave conditions drive the day to day environment, waves observed during storm events are key for cross-shore sediment transport (the main cause of discrete erosion events) as well for the design of coastal protection structures.

Figure 5.5 Median significant wave heights along the Victorian coast (Source: Water Technology 2004)[7]



5.3.3 Water levels

Tides

The tide along the Victorian coastline is predominantly diurnal (one tide per day) in the west, transitioning to semi-diurnal (two tides per day) along the central and eastern parts of the coast but with a diurnal inequality (where one tide is bigger than the other). Representative tidal conditions are given in table 5.2, which also provides an indication of the variability along the coast. The table shows indicative tidal ranges in the order of 1.0 metre or less in the west (Portland), increasing to 1.5 to 2.0 metres in western Bass Strait (Apollo Bay and Lorne), further increasing to 2.0 to 2.5 metres in eastern Bass Strait (Waratah Bay) and then decreasing to 1.0 to 1.5 metres along the east coast (Point Hicks). The tide in Port Phillip Bay is significantly attenuated by its narrow entrance to have spring tidal ranges of around 0.8 metres (Williamstown), while the tide in Western Port becomes amplified to have spring tidal ranges typically of 2.0 to 3.0 metres (Stony Point).

Table 5.2 Tidal characteristics at tide gauges across Victoria. Heights are in metres relative to mean sea level (Source: McInnes et al. 2009[5])

Gauge name	Latitude °S	Longitude °E	Highest astronomical tide	Mean high water spring tide	Mean high water neap tide
Portland*	38.35	141.62	0.69	0.44	0.18
Apollo Bay*	38.75	143.67	1.09	0.83	0.13
Lorne	38.53	143.99	1.27	0.81	0.42
Williamstown*	37.87	144.92	0.52	0.42	0.12
Stony Point	38.37	145.22	1.56	1.11	0.67
Waratah Bay	38.85	146.04	1.49	1.11	0.74
Point Hicks	37.81	149.27	0.83	0.48	0.28

*At Portland, Apollo Bay and Williamstown the higher and lower of the two daily tides is used to calculate the mean spring and neap tide levels.

Storm tides

Storm surges are generated by the combined effect of wind set-up and low atmospheric pressure (termed the 'inverse barometric effect') that occurs during storms. Storm tides are the combination of the astronomical tide and storm surges. Storm tide elevations for a 100-year average recurrence interval (ARI) have been predicted for the Victorian coastline for present day and 2100 predicted conditions.[5] These show the highest storm tide elevations are expected to occur in Western Port (in excess of 2.0 metre above mean sea level) and eastern Bass Strait (up to 2.0 metre above mean sea level).

Storm tide at the entrance to Mordialloc Creek, 24 June 2014. Photo: Water Technology

Sea level rise

Sea level is predicted to rise with the increased temperatures associated with climate change. The increase will be due to a combination of the thermal expansion of the upper layers of the ocean and an increase in ocean volume due to partial melting of glaciers and of the Greenland and Antarctic ice shelfs. Global projections indicate sea level rise by 2100 could range from 0.4 to 1.0 metres. The estimated increase in mean sea level along the Victorian coast by 2100 is 0.82 metres.[5]

5.3.4 Currents

Currents along the Victorian coast can be divided into three main categories: tidal currents, net through flows, and interactions with larger-scale oceanic circulations. These are shown schematically in figure 5.6.

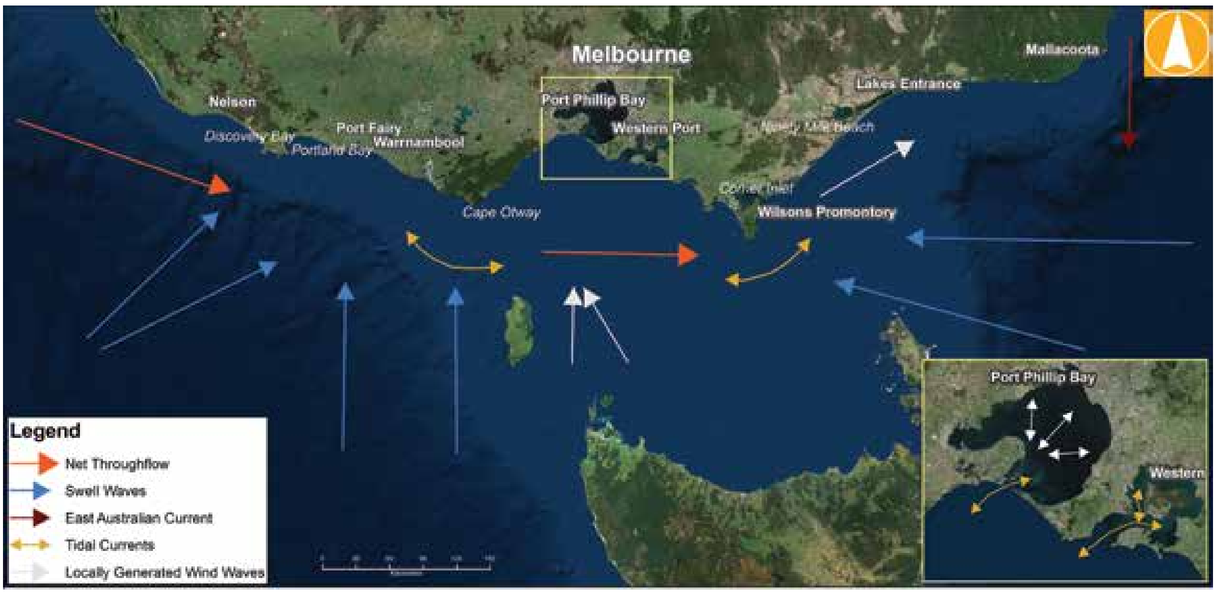
Tidal currents

Tidal currents propagate into Bass Strait from both the west and the east. This results in the strongest tidal currents along the open coast occurring at Cape Otway and east of Wilsons Promontory. The strongest tidal currents along the entire coast are, however, associated with the entrances and main channel systems of large tidal embayments, such as Port Phillip Bay, Western Port, and Cornet Inlet. Strong tidal currents also occur at Lakes Entrance.

Net flows

Net flows through Bass Strait are strongly linked with wind speed and direction. Although net flows can occur in either direction the greater proportion of westerly winds in the region result in a greater proportion of west to east net flows. Based on measurements carried out in autumn and winter, researchers found that much of the west to east net flow (referred to as 'flux') occurred in surges lasting two to three days following the passage of a cold front through the region.[8]

Figure 5.6 Indicative wave and current characteristics



5.3.5 Sea surface temperature, pH and salinity

Sea surface temperature varies from the west to east along the coast by approximately 3 to 4°C. The seawater along the western and central sections of the Victorian coast tends to be relatively cold and more saline. Temperatures of around 13°C in winter may increase to around 17 to 18°C in summer. However, temperatures can vary locally from beach to beach depending on the relative position of the beach in proximity to the movement of water masses entering Bass Strait from the colder Southern Ocean.[9]

In bays with limited connection to oceans (such as Port Phillip Bay), evaporative cooling processes can result in water temperatures being lower in winter in comparison to the ocean outside the bay. Conversely, the shallower water in bays retains more radiant heat during summer, which results in bay waters being warmer than the ocean waters.

The eastern Victorian coast is affected by the East Australia Current. This is a warm, relatively saline current that flows down the east coast of Australia. As it continues southwards from Gabo Island, it can flow west and south-westward to form a front of warm surface water off the Gippsland coast.

During winter, net east-going flows can form a down-welling or ‘cascade’ of colder, and denser Bass Strait water down the eastern edge of the continental shelf.[10] During summer, upwelling of cold deep water can occur west of Portland. This is due to the presence of high-pressure systems and is known as the Bonney Upwelling.[11]

The typical pH of marine waters in Victoria is close to 8.2, whereas most freshwaters are between 6.5 and 8.0. The pH of marine waters is influenced by dissolved carbon dioxide concentrations, alkalinity, hydrogen ion concentrations and temperature (see www.ozcoasts.org.au).

Responses to climate change

The main effects of climate change on the oceanographic conditions along the Victorian coast are expected to include:

- an increase in mean sea level in the range of 0.4 to 1.0 metres by 2100[12]
- increases in the frequency and intensity of storms and their associated storm surges[11]
- increases in sea surface temperatures in the range of 1.9 to 3.8°C by the year 2090[13]
- decreases in pH between -0.07 to -0.3 by 2090.[6] Oceans absorb carbon dioxide from the atmosphere. As atmospheric carbon dioxide increases, ocean pH will drop in a process known as ocean acidification.
- oceans have absorbed 30 per cent of the carbon dioxide emitted in the last 200 years; correspondingly ocean pH has already fallen by 0.1 units, which represents a 30 per cent increase in the concentration of hydrogen ions in sea water.
- increases in salinity along the east coast of up to 0.35 ppt by the year 2090.[14] Salinity increases are expected to be lower along the west coast, with some areas predicted to decrease slightly.
- sea surface temperatures offshore from Victoria have increased by 0.1 to 0.2°C per decade since 1970. Additionally, the south-east region of Australia is warming at a rate faster than the global average.[15] This has been linked to an increase in strength of the East Australian Current which is forecast to increase its core area by 12 per cent by 2060 and to extend its path further southward.

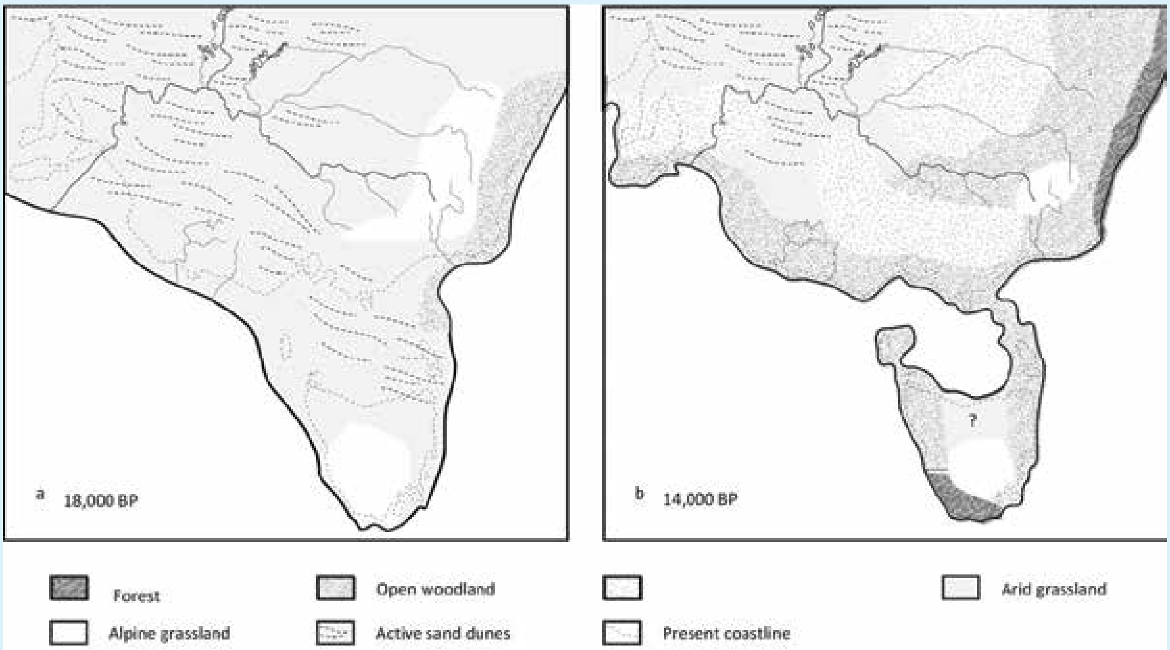
Bass Strait land bridge

During the last ice age, which began about 30,000 years ago, sea levels were approximately 120 metres lower than present-day levels. What we know today as Victoria was connected via a land bridge to Tasmania. As the ice melted around 14,000 years ago, sea levels rose. The coastline receded, and Tasmania became separated. Current sea levels were reached around 6,000 years ago.17

Anthropologists Lorimer Fison and Alfred Howitt in their 1880 book Kamilaroi and Kurnai recount a story from the Gunaikurnai people of Gippsland:

> *long ago there was land to the south of Gippsland where there is now sea, and that at that time some children of the Kurnai, who inhabited the land, in playing about found a turndun [musical instrument used in ceremonies traditionally only for men's use so its discovery by children and women was an invitation to disaster] which they took home to the camp and showed to the women. 'Immediately', it is said, 'the earth crumbled away, and it was all water, and the Kurnai were drowned.*

Nunn and Reid (2015) present 21 stories of inundation by rising sea levels from around Australia that were told to early Australian anthropologists by Aboriginal groups.[18] These stories consistently corroborate postglacial sea level rise and, together with archaeological evidence, show that Aboriginal people both occupied the land and were adapting to the effects of sea level rise by moving with the changing coastline.



Coastline and vegetation types of south-eastern Australia at (a) 18,000 BP and (b) 14,000 BP (from Bird and Frankel 1998, reproduced in ACHM 2010)[19,20]

5.4 Geology and geomorphology

Three distinct geographic zones are used to describe the geology and geomorphology of the Victorian coast:

- *Western* - South Australian border at Discovery Bay to Cape Otway
- *Central* - Cape Otway to the point of Wilsons Promontory
- *Eastern* - Wilsons Promontory to Gabo Island near the New South Wales border

In 2012 VEAC commissioned a study to document sites of geological and geomorphological significance along Victoria's coast.[16] The study included discussion of Victoria's coastal geology and geomorphology, focusing on the dominating influences on coastal landscape processes and features and a summary of human factors that can negatively impact sites of significance.

5.4.1 Geology

Victoria's coastal geology is a broad representation of the rest of the state, hosting rocks from Cambrian (580 million years ago) to the earlier Quaternary dune systems and sedimentary lagoons (10,000 years ago). The Victorian coastline has been considerably influenced by tectonic activity and earth movements as well as sea level changes, faulting, uplift and subsidence. Landscape features associated with tectonic activity include the formation of the Otway Ranges, the Mornington Peninsula, and the South Gippsland Ranges. Subsidence formed the Western District, the Port Phillip Bay and Western Port sunklands and the Corner Inlet depression. Further description of the geology is provided below for the three geographical zones. Figure 5.7 presents the geology type along the coast.

Western

In the west, unconsolidated Quaternary dunes overlay Pleistocene calcarenite from Discovery Bay to Bridgewater promontory. The promontory itself consists of ancient volcanics namely basalt and tuff capped by calcarenite that form vertical cliffs. Much of this area is covered by limestone and karstic processes forming numerous caves. The cliffs are topped by Quaternary dune systems formed by wind and wave action.

Central

This region comprises pre-Cainozoic rocks, in fault-bounded structural blocks expressed as the Otway Ranges and other elevated areas (including Mornington Peninsula and Wilsons Promontory). These features overlie limestones, basalts and unconsolidated sand dunes. Port Phillip Bay and Western Port represent the Sunklands: fault-bounded blocks displaying relative subsidence partially inundated by the present-day sea level.

Eastern

The Eastern Plains are underlain by sediments and pre-Cainozoic rocks and are dominated by fluvial sedimentary deposits developed on a marine plain. The sedimentary deposits are made up of siltstone, silty shale and felspathic sandstone. Outcropping of these rocks is restricted to East Gippsland.

5.4.2 Geomorphology

Victoria's coastal landforms include a variety of geomorphological features that evolved as a result of interactions between geological factors and coastal processes such as ocean swell, storm surge, wind, current, changing sea levels and tidal activity. Broadly, Victoria's coastal region is influenced by the presence of Tasmania, and the relatively shallow waters of Bass Strait that drives the degree and direction of wave and storms.[21]

Western

This region is characterised by high-energy conditions subject to consistent southwest wind and wave swell activity. It includes large, gently-curved embayments with a gentle seawards slope that are areas of tectonic subsidence. These feature large continuous sandy beaches (e.g. Discovery Bay) terminating in rocky erosion resistant headlands (e.g. Cape Bridgewater). Protected regions such as Portland Harbour and Port Fairy Bay developed with the aid of natural shelters (e.g. Bridgewater Promontory, Griffiths Island) from the prevailing southwest swells.

Much of this region is also marked by limestone and karstic features which form numerous cave systems. Other dominant landform features include 60-metre high cliff faces and offshore stacks (e.g. Twelve Apostles).

Figure 5.7 Generalised geology of Victoria's coastline (Source: Water Technology)

Central

The Otway coastline experiences significant southwesterly storm and wave action, creating spectacular cliffs and shore platforms. Coastal erosion is active, with softer lithologies (mudstones) displaying greater rates of erosion and thus coastal retreat. Comparatively the lower lying areas such as Port Phillip Bay and Western Port are protected and therefore influenced by locally generated waves, swell and storms which form a complex display of either broad, well-sorted sandy beaches or narrow, poorly sorted, shelly, sandy beaches, low cliffs and sediment accumulation.

Eastern

This region is characterised by low cliffs, beaches and lagoons. This relatively low-lying coastal plain is fairly broad in the western part, allowing for the development of large lakes and tidal inlets (Anderson Inlet, Corner Inlet, Nooramunga, Gippsland Lakes). In the east, the high country is closer to the coast, so the coastal plain is much narrower, and the pre-Cainozoic rocks extend out in places to form cliffed headlands.

In general, much of the eastern zone's coastline is low lying and somewhat unprotected from the south-easterly wind and wave action which cause long-term erosion.

5.4.3 Coastal stability

Processes affecting the coastal zone are multiple and complex: storm surge, tidal movement, shoreline stability, stormwater drainage and the interactions of surface and groundwater all contribute in differing degrees. Increasing sea levels and storm intensities will intensify coastal hazards such as coastal inundation (coastal flooding), storm erosion and long-term shoreline recession.[12]

Sea level rise will lead to more frequent inundation of low-lying areas, loss of coastal habitat, and cliff, beach and foreshore erosion. The extent of saltmarsh and mangrove habitat may also change. Due to changes in wave and wind direction, there may be a realignment of the coastline in some areas.[6] The predictions indicate the intensity of storms is likely to increase, leading to greater erosion. Less is known about the likely changes to wind direction and corresponding wave direction. However, if changes do occur this will lead to coastal realignment.

A statewide assessment of the vulnerability of the coast mapped the potential impact (figure 5.8) and corresponding vulnerability (figure 5.9) of the coastline due to climate change.[22] The most extensive area vulnerable to erosion by 2040 is along the Gippsland coast. Also at risk is the coastline west of Portland, beaches in Port Phillip Bay between Mordialloc and Frankston, and the coast between Cape Paterson and Cape Liptrap in South Gippsland, including beaches near Inverloch.

Coastal areas most vulnerable to inundation by 2040 with a 20-centimetre sea level rise (from a baseline set in 2009) include areas around Portland, Port Fairy and Barwon Heads in the west; Queenscliff, Point Wilson, Point Cook to St Kilda and Mordialloc to Seaford around Port Phillip Bay; Tooradin and Lang Lang in Western Port; and Seaspray on the Ninety Mile Beach, Gippsland. Figure 5.10 presents an example output adapted from the 2017 modelling.[22]

In response to the threat from coastal erosion and inundation, DELWP are coordinating the Victorian Coastal Monitoring Program.[23] The program aims to provide communities with information on coastal condition, change, hazards, and the expected longer-term impacts associated with climate change that will support decision making and adaptation planning. Partnerships with community groups (citizen science) and institutions co-investing in coastal monitoring projects at both regional and local scales is central to the program.

Figure 5.8 Predicted coastal erosion vulnerability along Victoria's coastline (adapted from Spatial Vision 2017)[22]

Figure 5.9 Predicted coastal erosion impact along Victoria's coastline (adapted from Spatial Vision 2017)[22]

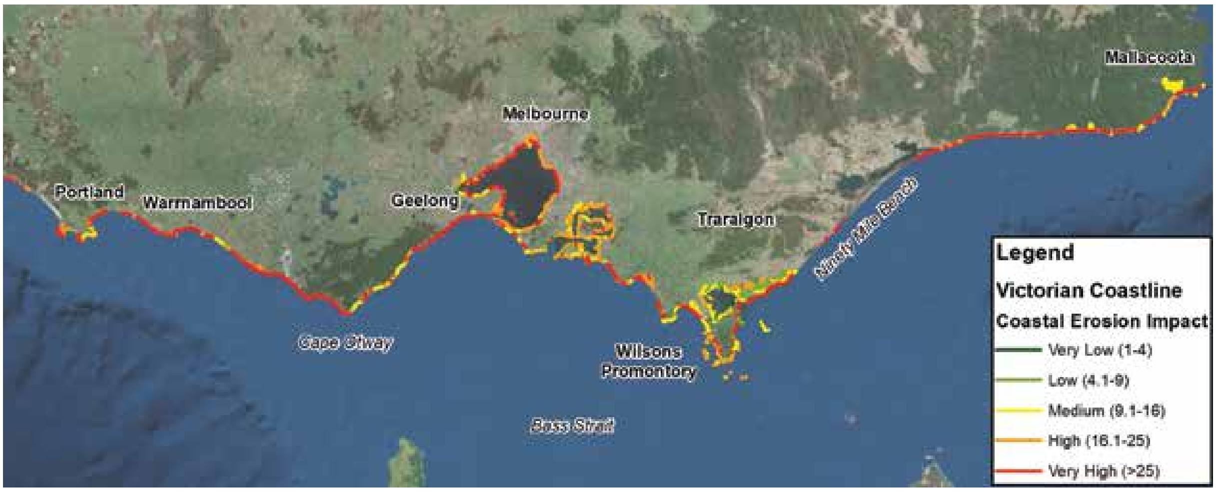
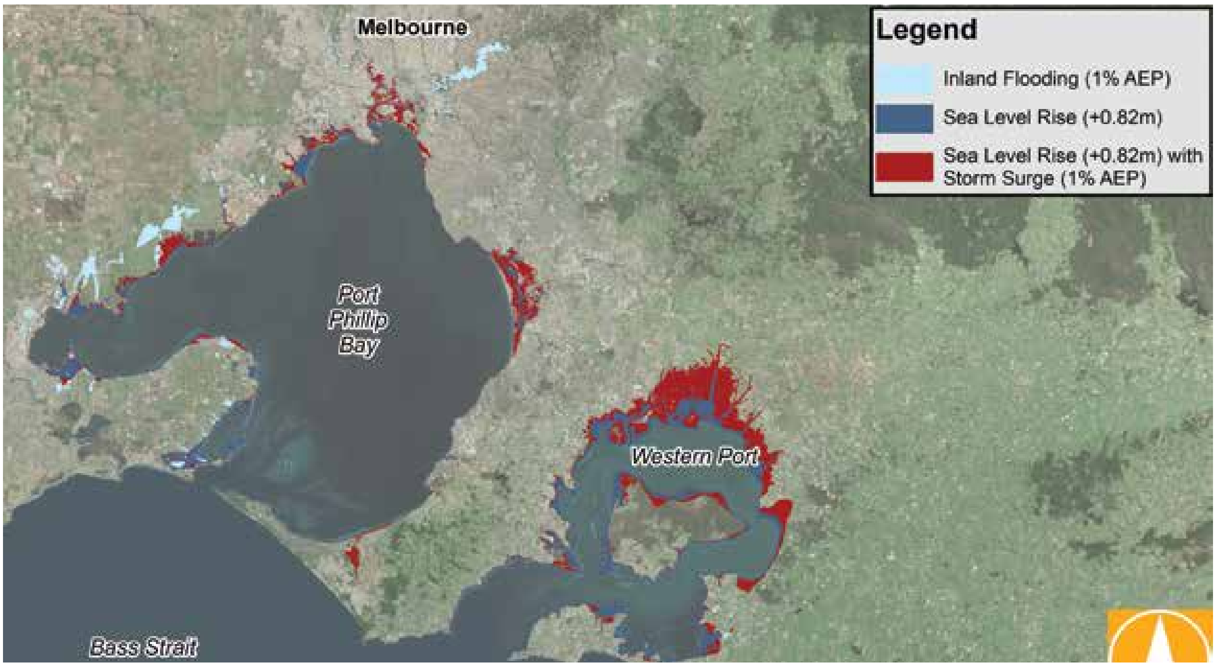


Figure 5.10 Predicted extent of inundation within Port Phillip Bay and Western Port under sea level rise (adapted from Spatial Vision 2017)[22]



5.5 References

1. Hope, P., Timbal, B., Hendon, H., Ekström, M. and Potter, N. (2017) *A synthesis of findings from the Victorian Climate Initiative (VicCI).* Bureau of Meteorology, Australia. https://www.water.vic.gov.au/__data/assets/pdf_file/0030/76197/VicCI-25-07-17-MR.pdf
2. Bureau of Meteorology (2010) *Australian climate influences.* Bureau of Meteorology. Commonwealth of Australia, Canberra. http://www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.shtml
3. Bureau of Meteorology (2012) *The wind across Australia.* Bureau of Meteorology. Commonwealth of Australia, Canberra. http://www.bom.gov.au/climate/averages/wind/IDCJCM0021_wind_roses.shtml
4. Bureau of Meteorology (2016) *Average annual, seasonal and monthly rainfall.* Bureau of Meteorology. Commonwealth of Australia, Canberra. http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp?period=an&area=vc#maps
5. McInnes, K., Macadam, I. and O'Grady, J. (2009) *The effect of climate change on extreme sea levels along Victoria's coast.* Report for the Department of Sustainability and Environment. Marine and Atmospheric Research. CSIRO, Melbourne.
6. Holper, P., Torok, S. and Pearce, K. (2018) *Victoria's coast and marine environments under projected climate change: Impacts, research gaps and priorities.* Victorian Coastal Council, East Melbourne. https://www.coastsandmarine.vic.gov.au/home/victorian-coastal-council/publications-and-resources
7. Water Technology (2004) *Wave and tidal power assessment for the Victorian coastline.* Report No J121/R01. Report prepared for the Victorian Sustainable Energy Authority.
8. Baines, P.G., Hubbert, G. and Power, S. (1991) Fluid transport through Bass Strait. *Continental Shelf Research* 11: 269-293.
9. Bureau of Meteorology (2018) *Sea temperature, currents and salinity: Victoria and Tasmania.* Bureau of Meteorology. Commonwealth of Australia, Canberra. http://www.bom.gov.au/oceanography/forecasts/idyoc300.shtml?region=VICTAS&forecast=SST
10. Tomczak, M. (1985) The Bass Strait water cascade during winter 1981. *Continental Shelf Research* 4: 255-278
11. Department of Sustainability and Environment (2012) *Victorian coastal hazard guide.* Department of Sustainability and Environment, Melbourne. https://www.coastsandmarine.vic.gov.au/__data/assets/pdf_file/0032/405995/Victorian-Coastal-Hazard-Guide.pdf
12. Intergovernmental Panel on Climate Change (2014) Climate Change 2014: *Synthesis Report, Contribution of Working Groups I, II and III to the Fifth assessment report of the Intergovernmental Panel on Climate Change*. Pachauri, R.K. and Meyer, L.A. (eds.). IPCC, Geneva, Switzerland. https://www.ipcc.ch/report/ar5/syr/
13. McInnes, K. (2017) *Coastal climate projections summary.* Presentation to the Victorian Coastal Council.
14. CSIRO (2017) *Marine Explorer.* https://www.climatechangeinaustralia.gov.au/en/climate-projections/coastal-marine/marine-explorer/#
15. Environment and Communications References Committee (2017) *In hot water: the impacts of climate change on marine fisheries and biodiversity.* Report to the Senate, Parliament of Australia, Canberra. https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/ClimateChangeOceans/Report
16. Wakelin-King G, White S (2013) *Sites of geological and geomorphological significance in the VEAC marine investigation area.* Report prepared for Victorian Environmental Assessment Council.
17. Mulvaney, J. and Kamminga, J. (1999) *Prehistory of Australia*. Allen and Unwin, St Leonards..
18. Nunn, P.D. and Reid, N.J. (2015) Aboriginal memories of inundation of the Australian coast dating from more than 7000 years ago, *Australian Geographer* 47: 11-47.
19. Bird, E.C.F. and Frankel, D. (1998) Pleistocene and Early Holocene archaeology in Victoria. A view from Gariwerd. *The Artefact* 21: 48-62.
20. Australian Cultural Heritage Management (ACHM) (2010) *Indigenous cultural heritage and history within the metropolitan Melbourne investigation area.* Australian Cultural Heritage Management. Report to the Victorian Environmental Assessment Council, Melbourne.
21. Bird E.C.F. (1993) *The Coast of Victoria*. Melbourne University Press, Melbourne.
22. Spatial Vision (2017) *Victorian coastal hazard assessment 2017: A second-pass statewide assessment of erosion and inundation hazards resulting from future climate change scenarios to inform the Victorian coastal monitoring program.* Report prepared for Department of Environment, Land, Water and Planning, Melbourne.
23. Department of Environment, Land, Water and Planning (2019) *Victorian coastal monitoring program.* Department of Environment, Land, Water and Planning, Melbourne. https://www.coastsandmarine.vic.gov.au/coastal-programs/victorian-coastal-monitoring-program

6 Biodiversity

This chapter begins by outlining the major habitat types in Victoria's marine environment and describes a new system of characterising marine habitats (Combined Biotope Classification Scheme – CBiCS) which is analogous to terrestrial ecological vegetation classes. The second section details marine species and communities which are subject to conservation listing under state, federal or international acts and agreements. Eleven major groups of marine organisms are then described, and example species within each group are used to demonstrate or highlight relevant ecological processes and potential threats. These examples should assist policy makers and planners to identify other biodiversity values that may be subject to such threatening processes, particularly where species share key ecological attributes that make them more vulnerable to those threats.

KEY POINTS AT A GLANCE

- Broad-scale variables such as tidal level, substrate type, exposure and dominant flora shape the major habitat types in Victorian coastal waters. These are: beaches, intertidal reefs, subtidal reefs, coastal saltmarsh and mangroves, seagrasses, sheltered intertidal flats, subtidal soft substrates, open waters, coastal islands and artificial habitats.
- The southern coast of Australia is the only major south-facing coastline in the southern hemisphere, and it has been isolated for some 65 million years. As a result, many of the species that occur in this region are found nowhere else (endemic).
- Australia's southern coast has high species richness and diversity, determined by contributions from the endemic element, the widely distributed temperate element, the tropical element and a cold-water element, especially from continental upwelling.
- There are large knowledge gaps in relation to marine biodiversity, and the number of conservation-listed species and communities is almost certainly an underestimate of the number of rare or threatened marine species and communities. Nevertheless, 172 species and four communities that occur in Victorian marine waters have already been listed under state or Commonwealth legislation or international agreements.
- Marine species and communities are susceptible to a range of threats – that range from local to global scales. For example, long-lived fish species with limited reproductive potential are most susceptible to overfishing.
- Species or communities with very restricted habitat requirements, small home ranges or limited mobility are likely to be most severely affected by localised disturbances. For example, communities of invertebrates in soft sediments on the sea floor – and the important ecological services they provide – can be threatened by dredging of waterways as this causes changes to wave patterns, sediment deposition and erosion.
- Seagrass beds, estuarine mudflats and mangroves are amongst the most vulnerable habitat types in Victoria as they require sheltered environments that are at increased risk from nutrients and contaminants transported by stormwater. These specialised habitats are critical for all or some life cycle stages of many marine species.
- Some marine species are threatened by land-based processes including loss of habitat, predation and disturbance (e.g. the impacts of humans, dogs and horses on beach-nesting birds).
- Many of the threatening processes affecting marine biodiversity values will be compounded by climate change. For example, changes to continental currents, sea level, pH, water temperature and frequency of storms are likely to affect a wide range of ecological processes with resulting reductions in the availability of some species, areas of suitable habitat and safe breeding/roosting sites. The impacts on biodiversity values cannot be accurately predicted.

The broad categories of threats to marine biodiversity are summarised and examples are provided for each threat in table 6.1; for more detail see the relevant section of this chapter. For discussion of the methodology behind the threat identification process, see chapter 2. Discussion of threats in this chapter are threats to marine biodiversity. The threats that marine biodiversity might pose to other values are discussed in the relevant chapter.

Table 6.1 Summary of threats to marine biodiversity in Victoria

Threat class	Pathway/outcome	Example (with section reference)
Climate change	Altered oceanography	Changes in East Australian Current and Leeuwin Current impact on dispersal for fish relying on pelagic transport of adults and larvae (6.4.7: short-finned eel, western blue groper)
	Sea level rise	Along developed coastlines, saltmarsh cannot retreat in response to pressure from mangrove encroachment, a response to rising sea levels (6.4.4, 6.4.5)
	Ocean warming	Warming oceans have facilitated the southern expansion of northern invertebrate species (6.5.1: black sea urchin)
	Ocean acidification	In more acidic oceans, invertebrates will experience reduced reproduction, immune response and survival, and may struggle to grow shells (6.4.6: abalone, scallops)
	Increased storm frequency	Extreme rainfall events increase sedimentation in bays and estuaries. High levels of suspended sediments increase turbidity and smother important habitats (6.4.3: seagrass beds)
	Increased hot dry weather	Hot dry weather puts beach-nesting birds at risk of overheating on land and from increased fire risk (6.4.9: little penguins)
Physical change	Habitat loss/ degradation	Weed encroachment can lead to beach-nesting birds nesting in sub-optimal habitats that are at greater risk of wave inundation (6.5.2)
	Trampling	Rocky intertidal macroalgae species are particularly vulnerable to trampling at popular beach locations (6.4.2: Neptune's necklace)
	Erosion	Changes to wave regimes and patterns of sediment deposition and erosion threaten seafloor communities and the ecological services they provide (6.4.6: benthic infauna)

Biological change	Pathogens	Abalone viral ganglioneuritis caused up to 90 per cent mortality in impacted populations (6.5.3)
	Introduced species	When native kelp forests are defoliated, faster-growing invasive kelps (e.g. *Undaria pinnatifida*) can take over; once established it is challenging and costly to eradicate (6.5.1)
	Overabundant native species	White sea urchins create barrens in northern parts of Port Phillip Bay (6.5.1)
	Range expanding species	Black sea urchins expanded range from New South Wales now form barrens along Gippsland coast where natural predators are limited (6.5.1)
	Food web disruption/collapse	Ocean acidification will impair species at the bottom of food webs (e.g. calcifying plankton), with impacts on species that feed on them (e.g. fish, invertebrates, marine mammals) (6.4.1)
	Harvesting/bycatch	School shark are vulnerable to overexploitation because they are long-lived and slow to reproduce. They are considered overfished but are still taken as bycatch for gummy shark (6.4.7)
	Behavioural alteration	Hooded plovers are prone to abandon eggs and chicks when disturbed on beaches, particularly by dogs off lead (6.4.10)
	Species loss/ extinction	Rising sea levels threaten saltmarsh that provides important carbon sequestration services (6.4.5)
Catchment processes	Altered hydrological regimes/reduced freshwater flows	Australian Bass require high river flows and cool water temperatures for successful recruitment. Predicted climate change coupled with increasing river regulation will negatively impact this species (6.4.7)
	Sedimentation/ nutrients	Nutrients and sediments are the main sources of poor water quality in embayments. Filter feeders are particularly sensitive to poor water quality (6.4.6)
Pollution	Marine debris	Leathery turtles are vulnerable to plastic ingestion, which prevents feeding, creates internal blockages and accumulates toxic chemicals (6.4.8)
	Chemicals/heavy metals	Species that occur in embayments are exposed to higher levels of toxins due to lower flushing times and accumulation of upstream catchment impacts (6.4.11: Burrunan dolphin)
	Light	Nocturnally-active fledglings are attracted to artificial light sources, rendering them vulnerable to collision with infrastructure or predation on the ground (6.4.9: short-tailed shearwater)
	Noise	Anthropogenic noise (e.g. seismic testing) impacts on cetacean communication and physiology (6.4.11: blue whale)
Community/ industry demand	Expansion of industry	Port development and expansion can lead to destruction of sensitive habitats (e.g. Ramsar wetlands) (12.1.1)
	Demand for ecotourism	Dolphins exposed to swim tours in Port Phillip Bay show some behavioural differences to those not exposed to tour vessels (6.4.11: Burrunan dolphin)
	Recreational access	Hooded plovers are prone to abandon eggs and chicks when disturbed on beaches, particularly by dogs off lead (6.4.10)

6.1 Introduction

At its simplest, biodiversity is the variability of all organisms from terrestrial, marine and other aquatic ecosystems. Biodiversity is more than a list of species; it encompasses the genetic diversity within species, the diversity of habitats and ecosystems species belong to, and the ecological and evolutionary processes that maintain ecosystems.[1] This definition emphasises the complexity of interrelationships within ecosystems, of which people are also a part.

Biodiversity is important to people for diverse reasons. In understanding why biodiversity matters, it is useful to understand the range of values individuals and communities assign to the living world, as these values reflect peoples' held values. Aboriginal culture embodies the intimate connections between people and nature, and Traditional Owners have responsibilities to care for and heal Country – which also maintains and heals culture (see chapter 7). Aboriginal peoples and many others value biodiversity for its own sake (intrinsic value) and believe that future generations should have the same access to natural biodiversity as current generations. Biodiversity is also valued for economic, ecological life support, recreational, cultural and scientific reasons.[2] The values people derive from biodiversity are often described as ecosystem services.[3] For more discussion of ecosystem services, see chapter 14.

The southern coast of Australia is the only major south-facing coastline in the southern hemisphere. Stretching from Cape Naturaliste in Western Australia to Cape Howe on the Victoria/New South Wales border, the coastline has been isolated for some 65 million years. As a result, Australia's southern waters are unique. Many of the species that occur in this region are found nowhere else (endemic). For example, up to 67 per cent of polychaete worms[4], 70 per cent of brown algae[5], 74 per cent of echinoderms and decapods[6], and 77 per cent of red algae[5] are endemic to southern Australia. Species with limited dispersal capacities (e.g. short-lived planktonic larval stage, brooding, asexual reproduction by fission or budding) or narrow ecological niches (e.g. seagrass specialists) are more likely to be endemic.[7] Estimates of endemism should be interpreted cautiously however, as they are influenced by the extent to which a taxon has been studied (survey effort) and how broadly the study area is defined.[6,7,8]

Australia's southern coast also has high species richness and diversity. There are four main contributions to this: the southern Australian endemic element (outlined above), the widely distributed temperate element, the tropical element and a cold-water element. Key processes responsible for this pattern include the ongoing range expansion and speciation of tropical species as Australia split from Gondwana and drifted northward; extinction of Gondwanan cool-temperate species at the limits of their range; a low level of immigration of new cool temperate species; and endemic speciation in response to fluctuating environmental conditions, abundant rocky substrata and substantial habitat heterogeneity.[6,9]

6.1.1 Threats and threatening processes

Any loss or deterioration in the condition of biodiversity can compromise all the values that are dependent on biodiversity. The threats to marine biodiversity are well-identified at a broad scale. Key threats include climate change, overharvesting, habitat loss and degradation, pollution, pests, weeds and disease.[10,11,12]

6.1.2 Ecological processes

Ecological processes are the interactions and connections between living and non-living systems, including movements of energy, nutrients and other chemical substances such as carbon, organisms and propagules.[13] The interactions and connections of physical, chemical and biological processes are necessary to sustain healthy functioning ecosystems. Diverse ecosystems rely on the interactions of a network of ecological processes operating on scales from millimetres to hundreds of kilometres. These processes may operate continually or on tidal, seasonal, decadal or event-driven scales.[14] Some key ecological processes have been described below (table 6.2) and relevant in-text examples are highlighted.

Table 6.2 Summary of ecological processes acting on marine biodiversity in Victoria[14,15]

Process type	Process	Example (with section reference)
Physical	Underwater light climate	Light limits influence the transition from macroalgae-dominated community to sessile invertebrate-dominated community (6.4.2)
	Long-term changes in water temperature	Warming oceans may facilitate reproduction of common seadragon (6.4.7)
	Sea level	Distribution of seagrass beds influenced by wave exposure and depth (6.4.3)
	Tides	Daily submersion of intertidal species (6.4.2)
	Storm frequency	Temporary loss of beaches by erosion (wind, waves, currents) (9.4.3)
	Large-scale oceanography	Reduction in strength of Leeuwin Current impacts on dispersal of species (6.4.7)
	Localised oceanographic fronts	Bonney Upwelling supports diverse and productive fishery and whale breeding (6.4.11)
	Geomorphology	Accretion and erosion of sands in embayments (9.7.3)
	Sedimentation and settling	Creation of central muddy zone in Port Phillip Bay essential for denitrification services (6.4.6)
	Seasonal changes in water temperature	Control on plankton growth in embayments (10.2.4)
Chemical	Dissolved CO2 concentration	Ocean acidification impacts growth of molluscs (6.4.6)
	Catchment processes	Silicate from catchment erosion stimulates diatom growth in bays and estuaries (6.4.1)
	Geochemistry	Benthic infauna play key role in denitrification in Port Phillip Bay (6.4.6).
Biological	All biological processes	Bioaccumulation of toxins in higher trophic orders (6.4.11)
	Trophic interactions	Recruitment of recreational fish species dependent on growth of favoured larval prey items (6.4.1)
	Benthic nutrient cycling	Benthic infauna play key role in denitrification in Port Phillip Bay (6.4.6)
	Ecological succession	Mangroves encroach saltmarsh (6.4.5)
	Biogenic habitat	Cunjevoi provide sheltered habitat for many small and cryptic molluscs, sponges, echinoderms and algae (6.4.6)
	Competitive interactions	Marine pests may negatively affect denitrification processes conducted by sediment-dwelling infauna by outcompeting or preying on infauna (6.5.1)
	Community composition	Trampling, grazing and nutrient inputs by herbivores changes saltmarsh community composition and allows weed invasion (6.5.2)
	Primary production	Nutrient-rich upwelling regions support a range of species and fisheries (6.4.1)

6.2 Habitats

6.2.1 Broad-scale habitat types

Broad-scale variables, such as tidal level, substrate type, exposure and dominant flora, shape the major habitat types in Victorian marine waters. The following categories of broad habitat descriptions are taken from the ECC's 2000 *Marine, coastal and estuarine investigation final report*[16] with some recent updates.[15]

Beaches

Beaches are a primary interface between the ocean and the coastal environment. Exposed beaches have high mobility and instability. Primary productivity is relatively low and comes predominantly from microscopic algae (e.g. diatoms). Beach-washed marine algae also provide food and shelter for terrestrial invertebrates and shorebirds. Hundreds of species of invertebrates, mainly nematodes, crustaceans, polychaetes and molluscs, many of which are less than half a millimetre in size, live in the sand.[17]

Intertidal reefs

Intertidal reefs occur predominantly around headlands and points. On steeply sloping intertidal reefs strong vertical zonation is often seen as species have different tolerances and adaptations to desiccation and submersion. Encrusting microalgae and larger macroalgae are important for food and shelter. The fauna is dominated by gastropod molluscs, with crabs, mussels, barnacles, seastars and tubeworms also common. Sessile colonial invertebrates (encrusting sponges, bryozoans, ascidians) may occur under boulders and ledges.

Subtidal reefs

Subtidal reefs can be extensions of intertidal reefs or isolated offshore reefs. Species composition varies according to exposure and depth. In shallow reefs, large kelp species form the dominant habitat structure. Numerous smaller macroalgae and sessile invertebrates make up the understorey. Gastropods, crustaceans, echinoderms and fishes are the dominant mobile fauna. With increasing depth, light and wave exposure decrease. Red algae and sessile invertebrates (bryozoans, ascidians and sponges) replace kelps. Beyond 20-30 metres, the biota is dominated by filter-feeding sessile invertebrates that form habitat for numerous fish and invertebrates.

Coastal saltmarsh and mangroves

Coastal saltmarsh and mangroves grow on intertidal sand and mudflats and occasionally on rocky reefs in sheltered bays and estuaries. Salt-tolerant succulent shrubs and herbs, grasses and sedges form a dense, low vegetation layer which provides food and cover for water birds and waders. Mangroves are restricted to the intertidal zone between the mid and mean high water mark. Their emergent roots (pneumatophores) are often covered with macroalgae, particularly red algae.[18]

Seagrasses

Seagrasses are flowering plants adapted to grow in intertidal and subtidal zones of bays, inlets and estuaries where they bind sandy and muddy sediments. Many epiphytic organisms (hydroids, red algae, bryozoans) live on the stems and leaves of seagrasses. Seagrass beds support a rich infauna and epifauna and form a key nursery habitat for many commercially and recreationally important fishes.

Sheltered intertidal flats

Sheltered intertidal flats have few macroalgae or vascular plants because of the sediment instability in sand and silt flats that offers little opportunity for them to establish. The sediment in mudflats is more stable and supports a higher biomass of microalgae and fine macroalgae. Common species include soldier crabs, gastropod molluscs, bivalve molluscs, polychaetes and crustaceans, depending on sediment type.

Subtidal soft substrates

Subtidal soft substrates also vary according to sediment type. Generally, poorly-sorted, coarse sediments support more diversity than muddy sediments. The most extensive subtidal sandflat in Victoria occurs off Ninety Mile Beach in east Gippsland. This habitat has a very diverse benthic infauna, with over 2800 individuals belonging to nearly 200 species recorded from just 0.1 cubic metres.[19] The dominant fauna are polychaetes, molluscs and crustaceans. Muddy substrates usually occur in sheltered embayments, estuaries, or deep offshore waters. Surface deposit feeders and scavengers dominate the fauna. Many species are cryptic, and only occur within tidal channel habitats.

Open waters

Open waters off Victoria's coast contain comparatively low concentrations of phytoplankton due to the low level of nutrients when compared to other coastlines, as well as a wide range of zooplankton that feed on them (including the larval stages of many invertebrates and fish). These zooplankton, which include sea jellies, are weak swimmers and are carried by currents. Actively swimming species (collectively termed nekton) include fish, cephalopods (squid and octopus), seabirds and marine mammals.

Coastal islands

Coastal islands and the waters surrounding them, are important places for conservation of plants, seabirds and mammals such as seals. Islands often support communities found nowhere else due to their relative isolation. The species composition depends on the island's size and isolation. Major coastal islands in Victoria include Lawrence Rocks, Deen Maar (Lady Julia Percy Island), Mud Islands, Phillip Island, French Island, islands in Corner Inlet and Nooramunga, numerous islands off Wilsons Promontory, and Gabo Island.

Artificial habitats

Artificial habitats typically contain less diverse communities than natural habitats. Their importance often depends on their level of protection, age of structures and materials used. For example, Pope's Eye and South Channel Fort provide reef habitat for a diverse fish fauna, as do shipwrecks.

6.2.2 Biotope mapping

DELWP has undertaken a statewide collation of marine habitat mapping and classification project using the Combined Biotope Classification Scheme (CBiCS). This a relatively new schema which draws on components from European (EUNIS) and US (CMECS) schemas. The CBiCS provides a unified way to classify all marine habitats and biotopes and is analogous with Victoria's terrestrial system of Ecological Vegetation Classes (EVCs) for describing vegetation. This system incorporates data from the littoral (intertidal) zone to the deep sea.

The CBiCS uses seven components to classify habitat, each containing between three and six nested hierarchical levels. These components are: biotic, biogeographic setting (marine region of the world i.e. Temperate Australasia), aquatic setting (marine, estuarine or marine lake), water column (includes current, wave, front, layers), geoform (includes rock, sediment, water column, deep sea bed), substrate (includes hard, bedrock sand, rubble sand, soft, bryozoan reef, rock and sediment mix) and morphospecies (species described by morphology rather than taxonomy). The biotic component is the core classification component, and centres around the idea of a biotope – a community of species in a defined abiotic (non-living) habitat. Within the biotic component there are six hierarchical levels: environment, broad habitat, habitat complex, biotope complex, biotope and sub-biotope.

This system has brought about significant changes in the classification and mapping of Victorian marine environments, and will aid in aligning methods with international best practice to meet the requirements of modern natural resource management.[20]

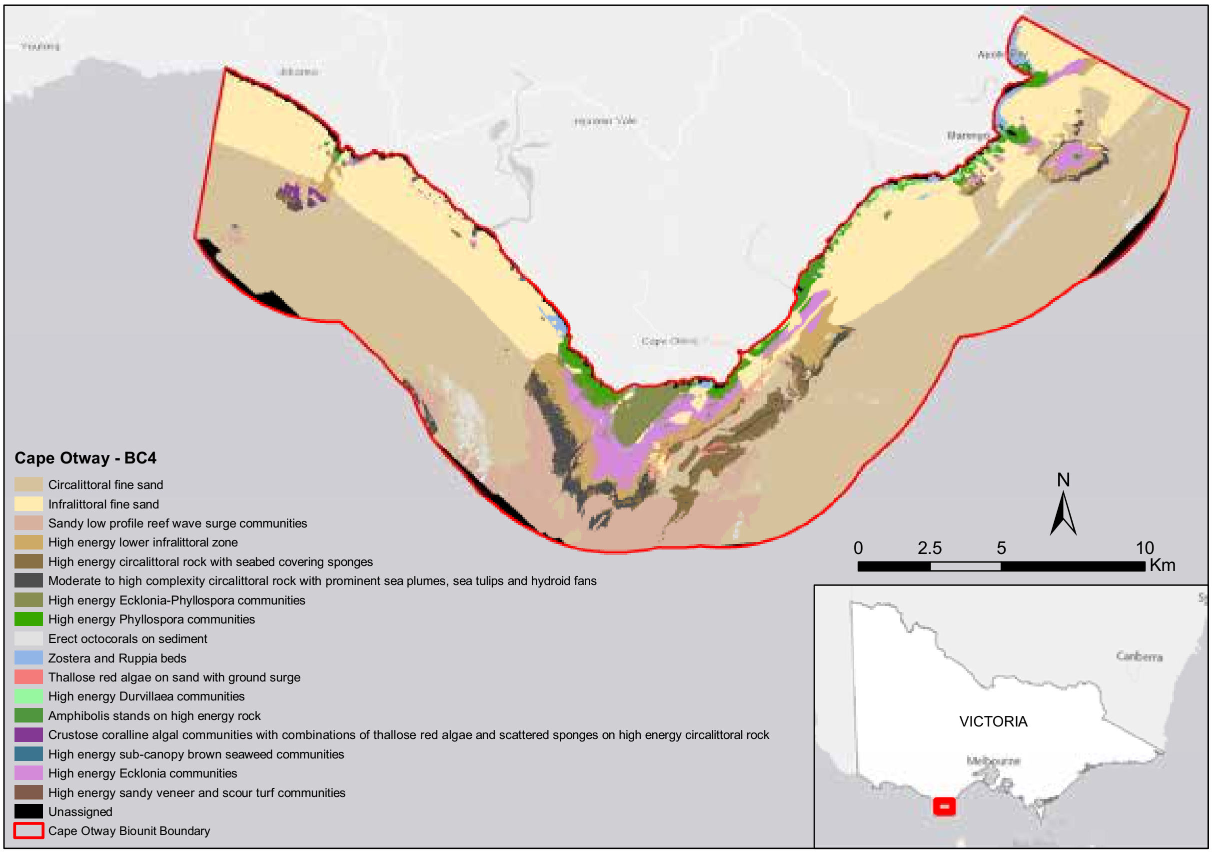
The implementation of CBiCS has involved reanalyses of quantitative monitoring data, classification of underwater imagery, analyses of historical information and the development of new methodology for future studies. Biotope data exists in a range of spatially-explicit formats, from geo-referenced point or line data (e.g. ground-truthed observations) to polygons (e.g. modelled or interpreted areas). The biotope data now provide a link between mapped inventory and ecosystem processes, and as such can be used to inform environmental accounting. New analytical metrics for describing biotope succession will also be useful for describing ecological condition as part of future monitoring and reporting programs[20].

More than 100 biotope complexes have been identified across Victoria. These are accessible through DELWP's Coast Kit online mapping tool (http://dev-coastkit.cbics.org/). For more detailed analysis of habitat and biotope complexes within each biounit, see the biounit pages in the atlas accompanying this report. Some 54 biotope complexes covering Victoria are described in appendix 2 of the atlas.

Figure 6.1 illustrates the biotopes that have been mapped within the Cape Otway biounit, which extends from east of Cape Otway to west of Apollo Bay. This biounit has been almost completely mapped, over 97 per cent at the biotope complex level.

In mapped areas, circalittoral fine sand and infralittoral fine sand dominate (48 per cent and 23 per cent respectively). Five biotope complexes contribute a further 20 per cent of the mapped area: sandy low profile reef wave surge communities, high energy lower infralittoral zone, high energy *Ecklonia* sp. communities, high energy circalittoral rock with seabed covering sponges and moderate to high complexity circalittoral rock with prominent sea plumes, sea tulips and hydroid fans. The remaining 7 per cent that has been mapped is composed of a further ten biotope complexes that each contribute a small amount to the total area. For descriptions of biotope complexes, see appendix 2 in the atlas.

Figure 6.1 Mapped biotopes within the Cape Otway biounit



6.3 Conservation-listed species

There has been less investment in the recognition of rare and threatened taxa in the marine environment compared to terrestrial species. As a result, the number of conservation-listed marine-dependent species is almost certainly an underestimate.[7,8] For the purposes of this assessment, only marine-dependent species have been considered. Recent reviews have compiled lists of coastal-dependent species.[11,15,21]

Within Victoria, species may be included on DELWP's non-statutory lists for vertebrates,[22] invertebrates,[23] and rare or threatened plants.[24] Species fulfilling certain criteria may be listed as threatened under the *Flora and Fauna Guarantee Act 1988*. Marine organisms (excluding mammals, birds, reptiles and amphibians) may be listed as protected aquatic biota under the *Fisheries Act 1995*. Federally, species may be listed under the *Environment Protection and Biodiversity Conservation Act 1999* as threatened, migratory, marine and/or cetacean. Migratory species may also be listed under agreements in the Convention on the Conservation of Migratory Species of Wild Animals (known as the Bonn Convention), the Japan-Australia Migratory Bird Agreement (JAMBA 1974), China-Australia Migratory Bird Agreement (CAMBA 1986) and the Republic of Korea- Australia Migratory Bird Agreement (ROKAMBA 2007).

Table 6.3 below tabulates numbers of species and communities that occur in Victorian marine waters and are included in any list, annex, appendix or other mechanism under relevant legislation or international agreement. There are 179 species and five ecological communities. Patterns of listing are not equal across species; there are many more large, charismatic species listed (e.g. marine mammals and birds) than invertebrates. This is not an indication of the conservation status of marine invertebrates. Rather, it reflects the existing state of knowledge and priorities for species' listing. For the full list of conservation-listed species and community names, see appendix 3.

Conservation-listed species are only one type of species with high conservation values. Other marine-dependent species with high value include old-age populations, recruitment source communities and keystone species. Understanding these species helps to identify areas of conservation values based on population, community and ecological values.[15]

Table 6.3 Numbers of conservation-listed marine-dependent species occurring in Victorian marine waters

Group	DELWP advisory list					FFG Act	Fisheries Act	EPBC Act							International treaty				Any listing
	CR	EN	VU	NT	DD			CR	EN	VU	CD	Mar	Mig	Cet	Bonn	JA	CA	RA	
Marine mammals	2	1	2	0	3	4		0	3	5	0	7	8	17	10				25
Seabirds	0	3	10	9	0	13		0	2	10	0	34	23		11	11	11	7	37
Shorebirds	4	6	10	5	0	9		3	3	2	0	32	28		27	29	28	29	34
Other birds	1	2	5	4	0	7		1	0	0	0	12	2		2	2	3	1	15
Marine reptiles	1	0	0	0	0	1		0	3	2	0	6	5		5				6
Teleost fishes	2	2	2	0	0	7	27	1	0	3	3	20	0		0				31
Chondrychthian fish	0	0	1	0	1	2	2	1	0	2	3	0	6		6				10
Cnidarians	0	0	2	0	0	1	1	0	0	0	0	0	0		0				2
Crustaceans	0	0	3	0	0	3	3	0	0	0	0	0	0		0				3
Echinoderms	0	0	8	0	0	7	7	0	0	0	0	0	0		0				8
Molluscs	0	0	3	0	0	3	3	0	0	0	0	0	0		0				3
Marine communities						2		0	2	1	0								5
TOTAL	10	14	46	18	4	59	43	6	13	35	6	111	72	17	61	42	42	37	179

CA= China-Australia migratory bird agreement (CAMBA), Cet= cetacean, CD= conservation dependent, CR= critically endangered, DD= data deficient, EN= endangered, JA= Japan-Australia migratory bird agreement (JAMBA), Mar= marine, Mig= migratory, NT= near threatened, RA= Republic of Korea-Australia migratory bird agreement (ROKAMBA), VU= vulnerable

6.4 Marine organisms

The following sections are organised largely according to major taxonomic groupings. Eleven major categories of marine organisms are described (plankton, macroalgae, seagrasses, mangroves, saltmarsh, invertebrates, fishes, marine reptiles, seabirds, shorebirds and mammals) firstly in general terms, followed by descriptions of selected individual species or communities within each group to highlight relevant ecological processes or threatening processes.

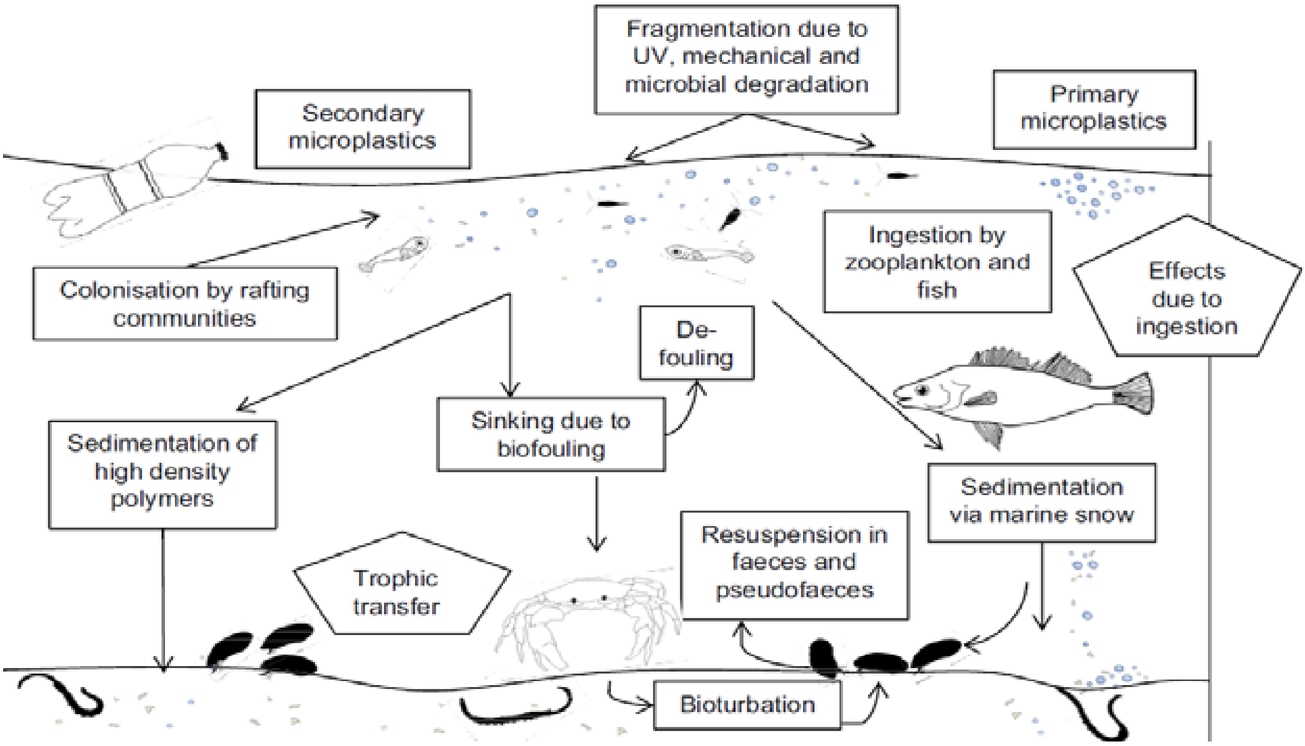
6.4.1 Plankton

Plankton (phytoplankton and zooplankton) form the basis of marine food webs. Phytoplankton are photosynthetic organisms and include blue-green algae, dinoflagellates and diatoms. Zooplankton feed on phytoplankton and consist mainly of protozoans, tiny fish and crustaceans such as krill. Zooplankton also include the larval stages of many invertebrates. Localised upwellings of nutrients, such as the Bonney Upwelling in the west and the Eden Upwelling in the east, increase primary productivity of phytoplankton and subsequently secondary production of zooplankton. Localised areas of high productivity in an otherwise nutrient-poor environment support key fisheries (as well as top predators like marine mammals and seabirds).

Plankton growth is also influenced by nutrient availability. In Port Phillip Bay, the Western Treatment Plant at Werribee and the Yarra River are the largest sources of nutrients and freshwater. Salinity and nutrient levels associated with these inputs influence the phytoplankton community. Diatoms are predominant during periods of moderate river flows, whereas other flagellates (e.g. *Plagioselmis prolonga* and *Helmiselmis* spp.) prefer lower flows. Copepods, the preferred zooplankton food of larval snapper (*Chrysophrys auratus*), thrive on abundant diatoms.[25] In this way, the recruitment of snapper, a key recreational fishing species, depends on nutrient and freshwater flows into Port Phillip Bay[14]

Because of their importance in marine food webs negative impacts to plankton can spread throughout marine communities. Microplastics (plastic particles between one nanometre to five millimetres) enter the marine environment either through the breakdown of larger plastics or as small particles used in the manufacture of other plastic items (e.g. nurdles). Microplastics also include small synthetic fibres from the breakdown of woven cloth, which typically results from washing clothes. There is increasing recognition of the impacts of microplastics, and even smaller nanoplastics (between one micrometre and one nanometre) in marine food webs.[26,27] There are multiple pathways for microplastics to enter the food chain (see figure 6.2).[26] Because of their small size, microplastics are easily ingested by planktonic organisms. Once ingested, microplastics can bioaccumulate toxins (e.g. persistent organic pollutants)[28] and impair feeding.[29] Nanoplastics are easily absorbed into cells and tissue[27] where they can inhibit growth, modify gene expression and increase mortality.[30]

Figure 6.2 Pathways for micro – and nanoplastics to enter marine food webs[26]



While the impacts of seismic surveys for oil and gas on marine mammals are well-acknowledged,[31,32] recent work indicates that zooplankton, particularly krill larvae and copepods, may also be negatively impacted more than one kilometre away from the source.[33,34]

6.4.2 Macroalgae

Victoria's marine algal biodiversity is particularly rich, with almost 960 algal species recorded so far. This diversity consists of nearly 90 species of microalgae, such as diatoms and phytoplankton, and 869 species of macroalgae (commonly known as seaweeds).

Macroalgae differ from other marine plants such as seagrasses and mangroves because they lack roots, leafy shoots, flowers and vascular tissues. Macroalgae can take a range of forms, ranging from simple crusts, leafy (foliose) and threadlike (filamentous) forms with simple branching structures to more complex forms with specialised structures. As they lack roots, most species of macroalgae cannot grow in mud and sand, but rather attach to hard surfaces such as rock.

Leather kelp (*Ecklonia radiata*) Photo: Bill Boyle

Neptune's necklace (*Hormosira banksii*) at Point Addis Marine National Park Photo: Sarah Garnick

Macroalgae are classified according to the pigments involved in photosynthesis: Rhodophyta (red algae, 615 species in Victoria), Ochrophyta (brown algae, 157 species in Victoria), and Chlorophyta (green algae, 97 species in Victoria).[35,36]

Several species of macroalgae typically occur in the lower intertidal zone on rocky shores. A brown alga, Neptune's necklace (*Hormosira banksii*) forms large beds on rock platforms and sea lettuce (*Ulva* spp.) a green alga also occurs at high densities, particularly in winter. Many species of microalgae form a fine layer over rock surfaces, while brown algae (*Gelidium pusillum*) and arborescent coralline red algae form turf-like beds. Rock pools harbour species more commonly found in subtidal reefs, particularly *Cystophora* spp., *Sargassum* spp., *Caulerpa* spp. and *Codium* spp.[37]

In subtidal reefs (0 to 20 metres) several species of kelp, which are brown algae, dominate. In highly exposed locations bubble weed (*Phyllospora comosa*) and bull kelp (*Durvillaea potatorum*) occur, in moderately sheltered locations southern giant kelp (*Macrocystis pyrifera*) occurs and on the most sheltered reefs leather kelp (*Ecklonia radiata*) is present. These large kelp beds support a rich algal understorey. Some smaller algae associated with kelp beds include *Cystophora* spp., *Sargassum* spp., *Codium* spp., *Cladophora* spp., and *Caulerpa* spp. Many small red algae including *Laurencia* spp., *Champia* spp., *Plocamium* spp. and *Polysiphonia* spp. and encrusting and coralline red algae form turf-like beds.

Beyond 20-30 metres depth, where less light penetrates, most of the algae are replaced by non-photosynthetic invertebrates (e.g. sponges, bryozoans, sea whips and ascidians).

Algae form the basis of intertidal and subtidal food webs. Numerous molluscs graze algae off rocks. Beach washed algae are also important in coastal food communities, providing food and habitat for numerous invertebrates (e.g. beach flies, amphipods) and shorebirds (e.g. hooded plover), and having a role in dune formation and nutrient cycling.[38]

Rocky intertidal reefs are popular locations for beach users to visit. Some macroalgae species, particularly Neptune's necklace (*Hormosira banksia*), are vulnerable to trampling.[39] Macroalgae can also be impacted through biological processes such as urchin overgrazing, leading to barrens or dieback.[40]

Drift algae

Some macroalgae species do not need to be permanently attached to the substratum. Drift algae (primarily red algae species) require substrate for their initial growth but can then remain alive in the water column, where they are carried by currents and tides and accumulate into extensive mats. These mats can occur in high densities along the northwest shore of Port Phillip Bay, possibly in response to higher levels of nutrients. Drift algae play an important role in primary productivity, nitrogen cycling, and the formation of biogenic habitat.[41]

Giant kelp (Macrocystis pyrifera)

Giant kelp (*Macrocystis pyrifera*) is the world's largest benthic organism. In the southern hemisphere, it has a circumpolar distribution on the coasts of South America, south-eastern Australia, New Zealand, Africa and various sub-Antarctic Islands.[42] Giant kelp grows in forests on rocky reefs up to 35 metres deep with sea temperatures between 5 and 20°C and moderate wave exposure.[43,44] Giant kelp acts as a habitat-forming species, supporting high levels of biodiversity through settlement of larvae, food and shelter for adults living among the fronds, organisms living directly on the kelp plant itself, and for organisms living on the seafloor in the low-light sheltered environment created beneath the canopy of the kelp.[42,43,44]

Giant kelp forests are listed as an endangered community under the EPBC Act. In line with patterns seen in other states, particularly Tasmania, the Victorian distribution of giant kelp has substantially decreased. At many locations where it was plentiful it is now either absent or represented by only a few plants. For example, giant kelp was once abundant in the Port Phillip Heads region, particularly off Lonsdale Point and in Lonsdale Bight, where it covered most of Kelp Reef. It is no longer present at these sites.[45] Indeed, since 2005 few plants have been observed within the depth range of the ecological community.[15]

The main threats to giant kelp forests are climate change-induced sea surface temperature increases associated with the southward extension of the East Australian Current and a corresponding range expansion of kelp-grazing sea urchins. Growth and reproduction in giant kelp are strongly linked to nutrient availability because adult plants have a limited capacity to store nitrates.[44] Increasing temperatures gives a competitive advantage to brown and red foliose algae which changes the ecosystem structure.[46] Kelps are also vulnerable to removal by strong wave conditions and may take years to recolonise.[44]

The strengthening of the East Australian Current and warming ocean temperatures has resulted in ocean temperatures that allow the black sea urchin (*Centrostephanus rodgersii*) to successfully reproduce.[47] C. *rodgersii* feed on macroalgae and have the capacity to overgraze giant kelp, which triggers a shift from dense giant kelp beds to sea urchin 'barrens' devoid of macroalgae. Recent survey work has confirmed the existence of such barrens in east Gippsland.[20]

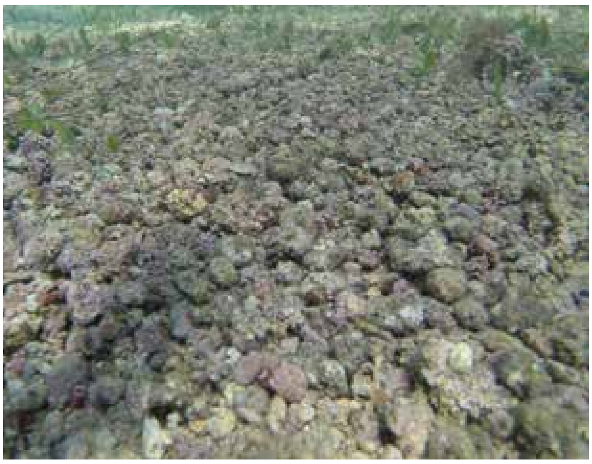
Rhodolith beds

Rhodoliths are unattached marine growths composed predominantly of coralline red algae. Rhodolith beds (also known overseas as maerl) are aggregations of rhodoliths on muddy, sandy or pebbly bottoms in areas where the wave motion or currents are strong enough to prevent burial by sediments.[48] At least seven genera and eight species of rhodolith-forming algae have been identified in Australian waters. A single rhodolith bed may consist of one or multiple species.[49]

While rhodolith beds are common and distributed worldwide, they were first documented in Victoria in 1993.[50] Currently, 16 rhodolith sites have been identified in Victorian state waters with a further six mapped in adjacent Commonwealth waters.[51] The majority of Victorian rhodolith beds occur between Apollo Bay and Cape Liptrap. They have an extensive but patchy distribution at between 20 to 50 metres depth.[15,50,52]

Rhodoliths form spatially-complex habitats, with correspondingly high biodiversity and biomass, in otherwise sparsely populated soft substrates. While rhodoliths have low associated fish biomass.[53] Australian rhodolith habitats support a high diversity of fleshy algae and invertebrates.[49] Further research is required to understand the role rhodolith beds play in larval settlement of commercially-important invertebrate species.[51,54] Rhodoliths are also important calcium carbonate producers, with rates approaching those of coral reefs.[51]

Rhodoliths are long lived (over 900 years), slow growing (between 0.01 to 0.6 millimetres per year depending on water depth)[48] and occur in localised patches.[55] Because of these traits, rhodoliths are particularly vulnerable to localised impacts. Bottom trawling is particularly damaging. Localised loss of canopy-forming algae and seagrass above rhodolith beds, such as has been observed due to recreational anchoring at San Remo in Western Port.[49] Increasing terrestrial sediment and nutrient loads also threaten rhodoliths through burial and overgrowth of fleshy algae.[49]



Rhodolith bed, Western Port. Photo: La Trobe University

Posidonia australis, Corner Inlet. Photo: Parks Victoria

Amphibolis antarctica washed up on Cowes beach, Phillip Island. Photo: Robert Molloy

6.4.3 Seagrasses

Seagrasses are flowering plants (angiosperms) that grow in the shallow zones of bays, inlets and estuaries (typically less than 15 metres depth) exposed to low to moderate wave energy. They produce seed but can also reproduce clonally. At least seven species of seagrasses occur in Victoria in four genera: *Zostera* (eelgrass, includes *Heterozostera*), *Amphibolis* (sea-nymph), *Halophila* (paddlegrass), and *Posidonia* (strapweed). *Althenia* (water mat, formerly known as *Lepilaena*) is sometimes classified as a seagrass, and *Ruppia* (estuary grass) is related to true seagrass and considered analogous habitat (see appendix 4 for more details). Several species occur throughout the state (e.g. *Zostera mulleri*), while others have more restricted distributions (e.g. *Posidonia australis* which is only found in Corner Inlet and Nooramunga).[56]

The broad-scale distribution of seagrass is influenced by wave exposure and depth (the latter a proxy for light exposure). The species composition of a particular site reflects different species' tolerances to these physical processes. For example, *Amphibolis antarctica* is better able to withstand higher flow.[56] Turbulent wave action is likely to preclude shallow-rooted species from high-energy environments through erosion, uprooting and burial of plants, particularly during storm events.[57]

Seagrass beds are highly productive and support diverse communities.[56] Macroalgae often co-occur in seagrass beds, increasing primary productivity and providing further biogenic habitat. Micro- and macroalgae can be found as epiphytes growing on seagrass leaves and seagrass beds also accumulate drift algae.[56]

Seagrass habitats support sessile and mobile meio- and macroinvertebrates. Meioinvertebrate assemblages are often dominated by small crustaceans, whereas macroinvertebrate assemblages include gastropods, polychaetes, bivalves and decapods.[56]

Numerous fish species associate with seagrass beds for at least part of their lifecycle, and many of these are of recreational or commercial interest.[58] Seagrass resident species include pipefish and seahorses, leatherjackets, rock and weed whitings and gobies. Fish that use seagrass as juveniles include whiting, flathead, seabream and garfish.[56,59] The importance of seagrass as a 'nursery habitat' to such species is related to the high primary and secondary productivity of seagrass beds, physical shelter from predation and the position of seagrass beds within estuaries.[60]

In addition to their ecological function, intact seagrass beds provide sediment stabilisation, nutrient cycling, carbon sequestration and coastal protection.

Seagrass is particularly sensitive to water quality. Suspended sediments have the potential to smother seagrass leaves and reduce photosynthetic efficiency. Large areas of seagrass were lost in Western Port in the 1970s and 1980s. There was some recovery in the late 1990s, but not in all locations. It is likely that this loss was due to smothering in shallow waters, with suspended sediments trapped by epiphytes. These fine sediments also raised the height of intertidal flats, which increased desiccation and temperature stress for seagrass recruits trying to recolonise.

Attempts to manually replant areas of seagrass loss were unsuccessful.[61,62] Elevated levels of nutrients foster the growth of competitors like macroalgae and phytoplankton that shade seagrass leaves and trap suspended sediments. This can exacerbate smothering effects. However, low levels of nutrients (particularly nitrogen) associated with reduced freshwater flows into Port Phillip Bay were also linked to seagrass declines following prolonged droughts.[63] Losses and gains are species-dependent, with some species more likely to be ephemeral than others. Similar losses of seagrass have also been reported globally.[64]

6.4.4 Mangroves

Mangroves are confined to protected low-energy coastal environments where there is sufficient shelter from strong wave action and currents to allow the accumulation of fine sediments, generally on mudflats within the tidal zone.[65] While 39 species of mangroves occur in tropical Queensland only one species, white mangrove (*Avicennia marina ssp. australasica*), occurs in Victoria[66] from the Barwon River estuary in the west to Corner Inlet. The world's southernmost natural population of mangroves occurs at Corner Inlet.

Vegetation extent mapping undertaken by DELWP indicates that there is some 4240 hectares of mangrove shrubland in Victoria. This represents 79 per cent of the pre-European extent, three quarters of which is on public land. A further 4600 hectares of mangroves occur in mosaics with coastal saltmarsh, berm grassy shrubland, and estuarine flats grassland mosaics.

Mangroves provide structurally complex habitat and nutrients for a detritus-based food web. They bind sediment[67] that provides habitat for a range of infauna including oligochaete and polychaete worms.[68] Pneumatophores, trunks and/or leaves are colonised by macroalgae[18] and invertebrates (e.g. *Elminius covertus*).[69] Sessile macroinvertebrates include bivalves and barnacles, while gastropods dominate the mobile fauna.[68]

Mangroves provide nursery habitats for juvenile fish, some of which are important commercial species (e.g. yellow-eye mullet *Aldrichetta forsteri*).[70] They also have an important role in coastal protection against storm surges and erosion by reducing water flow, velocity and turbulence, dampening wave energy, attenuating wave height and trapping sediments.[68,71] Habitat loss and fragmentation is putting this valuable ecosystem service at risk. Another concern is that white mangrove has poor dispersal capacity, which means natural recovery is slow,[72] and only half of all mangrove restoration projects tend to be successful.[62]

6.4.5 Saltmarsh

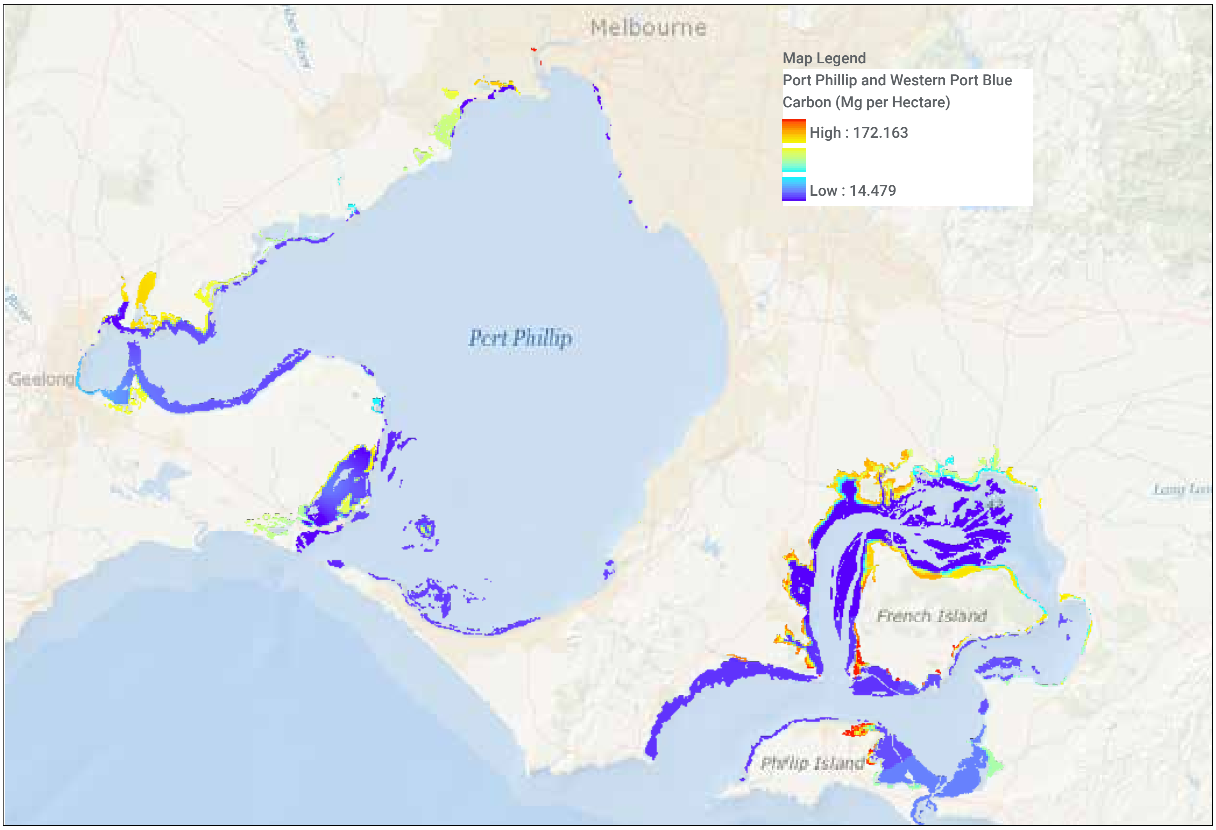
Coastal saltmarsh is present in a scattered distribution along Victoria's coastline in sheltered embayments and estuaries. Multiple sub-communities occur, often as bands or zones, depending on exposure to tidal inundation and substrate. Dominant plants include succulent herbs (e.g. austral seablite *Suaeda australis,* beaded glasswort *Sarcocornia quinqueflora,* creeping brookweed *Samolus repens,* rounded noon-flower *Disphyma clavellatum),* low succulent shrubs (e.g. shrubby glasswort *Tecticornia arbuscula,* southern sea-heath *Frankenia pauciflora),* grasses, rushes and sedges (e.g. Australian salt-grass *Distichlis distichophylla,* coast spear-grass *Austrostipa stipoides,* chaffy saw-sedge *Gahnia filum).*[73]

Mapping undertaken by DELWP indicates that some 12,470 hectares of saltmarsh occurs in Victoria. This represents 79 per cent of the pre-European extent, two thirds of which occurs on public land. A further 4600 hectares of saltmarsh occurs in mosaics with mangrove shrubland, berm grassy shrubland, coastal headland scrub, coastal dune scrub, coastal dune grasslands and estuarine flats grassland.[74] Coastal saltmarsh communities are highly variable depending on site characteristics. Seven component communities have been identified based on the dominant plant forms and exposure to tides.[75] These are described in appendix 5.

Mangroves often occur on the seaward side of coastal saltmarsh communities, and gradual mangrove expansion into saltmarsh is a widespread.[66,75] In undeveloped catchments, saltmarsh can simply retreat landward. However, in

Saltmarsh and mangrove mosaic at Corner Inlet Marine and Coastal Park. Photo: Rob Molloy

Figure 6.3 Mapping of soil carbon stored in blue carbon ecosystems in Port Phillip Bay and Western Port. Areas of highest value are shown in red through to lower levels in blue. Source: The Nature Conservancy http://maps.oceanwealth.org/)



developed catchments, where added nutrients facilitate the rate of mangrove encroachment, there is often nowhere for saltmarsh to retreat to.[67] The situation where saltmarsh is encroached by mangroves on the seaward edge and developments such as levee banks on the landward side is known as 'saltmarsh squeeze'.[75] Predicted sea level rise under climate change will only exacerbate this pressure on coastal saltmarsh.[66]

Blue Carbon

Coastal saltmarsh, mangroves and seagrass (collectively known as blue carbon ecosystems) have a key role in carbon sequestration. Burial rates of organic carbon in these ecosystems are exceptionally high[76] and can be 30-50 times higher than rates in the soils of terrestrial forests.[77] This is in part because blue carbon ecosystems can trap particles and suspend sediments out of the water column. Undisturbed, these sediments accrete over time.[71] This allows blue carbon ecosystems to continually capture carbon, unlike terrestrial ecosystems in which carbon capture may eventually plateau.[78]

In Victoria, over 2.91 million megagrams (Mg) of organic carbon is stored in the top 30 centimetres of sediment in blue carbon ecosystems. Coastal saltmarshes are responsible for almost 53 per cent of Victoria's blue carbon stock, even though they represent only 30 per cent of the blue carbon ecosystem area. Every year, Victoria's blue carbon ecosystems sequester around 22,700 Mg of organic carbon.[76]

6.4.6 Invertebrates

Invertebrates make up the major proportion of all marine biodiversity.[79] It has been estimated that more than 10,000 species, many of which are currently undescribed, occur in Victorian waters. The most speciose groups are the Crustacea (estimated 3000 species) and Mollusca (estimated 2000 species).[7] Some marine invertebrates are large and mobile, like the giant cuttlefish (*Sepia apama*). Others such as the cunjevoi (*Pyura stolonifera*) are sessile and fill an ecological niche more similar to plants in the provision of biogenic habitat for other species.

Sixteen conservation-listed marine invertebrates occur in Victoria: two cnidarians (one hydroid and one sea jelly), three crustaceans (all shrimps), eight echinoderms (two brittle stars and six sea cucumbers), and three molluscs (two opisthobranchs and one chiton). It is likely that many more invertebrates require conservation listing as numerous species appear to have highly localised distributions.[80] The sheer number of undescribed and unknown species makes it challenging to adequately protect marine invertebrates.

Some marine invertebrates are harvested, either from the wild or cultured in aquaculture operations. Important species include molluscs (abalone, mussels, oysters, scallops, pipis, squid, octopus, cuttlefish), crustaceans (rock lobsters, crabs, prawns, shrimp), echinoderms (sea urchins, sea cucumbers), and polychaetes (sand worms).

Benthic infauna

Victoria's benthic infauna, invertebrates that live in tubes or burrows in soft sediments on the sea floor, is dominated by crustaceans (shrimp and lice), polychaetes (bristle worms), nemerteans (ribbon worms) and molluscs.[81] The diversity of species increases with depth and is highest in eastern Victoria.[19,81] Sandy sediments have higher diversity than muddy sediments.[82] While only a limited number of benthic infauna communities have been studied in depth globally, eastern Victoria has the most diverse community so far recorded.[81]

Ghost shrimps, in particular Biffarius arenosus and Trypaea australiensis, perform a key ecosystem function by enhancing bioturbation and bioirrigation through their burrowing. This alters the physical and chemical structure of soft sediments and facilitates nutrient cycling and denitrification[82,83,84] which is critically important in Port Phillip Bay.[85]

Seastars at Twelve Apostles Marine National Park, Photo: Parks Victoria.

The Nature Conservancy is leading a project to restore shellfish reefs in Port Phillip Bay. Photo: Simon Branigan

Dredging of waterways to allow passage of more or larger ships changes wave patterns and patterns of sediment deposition and erosion. Such activities can critically threaten infaunal communities and the important ecological services they provide[79].

Molluscs

Shellfish reefs

Shellfish (including native flat oyster *Ostrea angasi and blue mussel Mytilus edulis galloprovinicialis) were an important food resource for many Aboriginal people and are represented in shell middens all along Victoria's coastline.*[86] A combination of large-scale removal and destructive fishing practices led to the loss of over [95] per cent of these reefs, leading scientists to classify this habitat as functionally extinct[86]. In flat oysters, disease caused by the parasite Banamia sp. may have played a role in the historical decline.

Although the causes for decline have ceased natural recovery has been hampered by sedimentation, a lack of shell substrate for settlement, disease, and competition and predation from introduced species.[86] A collaborative project between Albert Park Yachting and Angling Club, The Nature Conservancy and the Victorian Fisheries Authority is working to re-establish native flat oysters and mussels raised at the Victorian Shellfish Hatchery in Queenscliff at three sites in Port Phillip Bay: Geelong, St Kilda and Chelsea.

Gastropods

It is estimated that there are more than 50,000 species of marine gastropods (sea snails and sea slugs) - the largest and most varied group of molluscs.

Gastropods use a range of dispersal tactics. Some, like the dog whelk (*Dicathais orbita*) that lay egg masses from which well-developed juveniles emerge, have very limited dispersal as juveniles remain on or near the maternal reef. Broadcast spawning species with a short non-feeding larval phase, such as periwinkles (*Austrocochlea* spp.), have restricted dispersal with most larvae settling within metres to kilometres of spawning sites. Conversely, species that lay eggs with long-term planktotrophic (feeding) larvae that spend months in the water (e.g. *Nerita atramentosa*) have long-range dispersal potential,[14] as larvae that spend more time in the water are more likely to be transported from their reefs of origin.[87]

Larval dispersal distances, and therefore population connectivity, are greater on the open coast compared to embayments due to stronger currents. *Cellana tramoserica* larvae from reefs on the open coast disperse in the direction of the prevailing eastward-flowing current and travel further than those from within Port Phillip Bay.[87] Long-term changes to ocean currents could negatively impact population connectivity and persistence for species that depend on outside sources of larvae.[87,88]

Ocean chemistry is predicted to change as oceans absorb carbon dioxide from the atmosphere. Among the most dramatic changes will be a reduction in pH (acidification) and the availability of carbonate ions (CO_3^{-2}).[89,90] The impacts of this altered chemistry could be particularly serious for molluscs as they are major producers of calcium carbonate ($CaCO_3$) and comprise the second-most diverse animal phylum, with more than 30,000 species globally.[90] Many important commercially and recreationally harvested species are molluscs, including abalone, scallops, pipis and periwinkles.

Banded periwinkle (*Austrolittorina* sp.) at Ricketts Point. Photo: Mel Mitchell

Nudibranch at Rickett's Point. Photo: Mel Mitchell.

Under increasingly acidic oceans, molluscan larvae and adults will find it more challenging to make their calcium carbonate shells, and are expected to experience reduced reproduction, immune response and survival.[90] Ocean acidification will also negatively impact on reef-building corals, calcifying macroalgae (e.g. crustose coralline algae), bryozoans, echinoderms and calcareous plankton. As many of these species are at the bottom of food webs and/or provide biogenic habitat for other species, negative impacts of ocean acidification will magnify up food chains to species like fish, seabirds and marine mammals.[89]

Marine opisthobranchs

Marine opisthobranchs are a diverse group of soft-bodied gastropod molluscs, now categorised in the Subclass Heterobranchia. The name 'opisthobranch' refers to the animals' gills being located behind their hearts. In addition to the photogenic nudibranchs (Order Nudibranchia), opisthobranchs also include sea slugs, sea butterflies, and sea angels (which are also sometimes referred to as nudibranchs).

In Victorian and Bass Strait waters 364 species have been recorded, 38 per cent of which still require formal taxonomic description; 212 of these species are nudibranchs and 152 are shell bearing.[91] Opisthobranchs occur from the intertidal zone to the deep sea with most species small and challenging to distinguish from their food host.

A number of sites in Victoria have been sampled and species lists assembled. At Point Danger in Torquay 95 species have been recorded, and more than 120 species were recorded in the channel banks at San Remo, Western Port.[91]

The nudibranchs at San Remo are part of the San Remo Marine Community listed under the *Flora and Fauna Guarantee Act.* It is a species-rich intertidal and subtidal marine community known from only one site in Victoria, an area of about 600 by 300 metres near the township of San Remo. The community extends from the shore out to the edge of a deep channel with a fast-flowing current. The most species-rich part of the community occurs along the edge of the channel. The diverse substrata of sand, mud, boulders, soft weathered basalt, algae and seagrass is an important determinant of the community, providing habitats suitable for a wide range of species.[92,93]

The San Remo site is characterised by an unusually large number of species of opisthobranch molluscs and bryozoans, many of which are rare. Other species in the community include seagrasses, intertidal algae, and a variety of sponges, bryozoans, molluscs, crabs, echinoderms and fish. Of significance is the relative abundance of the rare bivalve *Anadara trapezia*, once widespread and frequently found in fossil beds and Aboriginal middens, but which has declined markedly in range since European settlement.

Pyura stolonifera (cunjevoi)

On rocky intertidal shores, surfaces for sessile organisms to attach to are often in short supply. Species therefore attach to other species like mussels, kelps or cunjevoi that form biogenic habitat.[94] The presence of biogenic habitat greatly increases species diversity on individual reefs.[95,96]

The cunjevoi (*Pyura stolonifera*) is a large ascidian that forms dense beds on rocky intertidal reefs and

Cluster of sea-squirts (*Pyura stolonifera*) on the seafloor. Photo: Museum Victoria

consolidated sediments from the intertidal zone to a depth of about 12 metres. They are filter-feeders, so tend to be more abundant in areas of strong wave action. *P. stolonifera* are widespread in Port Phillip Bay and dominate the bedforms at all shallow-water sites outside the Geelong Arm, but become less common in deeper waters where fine muds dominate the substrate.[95]

The crevices and gaps among individuals *P. stolonifera* beds provide a sheltered environment for a wide variety of organisms including molluscs, sponges, echinoderms, anemones, crustaceans and algae. Some organisms also live directly on the tests (outer covering) of *P. stolonifera* individuals, including molluscs, algae, polychaetes and isopods, many of which are small and cryptic.[96] Living on and amongst *P. stolonifera* may allow animals and plants to benefit from living in a high-energy environment (i.e. oxygenated water, continuous flow of food) without being subjected to strong wave-action or currents.[96]

Port Phillip Bay Entrance Deep Canyon Marine Community

The Port Phillip Bay Entrance Deep Canyon Marine Community is the second of only two marine communities listed under the *Flora and Fauna Guarantee Act.* The community covers the reef surface at depths below 20-25 metres within a steep-sided underwater canyon more than 90 metres deep at the entrance to Port Phillip Bay. The canyon bisects a plateau of limestone (calcarenite) reefs, up to 17 metres in depth and one kilometre in width, and is the main passageway for the bay's twice-daily tidal exchange. The strong water currents (3-8 knots) have created a unique set of marine habitats and conditions.

This invertebrate community is highly diverse, varied and complex. It is dominated by reef-dwelling sessile invertebrates, chiefly sponges, ascidians, bryozoans, hydrozoans and corals. The sponge gardens, which on average cover 65 per cent of the area, contain over 271 named species of sponges, 115 of which are endemic to the area. This community is also a centre of southern Australian bryozoan diversity, with a greater number of species represented than in the whole of Europe. It is also one of only three areas in Victoria known to support a highly diverse hydrozoan fauna, with the erect hydroids *Nemertesia procumbens, Halopteris glutinosa, Halicornopsis elegans* highly abundant.[97]

The community also differs from other known deep reef communities in south-eastern Australia (e.g. Point Addis, Wilsons Promontory, Twelve Apostles) by the scarcity of gorgonian coral (*Pteronisis* spp.), the absence of the sea whip coral *Primnoella australasiae*, and absence of thallose seaweeds and coralline algae.[93,98]

6.4.7 Fishes

The temperate waters of southern Australia have a remarkable diversity of fish species. At least 1200 marine and 120 estuarine species have been recorded and over 45 per cent of the species found in Australian temperate waters are found nowhere else.[99] Nearly 600 species of teleost (ray-finned) fish and 80 species of chondrichthians (sharks, chimaeras, rays, skates) have been recorded in Victorian marine and estuarine waters.[100,101,102]

Short-finned eel

The short-finned eel (*Anguilla australis*) is a catadromous (hatches in saltwater and matures in freshwater) species that is commonly found in freshwater lakes and wetlands from South Australia to New South Wales. When they reach maturity (at approximately 14 years of age for males and 18-24 years in females),[103,104] the eels cease feeding and migrate downstream and out into the open ocean to breeding sites in the Coral Sea, where they die after spawning.[105,106] The newly hatched larvae drift back to Australia on the South Equatorial and East Australian currents for about six to eight months.[105,106] The larvae metamorphose into glass eels in coastal and estuarine waters. The glass eels then transform into brown elvers as they migrate upstream into freshwater environments.

Short-finned eels are known as 'Kooyang' in the

Bluethroat wrasse, *Notolabrus tetricus* (above) and Old wife, *Enoplosus armatus* (below). Photo: Julian Finn, Museums Victoria

Common seadragon (*Phyllopteryx taeniolatus*) at Flinders Pier. Photo: Mark Norman

Aboriginal languages of southwest Victoria. They are an important part of the National Heritage-listed Budj Bim Landscape which extends from Budj Bim National Park (formerly known as Mount Eccles National Park) along the associated lava flows to the coast. Short-finned eels were actively farmed through a network of traps, channels and holding areas. Eels were smoked and probably traded across the region. The Maar people of the region lived in permanent villages around this important cultural and economic resource.[107,108,109]

Australian bass

The Australian bass (*Macquaria novemaculeata*) is a long-lived species (up to 47 years)[110] endemic to coastal streams from Queensland to Victoria. Adults live in freshwater but move downstream to estuaries to spawn. Juveniles develop in the estuary then migrate back upstream. In recognition of declining populations[110] and to support recreational anglers, the Victorian government has been restocking Australian bass. In 2018, 474,000 bass were stocked into Gippsland rivers.[111]

In the last 40 years, there have been only two major recruitment events in Australian bass. These events were correlated with high river flows and cooler water temperatures in spring.[110] Observations from other coastal rivers in eastern Victoria suggest that successful recruitment of Australian bass is driven by widespread climatic events (i.e. southern coastal low systems) rather than by localised catchment events. The predicted decrease in winter and spring rainfall and warmer temperatures under climate change[112] coupled with increasing river regulation in some systems is likely to have negative impacts on Australian bass population viability.[110]

Common seadragon

The common seadragon (*Phyllopteryx taeniolatus*), formerly weedy seadragon, is a member of the Syngnathidae family which includes pipefishes, pipehorses and seahorses. It is the Victorian marine emblem. The species is endemic to the temperate waters of southern Australia. Brightly-coloured common seadragons are popular with recreational divers.[113] While Flinders pier is a well-known site for the species, they more typically occur in natural habitats such as offshore reefs and in *Amphibolus antarctica* seagrass beds.

Many aspects of their biology render common seadragons highly sensitive to localised impacts. They are relatively weak swimmers and have small home ranges with strong site fidelity.[114] They have limited dispersal potential as the males incubate and tend to eggs attached to their tails in a special brood pouch. Males move into sheltered nursery areas to hatch the eggs, further increasing the chance that juveniles will be retained in their natal habitats.[114] Relative to other fishes, common seadragons have a low reproductive output, with males only able to care for between 250 and 500 eggs a year.[113] A consequence of their limited dispersal capacity is low genetic diversity among populations, particularly in the eastern part of their range.[115]

All syngnathids are protected in Victorian and Commonwealth waters. Like many marine organisms, seadragons are threatened by climate change. Rising sea levels threaten the inshore habitats used for nurseries.[114] However, as seadragons grow faster in warmer waters, warming sea surface temperatures could improve survival of juveniles.[113]

Western blue groper

The western blue groper (*Achoerodus gouldii*) is the largest bony fish found along Australia's southern coast. They live up to 70 years, first starting life as a female before some individuals change sex after about 35 years.[117] Western blue gropers are most abundant on shallow rocky reefs (less than 60 metres) where they show strong fidelity to relatively small home ranges.[118] The combination of being long lived, slow to mature and site attached makes western blue gropers vulnerable to overfishing.[117] First recorded in Victoria in 2011 through the citizen science program the Great Victorian Fish Count, they are now fully protected in Victoria.

Juvenile western blue gropers settle in sheltered environments such as nearshore lagoons or shallow reefs with good cover of macroalgae. As they mature, they gradually move offshore into more exposed habitats.[119] Mature adults spawn in offshore waters from early winter to spring. The prevailing Leeuwin current and weather patterns in spawning areas off Western Australia mean that many teleost fish and invertebrate larvae are carried offshore and eastwards.[117] The Leeuwin current is predicted to continue weakening under climate change which may affect recruitment in eastern populations.

School shark

The school shark (*Galeorhinus galeus*) is a commercially fished shark species that is widely distributed in temperate waters. School sharks are vulnerable to overexploitation as they live for more than 50 years[120] and have limited reproductive potential. Females do not breed until they are at least 10 years old, gestation is six months, average litter size is 26, and females breed only every two to three years.[121] School sharks are subject to commercial fishing in Commonwealth waters and are subject to commercial and recreational fishing pressure across temperate southern Australia. School sharks are managed as a single population in Australian state and Commonwealth waters and have been classified as overfished. In commercial fisheries they are now primarily taken as bycatch for gummy shark (*Mustelus antarcticus*).[122] Recovery of the species in Australian waters is coordinated through the School Shark Rebuilding Strategy.[123]

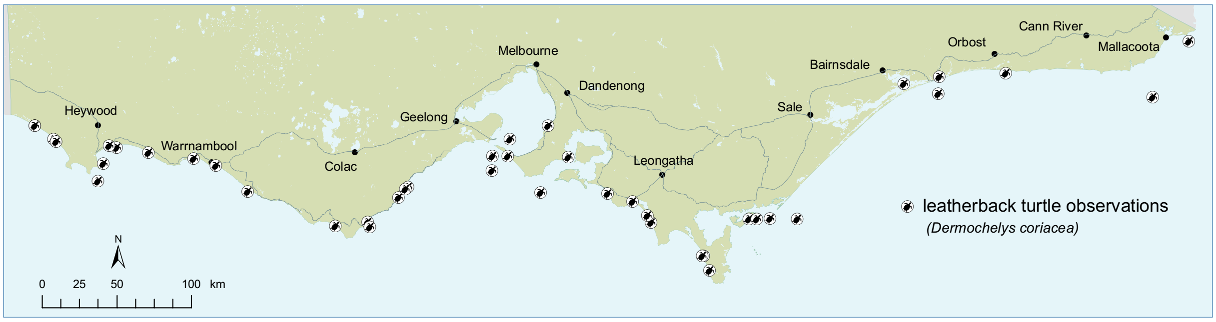
Recovery of the species is complicated by their long-distance movements. School sharks are highly migratory; individual migrations of over 3000 kilometres have been recorded in southern

Australia.[124] Genetic and tagging studies have shown that school sharks regularly move between Australian and New Zealand waters, and suggest that the population should be managed as a single stock.[124,125,126] School sharks in New Zealand are not considered overfished and in 2016/17, 2852 tonnes were landed of a total allowable catch of 3436 tonnes.[127] This highlights the need for international cooperation for listed species' recovery, as for migratory birds.

6.4.8 Marine reptiles

Five conservation-listed marine turtles have been recorded in Victorian waters. Only one, the leatherback or leathery turtle (*Dermochelys coriacea*), regularly occurs in Victoria. The other four species (loggerhead turtle *Caretta caretta*, Pacific ridley turtle *Lepidochelys olivacea*, green turtle *Chelonia* mydas, Hawksbill turtle *Eretmochelys imbricata*) are occasionally sighted as vagrants from warmer waters. Another marine reptile, the yellow-bellied sea snake (*Pelamis platurus*) is also an occasional vagrant. As waters warm and currents alter under climate change[112] the frequency of these sightings may increase.

Figure 6.4 Records for leatherback turtle in Victorian Biodiversity Atlas



Leathery turtles have a worldwide distribution, and occur in the tropical, temperate and sub-polar water of 65 countries. They are not known to breed in Victoria but have been sighted along most of the Victorian coastline during late summer and autumn.[128] Bass Strait is one of only a few key foraging sites identified for the Pacific population of leathery turtles.[129]

The Pacific leathery turtle has shown a 95 per cent decline throughout its range in the last 30 years. One of the major threats to the species comes from marine debris including lost or discarded fishing gear (e.g. discarded nets, crab pots, synthetic ropes, floats, hooks, fishing line and wire trace), land-sourced litter (e.g. plastic bags and bottles) and ship-sourced materials disposed of at sea (e.g. fibreglass, insulation).[128,130,131] Marine debris poses such a threat to marine vertebrates that it was listed as a key threatening process under the EPBC Act in August 2003.[132]

Leathery turtles mainly feed on pelagic invertebrates such as sea jellies. Plastics, particularly soft plastics such as plastic bags, were the most frequently recorded type of marine debris consumed by sea turtles.[133] This is possibly due to soft plastics resembling sea jellies. Ingestion of plastics can prevent sea turtles from feeding, leading to starvation, and can create intestinal blockages that increase buoyancy and stop turtles from diving. Toxic chemicals adhered to ingested plastics, particularly microplastics, can bioaccumulate up the food chain and have severe consequences for species' health and reproductive success.[134]

6.4.9 Seabirds

Seabirds spend much of their time at sea and tend to come to land only to breed. Almost 60 species of seabirds regularly occur in Victoria and nearly 50 additional species have been recorded as vagrants or beach cast specimens.[135] Compared with other bird species, seabird populations are declining rapidly. This decline is particularly linked to interactions with fisheries (especially longline fishing), loss of nesting habitat or nesting disturbances, and pollution.[136,137] There are 35 conservation-listed shorebirds in Victoria (see appendix 3).

Little penguin

The little penguins (*Eudyptula minor*) of Phillip Island support an extensive tourism industry, valued at an estimated $125 million annually in 2012.[138] Because of their high profile, the penguins on Phillip Island have been intensively monitored since 1968.[139] This monitoring program has yielded substantial data on little penguin breeding success and population dynamics,[139,140] foraging behaviour[141] and food web interactions, including how penguins responded to a crash in a key prey species associated with disease[142,143] (see also section 6.3.3). This data set has also enabled predictions of how climate change will impact on little penguins.[138,144]

Little penguins have substantial adaptations to maintain their body temperature while foraging in cool Bass Strait waters. With their specialised waterproof insulative feathers they can maintain their body temperature in water down to about 5°C. Temperature regulation is more challenging on land; little penguin body temperature increases with air temperature. Above about 35°C, little penguins cannot adequately maintain their core temperature for long.[145] Air temperatures in the Bass Coast Shire (including Phillip Island) are ~1.3°C warmer than in 1950.[146] The number of days over 35 degrees has also increased. By 2070, temperatures may increase by up to ~2.6°C and the number of days over 35°C will more than double.[146] Days over 35°C decrease adult penguin survival[138] and may induce nesting penguins to abandon chicks and eggs.[147]

Increased air temperatures when combined with lower rainfall and humidity[146] will increase fire risk in little penguin breeding habitat. Little penguins are particularly vulnerable to fire risk as they are flightless and reluctant to leave their burrows during the day.[138] After fires on Phillip and Seal islands numerous dead chicks and eggs were observed in burrows. Observations of birds nesting under vegetation indicated that adult penguins remained under vegetation until they were severely burnt or killed.[144] As little penguins breed synchronously, the impacts of fires during the breeding season could be particularly detrimental at a population level.

To protect penguin populations and the valuable tourism industry dependent upon them, the risks associated with increased temperatures and fire risk have been mitigated by burying power lines (an ignition risk) on Phillip Island. Other management actions that could assist penguins to adapt to increasing temperatures and fire risk include planting fire-resistant native vegetation in breeding habitats, providing nest boxes that reduce air temperature and prioritising fire response planning.[138]

Short-tailed shearwater. Photo: Mel Mitchell

Penguin parade. Photo: Phillip Island Nature Parks

Short-tailed shearwater

Short-tailed shearwaters (*Ardenna tenuirostris*) are the most abundant seabird in Australia. During the September to April breeding season, millions of shearwaters nest along Australia's south-eastern coast and offshore islands.[148]

Banding and recovery of short-tailed shearwaters has been undertaken by volunteers at Phillip Island since the 1950s and at other breeding colonies along the coast.[149] More recently, lightweight geolocators attached to captured birds have been used to track their long flights. The results from these monitoring programs have contributed to improved understanding of their age profile, migration, foraging and breeding characteristics.

In November, females lay a single egg in burrows up to two metres deep. When the chick hatches in early January both parents feed the chick with krill and small fish larvae caught on short, local trips and longer trips (of up to two weeks' duration).[150] At the end of March, adults make a stopover flight to Antarctica to forage in the cold, highly productive waters before migrating to overwintering grounds in the waters off Japan, the central Aleutian Islands or in the southern Bering Sea, a distance of approximately 11,000 kilometres in only 13 days (840 kilometres per day).[151] Short-tailed shearwater chicks spend a further three to four weeks in their burrows, moulting into adult feathers, before migrating north at the end of April.

In some locations the low-lying burrows of short-tailed shearwater and other beach-nesting birds[152] are threatened with inundation associated with sea-level rise and increases in wave run-up during extreme events.[153]

Once short-tailed shearwaters fledge and are ready to begin their migration, they are faced with another emerging threat, light pollution. Burrow-nesting petrels (including shearwaters and storm-petrels) are nocturnally active at their breeding colonies. This mean that when fledglings leave their nest to begin their migration, they become attracted to artificial light sources. Such attractions render fledglings vulnerable to injury or death by collisions with human infrastructure and once grounded, to predation or becoming road kill. Simple management actions, such as turning road lights off in key areas during the fledging season, can significantly decrease the number of fledglings found on the road.[154]

6.4.10 Shorebirds

Shorebirds are a group of wading birds that feed on swamps, tidal mudflats and beaches. Nearly 10 per cent of Australian birds are shorebirds. Just over 50 species of shorebirds occur regularly in Victoria and more than 20 additional species have been recorded as vagrants or beach cast specimens.[135] Thirty-four of these species are conservation listed, many due to threats to intertidal ecosystems either in Australia or at stopovers along international migratory pathways (see appendix 3).

Bar-tailed godwit

The bar-tailed godwit (*Limosa lapponica*) is a large shorebird (also known as a wader) that breeds in eastern Russia and Alaska between May and August

Hooded plovers. Photo: Mel Mitchell

Bar tailed godwits. Photo: Mel Mitchell

and then migrates to southern Australia and New Zealand for the non-breeding period from December to February. The Victorian subspecies *Limosa lapponica bauera* is a world record-holder for the longest nonstop flight of any land bird, more than 11,000 kilometres.[155] Estuarine mudflats, beaches and mangroves support important feeding and resting areas for godwits to recuperate after losing over 50 per cent of their body weight during their migration. Several internationally important sites for the species are protected in Victoria, including Corner Inlet, where over 10,000 individuals have been recorded,[156] feeding on molluscs, worms and aquatic insects in exposed mud and shallow areas.

The loss of intertidal habitat in the Yellow Sea region of East Asia, a critical stopover area during the northward migration back to breeding areas, has led to population declines in the species.[157] The species has been IUCN Red listed as near threatened. Under the Australian EPBC Act, the subspecies *Limosa lapponica* bauera has been listed as vulnerable and the subspecies L. l. *menzbieri* has been listed as critically endangered, while the parent species is listed only as marine and migratory. The reliance of the bar-tailed godwits on threatened stopover habitats on its long migration highlights the importance of international treaties and partnerships, such as the East Asian-Australasian Flyway Partnership to protect and conserve habitats for migratory species. Bar-tailed godwits are listed and afforded protection under the Bonn, JAMBA, CAMBA and ROKAMBA international treaties.

Hooded plover

Five species of Australian shorebirds nest exclusively or predominantly on beaches: pied oystercatchers (*Haematopus longirostris*), sooty oystercatchers (*H. fuliginosus*), beach stone-curlews (*Esacus magnirostris*), red-capped plovers (*Charadrius ruficapillus*) and hooded plovers (*Thinornis rubricollis*). Each species has slightly differing requirements. Some, such as the sooty oystercatcher, nest on rocky beaches, while others like the beach stone-curlews prefer sheltered beaches with muddy sand and mangroves. The greatest threat to all beach-nesting birds is disturbance by beach users. Unfortunately, most beach-nesting birds breed during spring and summer when more people visit the beach.

Hooded plovers in Victoria are particularly vulnerable to disturbance from beach users, as they nest only on sandy beaches backed by dunes that are exposed to ocean swell. They lay their small eggs directly on the sand in a simple, shallow nest anywhere above the high-tide mark. The eggs are well camouflaged, so can be stepped on and broken.[158] If the parent is scared off the nest, the eggs can become too hot or cold and the developing chick will die. When chicks are disturbed, they hide in sand dunes where they can overheat or starve. If incubating adults are disturbed away from the nest, both eggs and chicks are more vulnerable to predation.[159,160]

Dogs, particularly when they are off lead, disturb nesting hooded plovers. A study of beaches between Cape Otway and Wilsons Promontory, showed that chicks were left 51 per cent of times when off-lead dogs were present, compared with 33 per cent of times with on-lead dogs.[159] Another study, across all Parks Victoria-managed land, found that dogs off lead were 2.5 times more common than dogs on lead.[158] The impact of off-lead dogs was of particular concern in the Mornington Peninsula National Park, where

Hooded plover notification. Photo: Sarah Garnick

Common dolphins. Photo: Mel Mitchell

dogs were not permitted off-lead anywhere, yet were frequently unrestrained. Locations within the national park with the highest frequency off-lead dog use were the locations where hooded plover pairs had the poorest breeding success; 40 per cent of hooded plover pairs in dog-free areas produced chicks successfully compared to just 16 per cent of pairs in dog access areas in the park.[158] To mitigate this threat, and following public consultation, Parks Victoria now prohibit dogs at all times in the national park.

6.4.11 Whales, dolphins and seals

Twenty-nine species of whales and dolphins (cetaceans), and seven species of seals (pinnipeds) live in, or migrate through, Victorian waters. Cetaceans that regularly occur in Victorian waters include the blue whale (*Balaenoptera musculus*), humpback whale (*Megaptera novaeangliae*), killer whale (*Orcinus orca*), long-finned pilot whale (*Globicephala melas*), southern right whale (*Eubalaena australis*), bottlenose dolphin (*Tursiops truncates*), Burrunan dolphin (*T. australis*) and common dolphin (*Delphinus delphis*).[161]

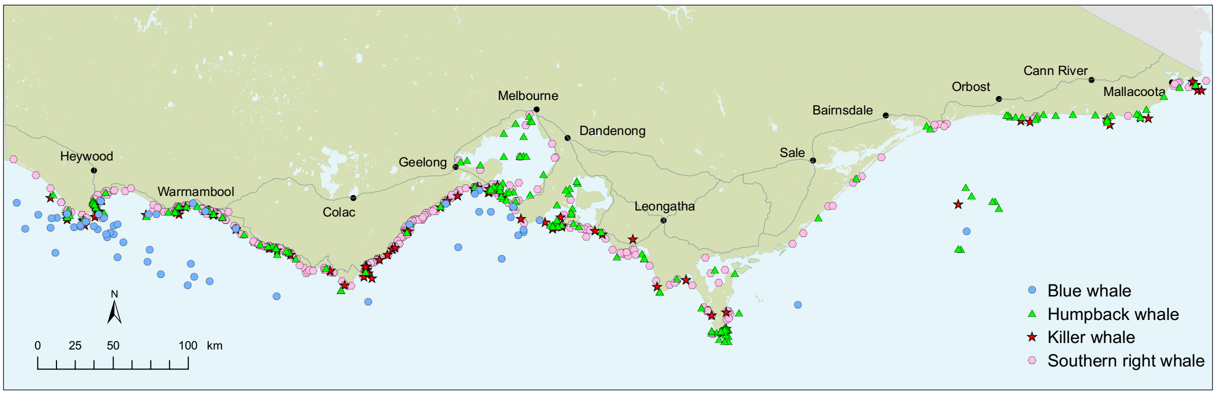
Seven species of seal commonly occur in Victoria. The Australian fur seal (*Arctocephalus pusillus doriferus*) and the Long-nosed fur seal (*A. forsteri*) breed at five and four sites respectively in Victorian waters. A further five species of seals occur less frequently and are not known to breed in Victoria: the Australian sea lion (*Neophoca cinerea*), crab-eater seal (*Lobodon carcinophagus*), leopard seal (*Hydrurga leptonyx*), subantarctic fur seal (*Arctocephalus tropicalis*) and southern elephant seal (*Mirounga leonine*).[162]

Blue whales

Blue whales migrate between breeding grounds at lower latitudes, where both mating and calving takes place during the winter, and feeding grounds at higher latitudes during the summer. Two subspecies of blue whales occur in southern Australian waters: the pygmy blue whale (*B. m. brevicauda*) is the major species in Victorian waters,[163] and the Antarctic blue whale (*B. m. intermedia*) which occurs further south.[164]

The Bonney Upwelling, a seasonally predictable zone of upwelling between Portland, Victoria and Cape Jaffa, South Australia[165] forms a major feeding site for pygmy blue whales between December and May.[163] High primary productivity of phytoplankton in the cold water supports swarms of zooplankton, especially coastal krill (*Nyctiphanes australis*) which is a key prey species for blue whales. Pygmy blue whales migrate from feeding areas in Victoria and Western Australia (Perth Canyon) in May towards breeding grounds that include Indonesia. The southward migration back to feeding grounds begins in September.[166] Because of this migration, blue whales are exposed to threats outside Victoria's and Australia's jurisdiction.

Figure 6.5 Blue whale, humpback whale, killer whale and southern right whale sightings since 1990. Data compiled by Marine Mammal Foundation



Commercial whaling was historically a major source of mortality for blue whales. Through the International Whaling Commission, a moratorium on the harvest of blue whales was signed in 1967 and an international ban on all commercial whaling was instituted in 1986. Prior to whaling, there were approximately 10,000 pygmy blue whales. There is currently insufficient data to estimate the present number of pygmy blue whales.[164] Blue whales reach sexual maturity at 10 years and females then give birth every two to three years after a ten-month gestation period.[167] Due to their relatively long time to reach sexual maturity and low reproductive output, any population recovery to or near pre-exploitation size is likely to be a long process.[168]

While whaling is no longer a current threat in Australian waters, anthropogenic (human-generated) underwater noise is an emerging concern across blue whales' range. Blue whales communicate with powerful, low frequency (10–500 Hz) calls.[169] All sound travels faster through water than air, and low frequency sounds travel further than high frequency ones. Blue whale vocalisations can be detected over hundreds of kilometres in some environments.[170] Anthropogenic noise comes from a variety of sources including seismic surveys for oil, gas and geophysical exploration; industrial development activities such as drilling, pile driving, blasting and dredging; gas processing and shipping.[171] Responses of cetaceans to anthropogenic marine noise include behavioural modification (e.g. avoidance of an area, aggression and calf abandonment), acoustic responses (e.g. changes in type or timing of vocalisations to overcome masking of calls) and physiological (e.g. tissue rupture, hearing loss, disruption of echolocation).[31]

Powerful, low frequency sounds which are rapidly repeated, such as those used by seismic surveys pose the greatest risk to cetaceans.[31,32] While there are policies in place to minimise the impacts of seismic surveys on whales[172] that advise surveys should be undertaken outside of biologically important areas at biologically important times, it is unknown how far from an individual seismic source behavioural impacts may occur.[168] In Victoria, discharge of seismic sources is not allowed within marine national parks and marine sanctuaries. Other sources of marine noise that could impact on blue whales feeding in the Bonney Upwelling include activities at the Port of Portland and ships using the shipping route that runs through the Bonney Upwelling.[168]

Figure 6.6 Burrunan dolphin stranding records since 1990 (n= 43). Stranding records outside of the known range may indicate animals that died outside of their range or could indicate extensions to the known range that require further detailed surveys to confirm. Data compiled by Marine Mammal Foundation

Burrunan dolphin

The Burrunan dolphin is a newly described species of dolphin[173,174] that occurs in two distinct population clusters. One population occurs in Port Phillip Bay and the other extends from the east coast of Tasmania across Bass Strait to the Gippsland Lakes. Recent genetic analysis suggests that there is little contemporary gene flow between the two populations.[175] Due to the species being restricted to a small region of the world and the proximity of the two small populations to anthropogenic pressures[173] the Burrunan dolphin is considered Endangered on the DELWP advisory list and is listed under the Flora and Fauna Guarantee Act.

Because Burrunan dolphins tend to occur in enclosed bays, they are at increased risk from pathogens and contaminants that are transported by stormwater.[176] For example, Indo-Pacific humpbacked dolphins (*Sousa chinensis*) that were stranded shortly after periods of heavy rainfall in Queensland were infected with the land-based parasite *Toxoplasma gondii.*[177] Mercury, which is retained in the marine environment through sediments, has the capacity to bioaccumulate up the food chain from prey to predators.[134] Living and beach-washed dead Burrunan dolphins from both populations, as well as their key prey species, contained levels of mercury within a range known to have multiple health effects.[178]

The Port Phillip Bay population of Burrunan dolphins is exposed to dolphin swim tours. There are currently three licensed dolphin swim tour operators who run four vessels. Each vessel is permitted to conduct a maximum of two trips per day. While the regulations that apply to the industry are currently being revised[179] the maximum number of permits is fixed at four.[180] Between 1998 and 2013, dolphin groups that were frequently exposed to tour vessels showed an increase in boat avoidance behaviours, with smaller groups (1-9 individuals) showing heightened levels of avoidance compared to larger groups (10 or more individuals).[181] While Burrunan dolphins spent less time foraging and more time socialising near tourist vessels, their overall annual allocation of time to these behaviours was unaffected by the presence of tourist vessels.[182] The data indicate that the assumption that tourist vessels have a negative impact on targeted populations may not always hold, especially when appropriately managed in line with regulations.[179]

Burrunan dolphins in Port Phillip Bay. Photo: Marine Mammal Foundation

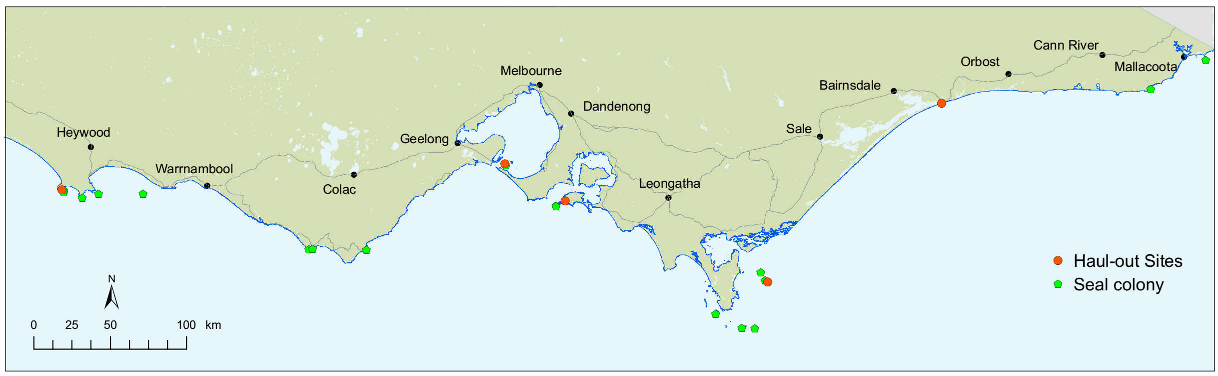
Fur seals

During the late 18th and early 19th centuries seals were heavily hunted, and populations were dramatically reduced. Seal products were one of Australia's first export industries. Populations of fur seals, both Australian and long-nosed fur seals, are gradually recovering but numbers are still below estimates for pre-European settlement. The joint pre-harvest population of both fur seal species has been estimated at 200,000 individuals.[183,184] Recent estimates put the Australian fur seal population in Victoria[184] at about 68,000, vastly outnumbering the long-nosed fur seal population[185] which is estimated to be about 1000. Counts of Australian fur seal pup production across their range[186] in 2013/14 and 2017/18 (R. McIntosh, pers. comm.) indicate that pup production is declining at large colonies but that new, small colonies are increasing.

The most well-known colony of Australian fur seals occurs at Seal Rocks at Phillip Island, where about a quarter of all seals in Victoria are located. This site is the most popular location to view seals. Other breeding colonies are located at Cape Bridgewater, Deen Maar (Lady Julia Percy Island), Kanowna Island, Rag Island, and the Skerries.[186] Seals rest at other non-breeding locations, known as haul-out sites. These are also popular locations for seal watching and include Marengo Reef near Apollo Bay and the Port Phillip Bay seal platform (known as 'Chinaman's Hat'). Other haul-out sites that could support breeding in the future include Moonlight Head and Gabo Island.[162]

Impacts of climate change including sea level rise, increased sea surface temperature and increased extreme events threaten the recovery of fur seals. Fur seals breed on low-lying islands and rocky outcrops. Colonies also tend to occur in areas limited by steep, hinterland slopes, with breeding sites of long-nosed fur seals frequently abutting cliffs. Consequently, increasing sea levels could result in reduced or insufficient space for breeding.[176] When sea temperatures are warmer during the breeding season, fur seals spend more time in the water. This exposes mothers to a higher risk of predation and reduces maternal investment in pups, both of which impact on pup survival.[176,187] Significant numbers of Australian fur seal pups drown when washed into the ocean by high swell and during storms,[188] elevating seal pup mortality rates.

Figure 6.7 Haul-out sites and seal colonies. Data compiled by Marine Mammal Foundation.



6.5 Pests and Diseases

6.5.1 Marine pests

The introduction of exotic organisms into Victorian marine waters is formally listed as a threatening process under the *Flora and Fauna Guarantee Act 1988* (FFG Act). Marine pests can negatively impact both habitats and ecological processes. For example, marine pests may negatively affect denitrification processes conducted by sediment-dwelling infauna by outcompeting or preying on infauna, intercepting organic matter before it reaches the sediment, or increasing organic matter in the water column by injecting wastes directly into the water column.[189]

A 2010 survey found 429 non-native species (introduced and cryptogenic) in Australian and New Zealand waters. Ports are particularly important places for the establishment of non-native species. Hull fouling and ballast water, both largely associated with commercial shipping, are high-risk vectors for the transfer and establishment of non-native marine species. More than half (248 species) of the non-native species recorded in Australian and New Zealand marine waters occurred in major Australian ports.[190]

Currently, Australian waters receive on average one new non-native marine species annually. This is predicted to increase to between five and ten new species annually by 2050. Significant source locations include north east Asia, northern Europe, south east Asia and North America.[191]

At least 160 non-native species have been identified in Port Phillip Bay. In 2004, around 10–15 per cent of the biota in any given taxon was either introduced or not demonstrably native, and in some habitats (e.g. inshore fouling communities), almost all the conspicuous biota was introduced or significantly affected by introduced species.[192]

Parks Victoria have listed introduced species of concern within marine national parks and sanctuaries as part of their marine natural values studies.[193] Introduced plants of concern include the invasive Japanese kelp (*Undaria pinnatifida*) and three other algal species (*Grateloupia turuturu, Caulerpa racemosa* var. *cylindracea* and *Codium fragile* subspecies *fragile*). Introduced animals of concern include two echinoderms (northern Pacific seastar *Asterias amurensis*, New Zealand seastar *Astrostole scabra*), one arthropod (green shore crab *Carcinus maenas*), one annelid (European fan worm *Sabella spallanzanii*), three molluscs (Asian date mussel *Musculista senhousia*, New Zealand screw shell *Maoricolpus roseus*, Pacific oyster *Crassostrea gigas*), and one bryozoan (*Bugula neritina*). These species have all been identified in Victoria, some within marine protected areas, and have potential to spread to further marine protected areas.

Recording the size of northern Pacific seastars (*Asterias amurensis*) found in Wilsons Promontory National Park. Photo: Parks Victoria

Urchin barren, Port Phillip Bay. Photo: Paul Carnell

Priority marine pests that are not yet established in Victoria have also been identified. There are five Asian species (Asian green mussel *Perna viridis*, Asian basket clam *Corbula (Potamocorbula) amurensis*, Chinese mitten crab *Eriocheir sinensis*, longnecked clam *Mya japonica,* veined rapa whelk *Rapana venosa*), one South American species (black striped mussel *Mytilis sallei*), two north American (American slipper limpet *Crepidula fornicata*, soft shell clam *Mya arenari*) and one northern European species (soft shell clam *Mya arenari*).[194] To minimise the risks associated with these and other marine pests, the Australian government, in conjunction with state and territory governments, industry, research organisations and non-government organisations, has released the Marine Pest Plan 2018-2023.[195] The five objectives of the plan are to minimise the risk of marine pest introductions, establishment and spread; strengthen the national marine pest surveillance system; enhance Australia's preparedness and response capability for marine pest introductions; support marine pest biosecurity research and development; and engage stakeholders to better manage marine pest biosecurity.

Sea urchins

Native species can also behave like pests if they are introduced outside of their normal range or if constraints to population growth, such as predation or food availability, are eased. For example, the black sea urchin (*Centrostephanus rodgersii)* has expanded its range from central and southern New South Wales to eastern Victoria and Tasmania in response to warming of sea surface temperatures and strengthening of the East Australian Current. This species forms barrens that are devoid of habitat-forming macroalgae such as kelp, which is the preferred food of commercially important black-lip abalone (*Haliotis rubra*).[196] Evidence from Tasmanian marine protected areas indicates that large rock lobsters *(Jasus edwardsii)* can effectively control *C. rodgersii* populations through predation and allow the re-emergence of kelp and abalone.[197] The Victorian species of white sea urchin (*Heliocidaris erythrogramma*) has also been increasing in abundance and forming barrens, especially in the northern parts of Port Phillip Bay.[193]

Undaria

Undaria pinnatifida, also known as Wakame or Japanese kelp, is an introduced kelp. It was first detected in 1996 near Point Wilson[198] and has progressively become established in all three of Port Phillip Bay's marine sanctuaries (Point Cooke, Jawbone and Ricketts Point) and Portsea Hole in the Port Phillip Heads Marine National Park. It was detected in Western Port but successfully eradicated.[199] *U. pinnatifida* has also become established at Apollo Bay. There is substantial concern about the spread of the species outside of Port Phillip Bay and Apollo Bay,[200] particularly about the impact of invasive kelp on native macroalgal community structure.[201]

Black sea urchin (*Centrostephanus rodgersii*) off Gabo Island. Photo: Bill Boyle

Japanese kelp (*Undaria pinnatifida*) at Popes Eye. Photo: Parks Victoria

As *U. pinnatifida* almost exclusively colonises bare substrate, native kelp can generally outcompete the species.[40] However, when native kelp forests are defoliated through processes such as urchin overgrazing leading to barrens (e.g. *Heliocidaris erythrogramma* in Port Phillip Bay)[200] or dieback, faster-growing invasive kelps can take over.[40] Once established, *U. pinnatifida* is challenging to eradicate199,202 and the costs are unlikely to justify the result.[200] Instead it has been suggested that management efforts focus on processes that initially disturb the seaweed canopy (e.g. urchin grazing) to prevent *U. pinnatifida* establishing in the first place.[200]

Spartina

Coastal saltmarshes are among the most invaded plant communities in Victoria. Of the 249 plant species that have been documented in these communities, some 118 (47 per cent) are exotic. The most concerning weed species include cord grass (*Spartina anglica and S. x townsendii*), tall wheat-grass (*Lophopyrum ponticum*), barb-grass (*Parapholis incurva and P. strigosa*), sea barley-grass (*Hordeum marinum*) and spiny rush (*Juncus acutus acutus*).[75] The impacts of cord grass are so great that the introduction and spread of *Spartina* to estuaries has been listed as a threatening process under the FFG Act. Tall wheat grass is promoted by government agencies for establishment on saline soils as a pasture species but is a weed species of concern in saltmarsh, as it causes major shifts in floristic compositions, local extinctions of native plant species and changes ecosystem function.[203]

Spartina (*Spartina anglica* and *S. x townsendii*) is an emergent saltmarsh grass that colonises the intertidal zone of temperate estuaries, inlets and waterways. Infestations can form dense aggregations of culms, rhizomes and roots that promote sediment accretion and channelisation and alter hydrology. While intertidal mudflat habitats are most commonly invaded, saltmarsh, mangrove and intertidal seagrass habitats are also impacted.[204,205] These changes have negative impacts on native macroinvertebrates, fish and shorebirds.[204,205,206]

6.5.2 Terrestrial pests

Weeds

There are no published estimates of the number of weed species in coastal Victoria. However, 67 per cent of the 1786 weed species on DELWP's advisory list of environmental weeds in Victoria[207] occur in either coasts and heaths or aquatic biomes. General impacts of weeds in coastal environments include competitive replacement of native taxa, negative impacts on sediment deposition and accretion, negative impacts on faunal habitat (e.g. colonisation of subtidal zones and bare mudflats where shorebirds forage) and biogeochemical effects (e.g. higher nitrogen and phosphorus but lower pH in *Spartina* encroached sediments).[208]

Marram grass (*Ammophila arenaria*) and sea wheat-grass (*Thinopyrum junceiforme*) were deliberately introduced from Europe for dune stabilisation. Species like these alter the structure of the beach and foredune habitats. This negatively impacts on the resources available to beach-nesting birds such as the hooded plover (*Thinornis rubricollis*). Weed encroachment can lead to birds building nests in sub-optimal habitats, which are then at greater risk of inundation.[209]

Pest mammals

Pest mammals cause two broad types of impacts to coastal environments: trampling and grazing vegetation, and preying on mammals, birds and reptiles. A range of introduced herbivores (e.g. sambar deer *Cervus unicolor*, hog deer *Cervus porcinus*, goats, brown hare *Lepus capensis*, and European rabbit *Oryctolagus cuniculus*), as well as domestic stock (horses, cattle, and sheep) graze in coastal saltmarsh. Many saltmarsh species are slow growing, and so take a long time to recover from impacts like grazing. Grazing opens up areas between individual plants, disturbs the soil, facilitates establishment of weeds and causes changes in species composition from more palatable to less palatable species. Trampling of vegetation by hard-hooved animals causes pugging of sensitive soils and sediments. Local accumulations of nutrients associated with urine and faeces can also cause changes in saltmarsh community composition.[75]

Predation by domestic and feral mammal species (e.g. pigs, dogs, foxes, cats and rats) leads to decreased populations of beach-nesting animals. Pest mammals prey on all life stages of vulnerable food species including eggs, hatchlings/nestlings and adults. In recognition of the severity of these impacts, predation of native wildlife by introduced or feral species (fox and cat) have been formally listed as threatening processes under the FFG Act. In response to these threats, agencies have put control programs in place. These include cat control programs on Phillip and French Islands, and rat removal on some coastal islands to protect seabirds.

Seabirds are particularly vulnerable to mammalian predation as they nest at ground level, leave nests unattended for long periods during foraging trips and have low annual productivity.[136] In western Victoria maremma guardian dogs are used to protect seabird colonies from fox predation. At Warrnambool, foxes had reduced penguin numbers on Middle Island to less than ten animals in 2005, down from a previous estimate of over 1000. With maremma dogs guarding the penguin colony in the breeding season, penguin numbers have increased. Following the success of the project additional maremma dogs have been used to protect Australasian gannets at Point Danger. In 2007, no gannet chicks successfully fledged despite a successful breeding season at a nearby offshore island (Lawrence Rocks). Since the introduction of the maremma dogs the breeding success of gannets has increased.[210]

6.5.3 Pathogens

Pathogens include all organisms (e.g. bacteria, viruses and parasites) capable of causing disease. In the marine environment, pathogens and infected individuals can be transmitted to new areas through a variety of vectors including unwashed recreational equipment (boat, personal water craft, dive/snorkelling gear), shipping traffic (diseased species fouling boats, ballast water discharges), discarded bait/fishing gear, aquaculture and through natural species movement (potentially increased through climate change impacts). The environmental and economic impacts of novel pathogens can be profound.

In 1995, Australasian pilchards (*Sardinops sagax*) experienced the largest mass mortality event of a single marine fish species ever recorded in Australian waters.[211,212] The population crash was attributed to a novel herpes-type virus,[211] which possibly arrived in Australia in imported frozen *S. sagax* meal used in tuna aquaculture operations off the South Australian coast. Pilchards are a key prey item for little penguins (*Eudyptula minor*).[142] Following the crash in pilchard numbers, the penguin population on Phillip Island declined significantly.[143] The decline in penguin numbers was related to low recruitment success due to food scarcity.[142]

In 2006, a herpes-like virus caused mass mortalities in several abalone aquaculture farms in south-west and central Victoria. Abalone viral ganglioneuritis was also found in wild populations and spread more than 200 kilometres along the Victorian coast. The impacts of this disease, which caused up to 90 per cent mortality in impacted populations, included significant financial losses to aquaculture facilities as well as to the commercial fishing industry.[213]

6.6 References

1. United Nations (1992) *Convention on biological diversity.* United Nations, New York. https://www.cbd.int/
2. Morton S and Hill R (2014) What is biodiversity, and why is it important? In: *Biodiversity: science and solutions for Australia.* Morton SR, Sheppard AW and Lonsdale WM (eds). CSIRO Publishing, Collingwood. Pages 1–12.
3. Millenium Ecosystem Assessment (2005) *Ecosystems and human well-being: synthesis.* Island Press, Washington DC.
4. Glasby CJ and Alvarez B (1999) Distribution patterns and biogeographic analysis of Austral Polychaeta (Annelida). *Journal of Biogeography* 26: 507-533.
5. Scott FJ (2012) *Rare marine macroalgae of southern Australia.* PhD Thesis. University of Tasmania.
6. O'Hara TD and Poore GC (2000) Patterns of distribution for southern Australian marine echinoderms and decapods. *Journal of Biogeography* 27: 1321-1335.
7. O'Hara TD (2002) Endemism, rarity and vulnerability of marine species along a temperate coastline. *Invertebrate Systematics* 16 671-684.
8. Butler AJ, Rees T, Beesley P and Bax NJ (2010) Marine biodiversity in the Australian region. *PLoS ONE*, 5, e11831.
9. Phillips JA (2001) Marine macroalgal biodiversity hotspots: Why is there high species richness and endemism in southern Australian marine benthic flora? *Biodiversity and Conservation* 10: 1555-1577.
10. Jenkins G (2013) *Assessment of anthropogenic threats to marine protected areas in Victoria.* Technical report to Victorian Environmental Assessment Council. University of Melbourne, Melbourne. http://www.veac.vic.gov.au/documents/VEAC%20risk%20assessment%20Zoology%20Technical%20Report_Final.pdf
11. Victorian National Parks Association (2014) *Natural Victoria: conservation priorities for Victoria's natural heritage. Nature conservation review.* Full report. Victorian National Parks Association, Melbourne. https://vnpa.org.au/publications/nature-conservation-review-2014/
12. Commissioner for Environmental Sustainability (2018) *Victorian State of the Environment Report 2018*. Commissioner for Environmental Sustainability, Melbourne.
13. McGregor A, Coffey B, Deutsch C, Wescott G and Robinson J (2008) *Ecological processes in Victoria: policy priorities for sustaining biodiversity.* Report for Victoria Naturally Alliance, Melbourne.
14. Longmore A (2014) *Spatial and temporal scales of key ecological processes in marine protected areas.* Fisheries Victoria Science report series # 4. http://www.veac.vic.gov.au/documents/Longmore%202014%20Spatial%20and%20temporal%20scales%20of%20key%20ecological%20processes.pdf
15. Edmunds M, Mustoe S, Stewart K, Sheedy E and Ong J (2010) *VNPA Nature Conservation Review: Marine conservation priorities and issues for Victoria.* Australian Marine Ecology Report #405 to Victorian National Parks Association, Melbourne.
16. Environment Conservation Council (2000) *Marine, coastal and estuarine investigation.* Final Report. Environment Conservation Council, East Melbourne.
17. Jones A, Gladstone W and Hacking N (2007) Australian sandy-beach ecosystems and climate change: Ecology and management. *Australian Zoologist,* 34, 190-202.

18. Davey A and Woelkerling WJ (1980) Studies on Australian mangrove algae. I. Victorian communities: Composition and geographic distribution. *Proceedings of the Royal Society of Victoria* 91: 53-66.
19. Coleman N, Gason ASH and Poore GCB (1997) High species richness in the shallow marine waters of south-east Australia. *Marine Ecology Progress Series* 154: 17-26.
20. Edmunds M and Flynn A (2018) *CBiCS classification of Victorian biotopes.* Australian Marine Ecology report #560 to Department of Environment, Land, Water and Planning, Melbourne.
21. Smyth C (2014) *The coast is unclear: An uncertain future for nature along the Victorian coast.* Report prepared for the Victorian National Parks Association, Melbourne. https://vnpa.org.au/wp-content/uploads/2017/02/The-Coast-is-Unclear.pdf
22. Department of Sustainability and Environment (2013) *Advisory list of threatened vertebrate fauna in Victoria.* Department of Sustainability and Environment, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists
23. Department of Sustainability and Environment (2009) *Advisory list of threatened invertebrate fauna in Victoria.* Department of Sustainability and Environment, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists
24. Department of Environment and Primary Industries (2014) *Advisory list of rare or threatened plants in Victoria-* 2014. Department of Environment and Primary Industries, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists
25. Murphy HM, Jenkins GP, Hamer PA and Swearer SE (2011) Interannual variation in larval survival of snapper (*Chrosophrys auratus, Sparidae*) is linked to diet breadth and prey availability. *Canadian Journal of Fisheries and Aquatic Sciences* 69: 1340-1351.
26. Wright SL, Thompson RC, Galloway TS (2013) The physical impacts of microplastics on marine organisms: A review. *Environmental Pollution* 178: 483-492.
27. Bhargava S, Lee SSC, Ying LSM, Neo ML, Teo SL-M and Valiyaveettil S (2018) Fate of nanoplastics in marine larvae: A case study using barnacles *Amphibalanus amphitrite. ACS Sustainable Chemistry and Engineering* 6: 6932-6940.
28. Hirai H, Takada H, Ogata Y, Yamashita R, Mizukawa K, Saha M, Kwan C, Moore C, Gray H, Laursen D, Zettler ER, Farrington JW, Reddy CM, Peacock EE and Ward MW (2011) Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. *Marine Pollution Bulletin* 62: 1683-1692.
29. Cole M, Lendeque P, Fileman E, Halsband C, Goodhead R, Moger J and Galloway TS (2013) Microplastic ingestion by zooplankton. *Environmental Science and Technology* 47: 6646-6655.
30. Bergami E, Pugnalini S, Vannuccini ML, Manfra L, Faleri C, Savorelli F, Dawson KA and Corsi I (2017) Long-term toxicity of surface-charged polystyrene nanoplastics to marine planktonic species *Dunaliella tertiolecta and Artemia franciscana. Aquatic Toxicology* 189: 159-169.
31. Nowacek DP, Thorne LH, Johnston DW and Tyack PL (2007) Responses of cetaceans to anthropogenic noise. *Mammal Review* 37: 81–115.
32. Di Iorio L and Clark CW (2010) Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters* 6: 51–54.
33. Day RD, McCauley RD, Fitzgibbon QP, Hartmann K and Semmens JM (2017) Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop *Pecten fumatus. Proceedings of the National Academy of Sciences* 114: E8537-E8546.
34. McCauley RD, Day RD, Swadling KM, Fitzgibbon QP, Watson RA and Semmens JM (2017) Widely used marine seismic survey air gun operations negatively impact zooplankton. *Nature Ecology and Evolution* 1: 0195.
35. Algaebase (2018) http://www.algaebase.org/
36. Diaz-Pulido G and McCook L (2008) Macroalgae (seaweeds) In: *The state of the Great Barrier Reef (on-line)*. Chin A (ed.). Great Barrier Reef Marine Park Authority, Townsville. http://www.gbrmpa.gov.au/corp_site/info_services/publications/sotr/downloads/SORR_Macroalgae.pdf
37. Land Conservation Council (1993) *Marine and coastal special investigation.* Descriptive report. Land Conservation Council, Melbourne.
38. Kirkman H and Kendrick GA (1997) Ecological significance and commercial harvesting of drifting and beach-cast macro-algae and seagrasses in Australia: A review. *Journal of Applied Phycology* 9: 311-326.
39. Keough MJ and Quinn GP (1998) Effects of periodic disturbances from trampling on rocky intertidal algal beds. *Ecological Applications* 8: 141-161.
40. Valentine JP and Johnson CR (2004) Establishment of the introduced kelp *Undaria pinnatifida* following dieback of the native *macroalga Phyllospora comosa* in Tasmania, Australia. *Marine and Freshwater Research* 55: 223-230.
41. Chidgey SS and Edmunds MJ (1996) Standing crop and nutrient content of *macrophytes in Port Phillip Bay.* Port Phillip Bay Environmental Study Technical Report No 32. CSIRO Environmental Projects Office, Melbourne.
42. Graham MH, Vásquez JA and Buschmann A (2007) Global ecology of the giant kelp Macrocystis: *From ecotypes to ecosystems. Oceanography and Marine Biology: An Annual Review* 45: 39-88.
43. Dayton PK (1985) Ecology of kelp communities. *Annual Review of Ecology and Systematics* 16: 215-245.
44. Edyvane K (2003) Conservation, *monitoring and recovery of threatened giant kelp* (Macrocystis pyrifera) beds in Tasmania. Report to Environment Australia. Department of Primary Industries, Water and Environment, Tasmania.

45. Gilmour P, Edmunds M, Stewart K and Monk J (2007) Victorian *subtidal reef monitoring program: The reef biota at Port Phillip Heads Marine National Park* (Volume 3). Parks Victoria Technical Series No. 49. Parks Victoria, Melbourne.
46. Wernberg T, Campbell A, Coleman MA, Connell SD, Kendrick GA, Moore PJ, Russell BD, Smale DA and Setinberg PD (2009) Macroalgae and temperate rocky reefs. Marine climate change in Australia: impacts and adaptation measures 2009 report card. In: *Marine climate change in Australia.* Poloczanska ES, Hobday AJ and Richardson AJ (eds) National Climate Change Adaptation Research Facility, Gold Coast.
47. Ling SD, Johnson CR, Frusher SD and King CK (2008) Reproductive potential of a marine ecosystem engineer at the edge of a newly expanded range. *Global Change Biology* 14: 907-915.
48. Foster MS (2001) Rhodoliths: between rocks and a hard place. *Journal of Phycology* 37: 659-667.
49. Harvey AS and Bird FL (2008) Community structure of a rhodolith bed from cold-temperate waters (southern Australia). *Australian Journal of Botany* 56: 437-450.
50. Boreen T, James N, Wilson C and Heggie D (1993) Surficial coolwater carbonate sediments on the Otway continental margin, southeastern Australia. *Marine Geology* 112: 35–56.
51. Harvey AS, Harvey RM and Merton E (2017) The distribution, significance and vulnerability of Australian rhodolith beds: a review. *Marine and Freshwater Research* 68: 411–428.
52. Holmes KW, Grove SL, Van Niel KP and Kendrick GA (2007) *Mapping the benthos in Victoria's marine national parks: Point Addis Marine National Park* (Volume 3). Parks Victoria Technical Series No. 42. Parks Victoria, Melbourne. https://parkweb.vic.gov.au/park-management/environment/research-and-scientific-management/technical-series2
53. Jenkins G, Kenner T and Brown A (2013) *Determining the specificity of fish–habitat relationships in Western Port.* Centre for Aquatic Pollution Identification and Management Technical Report #26 for Melbourne Water, Melbourne.
54. Daume S, Brand-Gardner S and Woelkerling WJ (1999) Settlement of abalone larvae (*Haliotis laevigata Donovan*) in response to non-geniculate coralline red algae (Corallinales, Rhodophyta). *Journal of Experimental Marine Biology and Ecology* 234: 125–143.
55. Scientific Working Group (2011) *The vulnerability of coastal and marine habitats in South Australia.* Marine Parks. Department of Environment, Water and Natural Resources, South Australia.
56. Warry FY and Hindell JS (2009) *Review of Victorian seagrass research with emphasis on Port Phillip Bay.* Arthur Rylah Institute for Environmental Research. Department of Sustainability and Environment, Heidelberg.
57. Jenkins G, Keough M, Ball D, Cook PLM, Ferguson A, Gay J, Hirst A, Lee R, Longmore AR, Macreadie P and Nayar S (2015) *Seagrass resilience in Port Phillip Bay.* Final report to the Seagrass and Reefs Program for Port Phillip Bay. University of Melbourne, Melbourne https://cpb-ap-se2.wpmucdn.com/blogs.unimelb.edu.au/dist/e/127/files/2015/11/Seagrass-Resilience_Finalreport-1fwc2xm.pdf.
58. Blandon A and zu Ermgassen PSE (2014) Quantitative estimate of commercial fish enhancement by seagrass habitat in southern Australia. *Estuarine, Coastal and Shelf Science* 141: 1-8.
59. Jenkins GP, May HMA, Wheatley MJ and Holloway MG (1997) Comparison of fish assemblages associated with seagrass and adjacent unvegetated habitats of Port Phillip Bay and Corner Inlet, Victoria, Australia, with emphasis on commercial species. *Estuarine, Coastal and Shelf Science* 44: 568-588.
60. Heck KL, Hays G and Orth RL (2003) Critical evaluation of the nursery role hypothesis for seagrass meadows. *Marine Ecology Progress Series* 253: 123-136.
61. Walker DI (2011) Seagrasses. In: *Understanding the Western Port environment: A summary of current knowledge and priorities for future research.* Keough M and Bathgate R (eds.). Melbourne Water Corporation, Melbourne. https://www.melbournewater.com.au/community-and-education/about-our-water/rivers-and-creeks/western-port-environment-research
62. Bayraktarov E, Saunders MI, Abdullah S, Mills M, Beher J, Possingham HP, Mumby PJ and Lovelock CE (2016) The cost and feasibility of marine coastal restoration. *Ecological Applications* 26: 1055-1074.
63. Ball D, Soto-Berelov M and Young P (2014) Historical seagrass mapping in Port Phillip Bay, Australia. *Journal of Coastal Conservation* 18: 257-272.
64. Waycott M, Duarte CM, Carruthers TJB, Orth RJ, Dennison WC, Olyarnik S, Calladine A, Fourqurean JW, Heck KL, Hughes AR, Kendrick GA, Kenworthy WJ, Short FT and Williams SL (2009) Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences of the United States of America* 106: 12377-12381.
65. Department of Sustainability and Environment (2004) *Ecological vegetation class (EVC) benchmarks.* Department of Sustainability and Environment, Melbourne. https://www.environment.vic.gov.au/biodiversity/bioregions-and-evc-benchmarks
66. Saintilan N and Williams RJ (1999) Mangrove transgression into saltmarsh environments in south-east Australia. *Global Ecology and Biogeography* 8: 117–124.
67. Rogers K, Saintilan N and Heijnis H (2005) Mangrove encroachment of salt marsh in Western Port Bay, Victoria: the role of sedimentation, subsidence, and sea level rise. *Estuaries* 28: 551–559.
68. Morrisey DJ, Swales AW, Dittmann S, Morrison MA, Lovelock CE and Beard CM (2010) The ecology and management of temperate mangroves. *Oceanography and Marine Biology: An Annual Review* 48: 43-160.
69. Satumanatpan S and Keough MJ (1999) Role of settlement in determining the distribution and abundance of barnacles in a temperate mangrove forest. *Journal of Experimental Marine Biology and Ecology* 241: 45-66.
70. Hindell JS and Jenkins GP (2004) Spatial and temporal variability in the assemblage structure of fishes associated with

mangroves (*Avicennia marina*) and intertidal mudflats in temperate Australian embayments. *Marine Biology* 144: 385–395.

71. Duarte CM, Losada IJ, Hendriks IE, Mazarrasa I and Marba N (2013) The role of coastal plant communities for climate change mitigation and adaptation. *Nature Climate Change* 3: 961–8.
72. Dittmann S (2011) Mangroves. In: *Understanding the Western Port environment: A summary of current knowledge and priorities for future research.* Keough M and Bathgate R (eds.). Melbourne Water Corporation, Melbourne. https://www.melbournewater.com.au/community-and-education/about-our-water/rivers-and-creeks/western-port-environment-research
73. Department of Sustainability and Environment (2012) *A field guide to Victorian wetland ecological vegetation classes for the index of wetland condition.* 2nd edition. Arthur Rylah Institute for Environmental Research. Department of Sustainability and Environment, Heidelberg. https://iwc.vic.gov.au/docs/DSE-EVCphotoguideRevised-web.pdf
74. Victorian Environmental Assessment Council (2016) *Statewide assessment of public land. Discussion paper.* Victorian Environmental Assessment Council, Melbourne. http://www.veac.vic.gov.au/investigation/statewide-assessment-of-public-land/reports
75. Boon P, Allen T, Brook J, Carr G, Frood D, Harty C, Hoye J, McMahon A, Matthews S, Rosengren N, Sinclair S, White M and Yugovic J (2011) *Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management.* Institute for Sustainability and Innovation. Victoria University, Melbourne.
76. Ewers Lewis CJ, Carnell PE, Sanderman J, Baldock JA and Macreadie PI (2018) Variability and vulnerability of coastal 'blue carbon' stocks: A case study from Southeast Australia. *Ecosystems* 21: 263-279.
77. McLeod E, Chmura GL, Bouillon S, Salm R, Bjork M, Duarte CM, Lovelock CE, Schlesinger WH and Silliman BR (2011) A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO^2. *Frontiers in Ecology and the Environment* 9: 552–60.
78. Schlesinger WH, Lichter J (2001) Limited carbon storage in soil and litter of experimental forest plots under increased atmospheric CO2. *Nature* 411: 466–9.
79. Ponder W, Hutchings P and Chapman R (2002) *Overview of the conservation of Australian marine invertebrates.* A report for Environment Australia. http://malsocaus.org/marine_invert/contents.html
80. O'Hara T and Barmby V (2000*) Victorian marine species of conservation concern: molluscs, echinoderms and decapod crustaceans.* Parks, Flora and Fauna Division, Department of Natural Resources and Environment, Melbourne.
81. Heislers S and Parry GD (2007) *Species diversity and composition of benthic infaunal communities found in marine national parks along the outer Victorian coast.* Parks Victoria Technical Series No. 53. Parks Victoria, Melbourne. https://parkweb.vic.gov.au/park-management/environment/research-and-scientific-management/technical-series2
82. Butler S and Bird FL (2010) *Monitoring the macroinvertebrates and soft sediments in the marine national parks in Western Port.* Parks Victoria Technical Series No. 60. Parks Victoria, Melbourne. https://parkweb.vic.gov.au/park-management/environment/research-and-scientific-management/technical-series2
83. Webb A and Eyre B (2004) Effect of natural populations of burrowing thalassinidean shrimp on sediment irrigation, benthic metabolism, nutrient fluxes and denitrification. *Marine Ecology Progress Series* 268: 205-220.
84. Kristensen E, Penha-Lopes G, Delefosse M, Valdemarsen T, Quintana CO and Banta GT (2012) What is bioturbation? The need for a precise definition for fauna in aquatic sciences. *Marine Ecology Progress Series* 446: 285-302.
85. Harris G, Batley G, Fox D, Hall D, Jernakoff P, Molloy R, Murray A, Newell B, Parslow J, Skyring G and Walker S (1996) *Port Phillip Bay Environmental Study.* Final Report. CSIRO, Canberra.
86. Ford JR and Hamer P (2016) The forgotten shellfish reefs of coastal Victoria: documenting the loss of a marine ecosystem over 200 years since European settlement. *Proceedings of the Royal Society of Victoria* 128: 87-105.
87. Bathgate RS (2010) *Ecological processes and connectivity of gastropod populations in a system of marine protected areas.* PhD thesis, Department of Zoology, University of Melbourne.
88. Lindsay MJ (2013) *The influences of Wilsons Promontory oceanography on regional phylogeography and larval settlement.* PhD thesis, Department of Zoology, University of Melbourne.
89. Guinotte JM and Fabry VJ (2008) Ocean acidification and its potential effects on marine ecosystems. *Annuals of the New York Academy of Sciences* 1134: 320-342.
90. Parker LM, Ross PM, O'Connor WA, Portner HO, Scanes E and Wright JM (2013) Predicting the response of molluscs to the impact of ocean acidification. *Biology* 2: 651-692.
91. Burn R (2006) A checklist and bibliography of the Opisthobranchia (Mollusca: Gastropoda) of Victoria and the Bass Strait area, south-eastern Australia. *Museum Victoria Science Reports* 10: 1–42. http://www.museum.vic.gov.au/sciencereports/
92. Department of Sustainability and Environment (2003) *San Remo Marine Community.* Flora and Fauna Guarantee Action Statement # 18. Department of Sustainability and Environment, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/flora-and-fauna-guarantee-act-1988/action-statements
93. Scientific Advisory Committee (2013) *Flora and Fauna Guarantee - characteristics of threatened communities* https://www.environment.vic.gov.au/conserving-threatened-species/flora-and-fauna-guarantee-act-1988
94. Jones CG, Lawton JH and Shachak M (1994) Organisms as ecosystem engineers. *Oikos* 69: 373–386.
95. Cohen BF, Currie DR and McArthur MA (2000) Epibenthic community structure in Port Phillip Bay, Victoria, Australia. *Marine and Freshwater Research* 51: 689-702.
96. Monteiro SM, Chapman MG and Underwood AJ (2002) Patches of the ascidian *Pyura stolonifera* (Heller, 1878): structure of

habitat and associated intertidal assemblages. *Journal of Experimental Marine Biology and Ecology* 270: 171– 189.

97. Zavalas R, Pritchard K, Lincoln Smith M, O'Donnell P, Nicastro A and Blount C (2015) *Six year post- construction survey of deep reef habitat at the entrance to Port Phillip Bay.* Report to Port of Melbourne Corporation. Professional Marine Science Services, Melbourne. https://www.parliament.vic.gov.au/images/stories/committees/pomsc/Transcripts/cdp-deep-reef_habitat-six-years-report.pdf
98. Barton J, Pope A and Howe S (2012) *Marine natural values study Vol 2: Marine protected areas of the Victorian embayments bioregion, Part 1 Port Phillip Bay.* Parks Victoria Technical Series No. 77. Parks Victoria, Melbourne. https://parkweb.vic.gov.au/park-management/environment/research-and-scientific-management/technical-series2
99. Hoese DF, Bray DJ, Paxton JR and Allen GR (2006) Fishes. In: *Zoological Catalogue of Australia.* Beesley PL, Wells A. (eds). Volume 35. ABRS and CSIRO Publishing: Australia. Parts 1-3: 1-2178.
100. Atlas of Living Australia (2018) http://www.ala.org.au
101. Australian Faunal Directory (2018) Australian Biological Resources Study. Canberra http://www.environment.gov.au/science/abrs/online-resources/fauna
102. Museums Victoria and OzFishNet (2018) *Fishes of Australia* http://fishesofaustralia.net.au/
103. Todd PR (1980) Size and age of migrating New Zealand freshwater eels (*Anguilla* spp.). *New Zealand Journal of Marine and Freshwater Research* 14: 283-293.
104. De Silva SS, Gunasekera RM and Collins RO (2002) Some morphometric and biochemical features of ready–to–migrate silver and pre–migratory yellow stages of the shortfin eel of south–eastern Australian waters. *Journal of Fish Biology* 61: 915-928.
105. Arai T, Otake T, Jellyman DJ and Tsukamoto K (1999) Differences in the early life history of the Australasian short-finned eel *Anguilla australis* from Australia and New Zealand, as revealed by otolith microstructure and microchemistry. *Marine Biology* 135: 381-389.
106. Shiao J-C, Tzeng W-N, Collins A and Jellyman DJ (2001) Dispersal pattern of glass eel stage of *Anguilla australis* revealed by otolith growth increments. *Marine Ecology Progress Series* 219: 241-250.
107. Framlingham Aboriginal Trust and the Winda Mara Aboriginal Corporation (2004) *Kooyang Sea Country Plan.* Report prepared by Smyth and Bahrdt Consultants on behalf of the Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/kooyang-sea-country-plan/
108. Drew MM, Koehn J, Clunie P and McCristal N (2008) *A guide to the management of native fish: Victorian coastal rivers, estuaries and wetlands.* Arthur Rylah Institute for Environmental Research and Corangamite Catchment Management Authority. Department of Sustainability and Environment, Victoria. http://www.ccmaknowledgebase.vic.gov.au/resources/NativeFishGuide.pdf
109. Gunditj Mirring Traditional Owners Aboriginal Corporation (2013) Cultural features of the Budj Bim Landscape: Short-finned eel (*Kooyang*). Gunditj Mirring Partnership Project Fact Sheet. https://www.gunditjmirring.com/gunditj-mirring-fact-sheets?lightbox=i172ly
110. Stoessel DJ, Morrongiello JR, Raadik TA, Lyon J and Fairbrother P (2018) Is climate change driving recruitment failure in Australian bass Macquaria novemaculeata in southern latitudes of the species range? *Marine and Freshwater Research* 69: 24-36.
111. Ho HK, Douglas J and Forster A (2018) Vic Fish Stock 2018, Victorian Fisheries Authority, Melbourne. https://vfa.vic.gov.au/recreational-fishing/fish-stocking#
112. Grose M, Abbs D, Bhend J, Chiew F, Church J, Ekstrom M, Kirono D, Lenton A, Lucas C, McInnes K, Moise A, Monselesan D, Mpelasoka F, Webb L and Whetton P (2015) Southern slopes cluster report. In: *Climate change in Australia's natural resource management regions: cluster reports.* Ekstrom M, Whetton P, Gerbing C, Grose M, Webb L and Risbey J (eds.). CSIRO and Bureau of Meterology, Australia. https://www.climatechangeinaustralia.gov.au/en/publications-library/cluster-reports/
113. Sanchez-Camara J, Martin-Smith K, Booth DJ, Fritschi J and Turon X (2011) Demographics and vulnerability of a unique Australian fish, the weedy seadragon Phyllopteryx taeniolatus. *Marine Ecology Progress Series* 422: 253-264.
114. Sanchez-Camara J and Booth DJ (2004) Movement, home range and site fidelity of the weedy seadragon *Phyllopteryx taeniolatus* (Teleostei: Syngnathidae). *Environmental Biology of Fishes* 70: 31–41.
115. Wilson NG, Stiller J and Rouse GW (2017) Barriers to gene flow in common seadragons (*Syngnathidae: Phyllopteryx taeniolatus*). *Conservation Genetics* 18: 53-66.
116. Sanchez-Camara J, Booth DJ and Turon X (2005) Reproductive cycle and growth of *Phyllopteryx taeniolatus. Journal of Fish Biology* 67: 133-148.
117. Coulson PG, Hesp SA, Hall NG and Potter IC (2009) The western blue groper (*Achoerodus gouldii*), a protogynous hermaphroditic labrid with exceptional longevity, late maturity, slow growth, and both late maturation and sex change. *Fishery Bulletin* 107: 57-75.
118. Bryars S, Rogers P, Huveneers C, Payne N, Smith I and McDonald B (2012) Small home range in southern Australia's largest resident reef fish, the western blue groper (*Achoerodus gouldii*): implications for adequacy of no-take marine protected areas. *Marine and Freshwater Research* 63: 552-563.
119. Shepherd SA and Brook JB (2007) Distribution and ontogenetic shifts in habitat and abundance of the temperate western blue groper, *Achoerodus gouldii* (Richardson). *Journal of Fish Biology* 71: 1457-1478.
120. Olsen AM (1984) *Synopsis of biological data on the school shark,* Galeorhinus australis (Macleay 1881). Food and Agriculture Organisation of the United Nations, Rome.

121. Olsen AM (1954) The biology, migration, and growth rate of the school shark, *Galeorhinus australis* (Macleay) (Carcharhanidae) in the south-eastern Australian waters. *Marine and Freshwater Research* 5: 353-410.

122. Marton N, Green C, Lyle J, Braccini M, Rogers P and Peddemors V (2016) School Shark (*Galeorhinus galeus*). *In: Status of Australian fish stocks reports* 2016. Stewardson C, Andrews J, Ashby C, Haddon M, Hartmann K, Hone P, Horvat P, Mayfield S, Roelofs A, Sainsbury K, Saunders T, Stewart J, Stobutzki I and Wise B (eds). Fisheries Research and Development Corporation, Canberra. http://www.fish.gov.au/

123. Australian Fisheries Management Authority (2014) *School shark (Galeorhinus galeus) stock rebuilding strategy (revised 2014)*. Commonwealth of Australia, Canberra. https://www.afma.gov.au/have-your-say-school-shark-rebuilding-strategy

124. Walker TI, Punt AE, Taylor BL, Brown LP, Hancock DA, Smith DC and Koehn JD (1999) Modelling school shark (*Galeorhinus galeus*) movement in the southern shark fishery. *Australian Society for Fish Biology workshop on movement and migration* pp. 160-168.

125. Hurst RJ, Bagley NW, McGregor GA and Francis MP (1999) Movements of the New Zealand school shark, *Galeorhinus galeus*, from tag returns. *New Zealand Journal of Marine and Freshwater Research* 33: 29–48.

126. Hernández S, Daley R, Walker T, Braccini M, Varela A, Francis MP and Ritchie PA (2015) Demographic history and the South Pacific dispersal barrier for school shark (*Galeorhinus galeus*) inferred by mitochondrial DNA and microsatellite DNA mark. Fisheries Research 167: 132-142.

127. Fisheries New Zealand (2018) *Fisheries Assessment Plenary, May 2018: stock assessments and stock status*. Compiled by the Fisheries Science and Information Group, Fisheries New Zealand, Wellington. https://www.mpi.govt.nz/growing-and-harvesting/fisheries/fisheries-management/fish-stock-status/

128. Department of Sustainability and Environment (2009) *Leathery turtle. Flora and Fauna Guarantee Action statement #250*. Department of Sustainability and Environment, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/flora-and-fauna-guarantee-act-1988/action-statements

129. Benson SR, Eguchi T, Foley DG, Forney KA, Bailey H, Hitipeuw C, Samber BP, Tapilatu RF, Rei V, Ramohia P, Pita P and Dutton PH (2011) Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2: art84.

130. Limpus CJ (2009) *A biological review of Australian marine turtle species: Leatherback turtle,* Dermo*chelys c*oriacea (*Vandelli*). Environmental Protection Agency, Brisbane.

131. Commonwealth of Australia (2017) *Recovery plan for marine turtles in Australia*. Department of the Environment and Energy, Canberra. http://www.environment.gov.au/marine/publications/recovery-plan-marine-turtles-australia-2017

132. Commonwealth of Australia (2018) *Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans*. Department of the Environment and Energy, Canberra. http://www.environment.gov.au/biodiversity/threatened/publications/tap/marine-debris-2018

133. Schuyler Q, Hardesty BD, Wilcox C and Townsend K (2014) Global analysis of anthropogenic debris ingestion by sea turtles. *Conservation Biology* 28: 129-139.

134. Menkhorst P, Rogers D, Clarke R, Davies J, Marsack P and Franklin K (2017) *The Australian Bird Guide*. CSIRO Publishing, Melbourne.

134. Teuten EL, Saquing JM, Knappe DRU, Barlaz MA, Jonsson S, Bjorn A, Rowland SJ, Thompson RC, Galloway TS, Yamashita R, Ochi D, Watanuki Y, Moore C, Viet PH, Tana TS, Prudente M, Boonyatumanond R, Zakaria MP, Akkhavong K, Ogata Y, Hirai H, Iwasa S, Mizukawa K, Hagino Y, Imamura A, Saha M and Takada H (2009) Transport and release of chemicals from plastics to the environment and to wildlife. *Philosophical Transactions of the Royal Society* B 364: 2027-2045.

136. Baker GB, Gales R, Hamilton S and Wilkinson V (2002) Albatrosses and petrels in Australia: A review of their conservation and management. *Emu* 102: 71–97.

137. Butchart SH, Stattersfield AJ, Bennun LA, Shutes SM, Akçakaya HR, Baillie JE, Stuart SN, Hilton-Taylor C and Mace GM (2004) Measuring global trends in the status of biodiversity: Red List Indices for birds. *PLoS biology* 2: e383.

138. Dann P and Chambers LE (2013) Ecological effects of climate change on little penguins *Eudyptula minor* and the potential economic impact on tourism. *Climate Research* 58: 67-79.

139. Dann P (1992) Distribution, population trends and factors influencing the population size of little penguins *Eudyptula minor* on Phillip Island, Victoria. *Emu* 91: 263-272.

140. Nisbet ICT and Dann P (2009) Reproductive performance of little penguins in relation to year, age, pair-bond duration, breeding date and individual quality. *Journal of Avian Biology* 40: 296-308.

141. Pelletier L, Kato A, Chiaradia A and Ropert-Coudert Y (2012) Can thermoclines be a cue to prey distribution for marine top predators? A case study with little penguins. *PLOS ONE 7*: e31768.

142. Chiaradia A, Forero MG, Hobson KA and Cullen JM (2010) Changes in diet and trophic position of a top predator 10 years after a mass mortality of a key prey. *ICES Journal of Marine Science* 67: 1710–1720.

143. Chambers LE, Renwick L and Dann P (2009). Climate, fire and the little penguins. In: *Australia's biodiversity and climate change: a strategic assessment of the vulnerability of Australia's biodiversity to climate change.* Steffen W, Burbidge AA, Hughes L, Kitching R, Lindenmayer D, Musgrave W, Stafford Smith M and Werner P (eds.). Report to the Natural Resource Management Ministerial Council commissioned by the Commonwealth Department of Climate Change. CSIRO Publishing, Melbourne.

143. Sutherland DR and Dann P (2014) Population trends in a substantial colony of Little Penguins: Three independent

measures over three decades. *Biodiversity Conservation* 23: 241–250.

145. Stahel CD and Nicol SC (1982) Temperature regulation in the little penguin, *Eudyptula minor,* in air and water. *Journal of Comparative Physiology* B 148: 93-100.

146. Department of Environment, Land, Water and Planning (2015) *Climate-ready Victoria: Gippsland.* Department of Environment, Land, Water and Planning, Melbourne. https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0021/60744/Gippsland.pdf

147. Ganendran LB, Sidhu LA, Catchpole EA, Chambers LE and Dann P (2016) Effects of ambient air temperature, humidity and rainfall on annual survival of adult little penguins *Eudyptula minor* in southeastern Australia. *International Journal of Biometeorology* 60: 1237-1245.

148. Skira IJ, Wapstra JE, Towney GN and Naarding JA (1985) Conservation of the short-tailed shearwater *Puffinus tenuirostris* in Tasmania, Australia. Biological Conservation 37: 225-236.

149. Boyle DB, Goyen BK, Cameron DG and Cameron RG (2018) Movement of short-tailed shearwaters *Ardenna tenuirostris* banded at Phillip Island, Victoria from 1956 to 2010. *Corella* 42: 80-85.

150. Weimerskirch H and Cherel Y (1998) Feeding ecology of short-tailed shearwaters: breeding in Tasmania and foraging in the Antarctic? *Marine Ecology Progress Series* 167: 261-274.

151. Carey MJ, Phillips RA, Silk JRD and Shaffer SA (2014) Trans-equatorial migration of short-tailed shearwaters revealed by geolocators. *Emu – Austral Ornithology* 114: 352-359.

152. Schumann N, Dann P and Arnould JPY (2013) Use of terrestrial habitats by burrow-nesting seabirds in south-eastern Australia. *Emu - Austral Ornithology* 113: 135-144.

153. Chambers LE, Devney CA, Congdon BC, Dunlop N, Woehler EJ and Dann P (2011) Observed and predicted effects of climate on Australian seabirds. *Emu-Austral Ornithology* 111: 235-251.

154. Rodriguez A, Burgan G, Dann P, Jessop R, Negro JJ and Chiaradia A (2014) Fatal attraction of short-tailed shearwaters to artificial lights. PLoS ONE 9: e110114.

155. Bamford M, Watkins D, Bancroft W, Tischler G and Wahl J (2008) *Migratory shorebirds of the East Asian - Australasian Flyway: Population estimates and internationally important sites.* Wetlands International – Oceania, Canberra. https://www.environment.gov.au/system/files/resources/782ebed5-6bdd-4a41-9759-b60273b52021/files/shorebirds-east-asia.pdf

156. Minton C, Dann P, Ewing A, Taylor S, Jessop R, Anton P and Clemens R (2012) Trends of shorebirds in Corner Inlet, Victoria, 1982-2011. *Stilt* 61: 3-18.

157. BirdLife International (2018) *Species factsheet*: Limosa lapponica. http://www.birdlife.org

158. Maguire GS, Cullen M and Mead R (2013) *Managing the hooded plover in Victoria: a site by site assessment of threats and prioritisation of management investment on Parks Victoria managed land.* Birdlife Australia report to Parks Victoria, Melbourne.

159. Weston MA and Elgar MA (2005) Disturbance to brood-rearing hooded plover *Thinornis rubicollis*: responses and consequences. *Bird Conservation International* 15: 193-209.

160. Weston MA and Elgar M A (2007) Responses of incubating hooded plovers (*Thinornis rubricollis*) to disturbance. Journal of Coastal Research 23: 569-576.

161. Charlton-Robb K (2018) *Marine mammal distribution maps.* Report prepared for Victorian Environmental Assessment Council. Marine Mammal Foundation, Melbourne.

162. Department of Sustainability and Environment (2009) *Wildlife* (*Marine Mammals*) *Regulations Regulatory Impact Statement.* Department of Sustainability and Environment, Melbourne.

163. Gill PC (2002) A blue whale (*Balaenoptera musculus*) feeding ground in a southern Australian coastal upwelling zone. *Journal of Cetacean Research and Management* 4: 179-184.

164. Branch TA, Stafford KM, Palacios DM, Allison C, Bannister JL, Burton CLK, Cabrera E, Carlson CA, Galletti Vernazzani B, Gill PC, Hucke-Gaete R, Jenner KCS, Jenner M-NM, Matsuika K, Mikhalev YA, Miyashita T, Morrice MG, Nishiwaki S, Sturrock VJ, Tormosov D, Anderson RC, Baker AN, Best PB, Borsa P, Brownell Jr RL, Childerhouse S, Findlay KP, Gerrodette T, Ilangakoon AD, Joergensen M, Kahn B, Ljungblad DK, Maughan B, McCauley RD, McKay S, Norris TF, Oman whale and dolphin research group, Rankin S, Samaran F, Thiele D, Van Waerebeek K and Warneke RM (2007) Past and present distribution, densities and movements of blue whales Balaenoptera musculus in the Southern Hemisphere and northern Indian Ocean. *Mammal Review* 37: 116–175.

165. Nieblas AE, Sloyan BM, Hobday AJ, Coleman R and Richardsone AJ (2009) Variability of biological production in low wind–forced regional upwelling systems: a case study off southeastern Australia. *Limnology and Oceanography* 54: 1548-58.

166. Double MC, Andrews-Goff V, Jenner KCS, Jenner MN, Laverick SM, Branch TA and Gales NJ (2014) Migratory movements of pygmy blue whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as revealed by satellite telemetry. PLoS One 9: e93578.

167. Yochem PK and Leatherwood S (1985) Blue whale. In: *Handbook of marine mammals: The sirenians and baleen whales (Volume 3)*: 193–240. SH Ridgeway and R Harrison (eds.). Academic Press, New York.

168. Commonwealth of Australia (2015) *Conservation management plan for the blue whale—a recovery plan under the Environment Protection and Biodiversity Conservation Act 1999*. Department of the Environment, Canberra. http://www.environment.gov.au/biodiversity/threatened/publications/recovery/blue-whale-conservation-management-plan

169. Cummings WC and Thompson PO (1971) Underwater sounds from the blue whale, *Balaenoptera musculus*. *The Journal of*

the Acoustical Society of America 50: 1193–1198.

170. Stafford KM, Fox CG and Clark DS (1998) Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean. *Journal of the Acoustical Society of America* 104: 3616–3625.

171. Hildebrand JA (2009) Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series* 395: 5–20.

172. Commonwealth of Australia (2008) *EPBC Act policy statement 2.1 – Interaction between offshore seismic exploration and whales*. Department of the Environment, Water, Heritage and the Arts, Hobart. http://www.environment.gov.au/resource/epbc-act-policy-statement-21-interaction-between-offshore-seismic-exploration-and-whales

173. Charlton-Robb K, Gershwin L-a, Thompson R, Austin J, Owen K and McKechnie S (2011) A new dolphin species, the Burrunan dolphin *Tursiops australis* sp. nov., endemic to southern Australian coastal waters. *PLoS ONE* 6: e24047.

174. Committee on Taxonomy (2017) *List of marine mammal species and subspecies*. Society for Marine Mammalogy, www.marinemammalscience.org

175. Charlton-Robb K, Taylor AC and McKechnie SW (2015) Population genetic structure of the Burrunan dolphin (*Tursiops australis*) in coastal waters of south-eastern Australia: conservation implications. Conservation Genetics 16: 195-207.

176. Schumann N, Gales NJ, Harcourt RG and Arnould JPY (2013) Impacts of climate change on Australian marine mammals. *Australian Journal of Zoology* 61: 146–159.

177. Bowater RO, Norton J, Johnson S, Hill B, O'Donaghue P and Prior H (2003) Toxoplasmosis in Indo-Pacific humpbacked dolphins (*Sousa chinensis*), from Queensland. *Australian Veterinary Journal* 81: 627–632.

178. Monk A, Charlton-Robb K, Buddhadasa S and Thompson RM (2014) Comparison of mercury contamination in live and dead dolphins from a newly described species, *Tursiops australis. PLoS ONE* 9: e104887.

179. Department of Sustainability and Environment (2009) *Wildlife (Marine Mammal) Regulations* 2009. Version 002, S.R. No. 143/2009. Version as at 1 May 2013. Department of Sustainability and Environment, Melbourne. http://www8.austlii.edu.au/cgi-bin/viewdb/au/legis/vic/consol_reg/wmr2009321/

180. Victoria Government Gazette (2010) *Special Gazette Number 298*. Dated 30 July 2010

181. Filby NE, Stockin KA and Scarpaci C (2014) Long-term responses of Burrunan dolphins (*Tursiops australis*) to swim-with dolphin tourism in Port Phillip Bay, Victoria, Australia: a population at risk. *Global Ecology and Conservation* 2: 62-71.

182. Filby NE, Christiansen F, Scarpaci C and Stockin KA (2017) Effects of swim-with-dolphin tourism on the behaviour of a threatened species, the Burrunan dolphin *Tursiops australis. Endangered Species Research* 32: 479-490.

183. Ling JK (2002) Impact of colonial sealing on seal stocks around Australia, New Zealand and subantarctic islands between 150 and 170 degrees East. *Australian Mammalogy* 24: 117-126.

184. Kirkwood R, Gales R, Terauds A, Arnould JPY, Pemberton P, Shaughnessy PD, Mitchell AT and Gibbens J (2005) Pup production and population estimates of the Australian fur seal. *Marine Mammal Science* 21: 260–282.

185. Kirkwood R, Warneke RM and Arnould JPY (2009) Recolonization of Bass Strait, Australia, by the New Zealand fur seal, Arctocephalus forsteri. *Marine Mammal Science* 25: 441–449.

186. McIntosh RR, Kirkman SP, Thalmann S, Sutherland DR, Mitchell A, Arnould JPY, Salton M, Slip DJ, Dann P and Kirkwood R (2018) Understanding meta-population trends for the Australian fur seal, with insights for adaptive monitoring. *PLoS ONE* 13: e0200253.

187. Willis K (2008) *Behavioural thermoregulation in the Australian fur seal,* Arctocephalus pusillus doriferus. Honours thesis, Deakin University.

188. Arnould JPY and Littnan CL (2000) Pup production and breeding areas of Australian fur seals *Arctocephlaus pusillus doriferus* at Kanowna Island and The Skerries in northeastern Bass Strait. *Australian Mammalogy* 22: 51–55.

189. Barbee N, Longmore A, Townsend K, Pettigrove V and Swearer S (2016) *Technical knowledge synthesis for nutrient cycling, marine pests and pollutants in Port Phillip Bay: informing the development of the new Port Phillip Bay Environmental Management Plan.* Centre for Aquatic Pollution Identification and Management Technical Report No. 60. University of Melbourne, Melbourne.

190. Hewitt CL and Campbell ML (2010) *The relative contribution of vectors to the introduction and translocation of invasive marine species.* Department of Agriculture, Fisheries and Forestry, Canberra. http://www.marinepests.gov.au/marine_pests/publications/Pages/the_relative_contribution_of_vectors_to_the_introduction_and_translocation_of_invasive_marine_pests.aspx

191. Sardain A, Sardain E and Leung B (2019) Global forecasts of shipping traffic and biological invasions to 2050. Nature Sustainability 2: 274-282.

192. Hewitt CL, Campbell ML, Thresher RE, Martin RB, Boyd S, Cohen BF, Currie DR, Gomon MF, Keough MJ, Lewis JA, Lockett MM, Mays N, McArthur MA, O'Hara TD, Poore GCB, Ross DJ, Storey MJ, Watson JE and Wilson RS (2004) Introduced and cryptogenic species in Port Phillip Bay, Victoria, Australia. *Marine Biology* 144: 183–202.

193. Parks Victoria (2012) *Marine natural values study summary.* Parks Victoria, Melbourne. https://parkweb.vic.gov.au/park-management/environment/research-and-scientific-management/marine-research2/marine-natural-values-reports

194. www.marinepests.gov.au/pests

195. Department of Agriculture and Water Resources (2018) *Marine pest plan 2018–2023: the national strategic plan for marine pest biosecurity.* Department of Agriculture and Water Resources, Canberra.

196. Carnell PE and Longmore AR (2014) Resilience of Victorian reefs to climate change: an investigation utilising the sub-tidal

reef monitoring program. Report prepared for VEAC Marine Investigation. Centre for Aquatic Pollution Identification and Management Technical report 42. University of Melbourne, Melbourne. http://www.veac.vic.gov.au/documents/Carnell%20&%20Longmore%202014%20Resilience%20of%20Victorian%20reefs%20to%20climate%20change.pdf

197. Ling SD and Johnson CR (2012) Marine reserves reduce risk of climate–driven phase shift by reinstating size–and habitat–specific trophic interactions. *Ecological Applications* 22: 1232-1245.

198. Campbell SJ and Burridge TR (1998) *Occurrence of Undaria pinnatifida* (Phaeophyta: Laminariales) in Port Phillip Bay, Victoria, Australia. *Marine and Freshwater Research* 49: 379-381.

199. Primo C, Hewitt CL and Campbell ML (2010) Reproductive phenology of the introduced kelp *Undaria pinnatifida* (Phaeophyceae, Laminariales) in Port Phillip Bay (Victoria, Australia). *Biological Invasions* 12: 3081-3092.

200. Crockett P, Johnson K, Brenker M, Ierodiaconou D and Carnell P (2017) Undaria pinnatifida *in Port Phillip Bay marine sanctuaries: removal strategies and interactions with the native algal canopy.* Parks Victoria Technical Series No. 113. Parks Victoria, Melbourne.

201. Casas G, Scrosati R and Luz Piriz M (2004) The invasive kelp *Undaria pinnatifida* (Phaeophyceae, Laminariales) reduces native seaweed diversity in Nuevo Gulf (Patagonia, Argentina). *Biological Invasions* 6: 411-416.

202. Hewitt CL, Campbell ML, McEnnulty F, Moore KM, Murfet NB, Robertson B and Schaffelke B (2005) Efficacy of physical removal of a marine pest: the introduced kelp *Undaria pinnatifida* in a Tasmanian marine reserve. *Biological Invasions* 7: 251-263.

203. Booth C, Carr G and Low T (2009) *Weedy pasture plants for salinity control: sowing the seeds of destruction.* Invasive Species Council, Melbourne. http://invasives.org.au/wp-content/uploads/2014/02/rpt_weedypastureplants.pdf

204. Hedge P and Kriwoken LK (2000) Evidence for effects of Spartina anglica invasion on benthic macrofauna in Little Swanport estuary, Tasmania. Austral Ecology 25: 150-159.

204. Weiss J and Dugdale T (2017) *Impacts of priority wetland weeds.* Knowledge document of the impact of priority wetland weeds Part 2. Report prepared for Department of Environment, Land, Water and Planning (DELWP) Water and Catchments Group by Agriculture Victoria. https://www.water.vic.gov.au/__data/assets/pdf_file/0024/61188/Knowledge-document-on-the-impact-of-priority-wetland-weeds-Step-2.pdf

206. Goss-Custard JP and Moser ME (1988) Rates of change in the numbers of dunlin, *Calidris alpina*, wintering in British estuaries in relation to the spread of *Spartina anglica*. *Journal of Applied Ecology* 25: 95-109.

207. White M, Cheal D, Carr GW, Adair R, Blood K and Meagher D (2018) *Advisory list of environmental weeds in Victoria*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 287. Department of Environment, Land, Water and Planning, Heidelberg. https://www.ari.vic.gov.au/__data/assets/pdf_file/0027/125919/ARI-Technical-Report-287-Advisory-list-of-environmental-weeds-in-Victoria.pdf

208. Bridgewater PB and Cresswell ID (1999) Biogeography of mangrove and saltmarsh vegetation: implications for conservation and management in Australia. *Mangroves and Salt Marshes* 3: 117-125.

209. Mead R (2012) *Clutch fate and success of the hooded plover* (Thinornis rubricollis). Honours thesis, Deakin University, Melbourne.

210. van Bommel L (2010) *Guardian dogs: best practice manual for the use of livestock guardian dogs*. Invasive Animals CRC, Canberra.

211. Jones JB, Hyatt AD, Hine PM, Whittington RJ, Griffin DA and Bax NJ (1997) Special topic review: Australasian pilchard mortalities. *World Journal of Microbiology & Biotechnology* 13: 383-392.

212. Ward TM, Hoedt F, McLeay L, Dimmlich WF, Kinloch M, Jackson G, McGarvey R, Rogers PJ and Jones K (2001) Effects of the 1995 and 1998 mass mortality events on the spawning biomass of sardine, *Sardinops sagax*, in South Australian waters. *ICES Journal of Marine Science* 58: 865–875.

213. Gavine F, Ingram B and Doroudi M (2009) *Development of management strategies for herpes-like virus infection in abalone.* Fisheries Research and Development Corporation Project No. 2006/243. https://vfa.vic.gov.au/operational-policy/pests-and-diseases/abalone-disease/research-and-surveillance/development-of-management-strategies-for-herpes-like-virus-infection-in-abalone#

7 Aboriginal Cultural Values for Sea Country

This chapter provides an outline of the Aboriginal cultural values for Sea Country in Victoria. It is based on a report prepared for VEAC by the Federation of Victorian Traditional Owner Corporations (the Federation). The cultural, social and spiritual meaning of Sea Country is outlined, and issues affecting Aboriginal cultural heritage are discussed. The roles of government, Traditional Owners and other partners are clarified with repect to achieving a holistic approach to land and water management.

A strategic framework prepared by the Federation articulates Victorian Traditional Owners' long-term goals and objectives for developing and applying Indigenous knowledge and practice for Sea Country in a contemporary Victorian context. In this approach policy and practice are founded on the voice of Elders, through interviews with Elders in a contemporary context and and through examination of the words of Elders in the historical record.

KEY POINTS AT A GLANCE

- Coastal and marine areas within contemporary Victoria are connected to cultural narratives of the Aboriginal peoples who lived and died within them for millennia before they came into contact with British colonisers.
- Aboriginal peoples of the coastal and marine areas of Victoria identify today as Monero/Ngarigo, Bidwell, Yuin, Gunaikurnai, Boon Wurrung, Bunurong, Wurundjeri, Wathaurung/Wadawurrung, Eastern Maar and Gunditjmara.
- Cultural, social and spiritual meaning of Sea Country to Aboriginal Victorians is demonstrated in historical and contemporary accounts of Aboriginal dreaming stories. These stories date back many thousands of years and are firmly situated in the ecological and social contexts of southeastern Australia.
- Dreaming stories are integral to informing understanding of the importance of Sea Country and how to develop frameworks that facilitate the cultural application of Sea Country management in the contemporary Victorian landscape.
- Contemporary Aboriginal Victorians continue to utilise and harvest the resources of their Country as they have done for countless years in the past. They and their extended families maintain regular camping sites along the length of the coast of Victoria in which they pass knowledge of the coastal and marine environment from generation to generation. This interaction with the coast has always been a crucial source of physical and spiritual sustenance and vital to Traditional Owners' identity as coastal people.
- The coast contains many sacred and significant sites for Victorian Aboriginal peoples.
- There is an important opportunity for Aboriginal values to be incorporated in the development of a statewide marine and coastal policy and strategy and in the marine spatial planning framework. However, the nature of Aboriginal culture and knowledge means that there is not a well-documented inventory of information relating to sections of the Victorian coast available to decision makers.
- Examples of threats to Aboriginal cultural values and environmental values more broadly are outlined; they illustrate how poor decisions are made when Aboriginal people do not have a real voice in policy, planning and implementation processes.
- If Aboriginal cultural values and threats to those values are to be more effectively addressed in marine planning and management, Traditional Owners need to be able to mobilise their knowledge and fulfil their rights and obligations to care for Country.
- The second part of this chapter sets out a strategic framework that articulates the measures that Traditional Owners advise are needed to fill knowledge gaps and avoid threats to natural and cultural values. The actions outlined in the strategic framework can also complement and support broader processes of reconciliation.

The broad categories of threats to Aboriginal cultural values for Sea Country are summarised and examples are provided for each threat in table 7.1; for more detail see the relevant section of this chapter. Discussion of threats in this chapter are threats to Aboriginal cultural values for sea country.

Table 7.1 Summary of threats to Aboriginal cultural values for Sea Country in Victoria

Threat class	Pathway/outcome	Example (with section reference)
Climate change	Altered oceanography	Changes in currents impact on dispersal for species relying on pelagic transport of adults and larvae (e.g. the culturally important short-finned eel) (6.4.7).
	Sea level rise and increased storm frequency	Sites of cultural significance (e.g. middens) at risk of inundation and exposure through coastal erosion (7.4.3)
	Increased hot dry weather	Hot dry weather increases likelihood of fires, which can alter coastal vegetation and destabilise dune systems, leading to exposure and degradation of culturally significant sites
Physical	Trampling	Extensive shellfish middens under threat from unplanned access (e.g. in Bridgewater Bay in Gunditjmara Country)
	Erosion	Extensive shellfish middens under threat from wind and wave erosion (e.g. in Bridgewater Bay in Gunditjmara Country)
	Site destruction	Sacred and significant sites/associations with dreaming stories: cave, middens, resting/burial places, can be damaged by coastal development and or coastal protection works (e.g. fencing)
Biological	Harvesting/bycatch	Over-fishing (including taking undersized) fish and abalone, and stripping beaches of shellfish such as pipis (7.4.4)
	Species loss/ extinction	Rising sea levels threaten saltmarsh which provides important habitat for culturally significant species (7.4.4).
Catchment processes	Altered hydrological regimes/reduced freshwater flows	Estuaries have a strong reliance on freshwater flows – significant changes have occurred (e.g. Wallagaraugh River coastal swamps and estuarine environments now smaller and more saline) (7.4.3)
	Sedimentation/ nutrients	Numbers of some important fish species (e.g. mullet and bream) dwindling as bottom has become silted and water shallower (e.g. Warrnambool, Hopkins River, Merri River area) (7.4.3)
Pollution	Marine debris and contaminants	The health of Sea Country is impacted by pollution – Traditional Owners have a responsibility to look after Country (7.5.4)
Community/ industry demand	Expansion of industry	Coastal development and expansion can lead to destruction of culturally important sites (7.5.4)
	Demand for ecotourism	Traditional Owners have strong understanding and care for Sea Country – opportunities for sustainable tourism (7.5.3)
	Recreational access	Damage to middens caused by access tracks and recreational activities (7.4.4)

7.1 Introduction

Traditional Owners feel a deep sense of connection and responsibility to Country and it is becoming increasingly acceptable as a practice for public land managers to involve Aboriginal people in land and water management, including policy, strategy and project activities.

An important part of this connection and recognition is authority to speak for and make decisions about the management of Country, including a shared understanding of cultural values and the application of Indigenous knowledge and practice.[1]

Victorian Traditional Owners are increasingly being recognised by the state as *partners* in land and water management. This recognition is reflected internationally. The World Conservation Union (IUCN) recognises six protected area categories, according to their management objectives. The sixth category – protected area with sustainable use of natural resources – identifies protected areas that are managed according to 'cultural values and traditional natural resource management systems'.[2]

Additional outcomes of this approach to partnership and improved public land management is the substantial contribution to the UN Sustainable Development Goals,[3] in particular goals 3 (good health and wellbeing), 8 (decent work and economic growth), 10 (reduced inequalities), 13 (climate action) and 14 (life below water).

To realise this increased level of participation in decision making,[4] this chapter addresses three key needs:

- firstly, the cultural, social and spiritual meaning of Sea Country is documented in cultural values, uses and interests
- secondly, a strategic framework articulates Victorian Traditional Owners' long-term goals and objectives at State-wide and Country (regional) levels, and proposes sensible and achievable strategies and actions to achieve those over time
- thirdly, it attempts to clarify the roles of government, Traditional Owners and other partners to achieve a holistic approach to land and water management. There will be benefit for all Victorians through Traditional Owners' involvement and leadership.

The values and the directions in the strategic framework in the second part of this report are reflective of the voice of Traditional Owners. The approach undertaken to understanding and managing the cultural values of Sea Country documented in this chapter represents a new way of engaging with Traditional Owners. In this approach, policy and practice are being founded on the voice of Elders, through interviews with Elders in contemporary context and through examination of the words of Elders in the historical record.

The cultural, social and spiritual meaning of Sea Country to Aboriginal Victorians is demonstrated in historical and contemporary accounts of Aboriginal dreaming stories. These stories date back many thousands of years and are firmly situated in the ecological and social contexts of southeastern Australia.

Dreaming stories can be used to inform contemporary policy statements as they show us how to behave towards each other and the environment.

These stories are integral to informing the way in which to understand the importance of Sea Country and how to develop frameworks that facilitate the cultural application of Sea Country management in the contemporary Victorian landscape. It is imperative that people continue to tell dreaming stories about Sea Country. An important outcome of this chapter and the proposed strategic framework will be the promotion of opportunities for Aboriginal custodians to continue to share Sea Country dreaming stories.

Bull kelp (*Durvillaea potatorum*) water collector and carrier. Image reproduced with thanks and acknowledgement to Bunurong Land Council Aboriginal Corporation. Photo: Rohan Henry.

How to read this chapter

[Blue Boxed text] contain quotes from recent interviews with Traditional Owner Elders and other knowledge holders. Indented text contains attributed quotes from the literature.

> *Aunty [Wurundjeri elder] noted [the need to] breaking down of storylines and song lines of the mission days…important to sit around and talk…re-jogs memories…even today's meeting yarn here … is rekindling memories…important to sit around and yarn. [We] need groups of people because different members of yarning circles remember different aspects of stories. [It' s] similar for walking on Country.*[5]

Furthermore, this report documents Sea Country with cultural integrity, as part of an interconnected system. Traditional Owners do not separate marine from coastal or associated catchment values. Sea Country is considered inclusive of all the sentient and non-sentient parts of the natural world and the interactions between them, according to Lore.

> *Uncle [Wurundjeri elder] said water goes into the [Port Phillip] Bay from river etc…therefore [we have] a responsibility to look after the estuarine and terrestrial systems, as systems that are connected to the coast and Bay.*[5]
>
> *[Gunditjmara knowledge holder]…talking about values and uses in particular we've got the pipis and their reliance on freshwater flows [bringing] important nutrients and organic matter high up from the Glenelg River, feeding the nearshore environments…pipis [were a] key to their [Gunditjmara peoples] survival.*[6]

The statements and discussion of values, uses, threats and strategies therefore reflects a broader range of Indigenous interests (and of an Aboriginal worldview) to include the causal and dependent natural connections between the marine and freshwater environments.

7.1.1 Consultation process and outputs

The Federation was engaged by VEAC to prepare a paper that identifies and discusses Aboriginal cultural values, uses, interests and knowledge associated with marine and estuarine waters in Victoria.

The Federation conducted a comprehensive consultation, involving as many Traditional Owner corporations/groups, Native Title holders, Registered Aboriginal Parties, knowledge holders and Elders as was possible in the time allowed. The consultation methodology included roundtable meetings with interested groups, one-on-one interviews with Elders and knowledge holders using a set of open questions and visits on-Country.

In addition to providing an understanding of cultural values the report also attempts to connect those values to both a policy discourse and to practical actions, through a strategic framework.

Victorian Traditional Owners have strong aspirations to ensure cultural practices are continued, adapted and applied wherever possible to allow for healing and caring for Country.

This chapter consists of two parts. The first, immediate purpose is to outline Aboriginal cultural values, uses and interests relating to Victoria's marine environment, to the extent possible within VEAC's relatively short timeframe for preparing the Assessment of the Values of Victoria's Marine Environment.

There is an important opportunity for Aboriginal values to be incorporated in the development of a statewide marine and coastal policy and strategy and in the marine spatial planning framework. However, the nature of Aboriginal culture and knowledge means that there is not a well-documented inventory of information relating to sections of the Victorian coast available to decision makers. This represents a very significant gap under VEAC's terms of reference for the assessment.

If Aboriginal cultural values and threats to those values are to be more effectively addressed in marine planning and management, Traditional Owners need to be able to mobilise their knowledge and fulfil their rights and obligations to care for Country.

7.2 Traditional Owner groups with interests in the Victorian Coast

This section provides a description of each Traditional Owner group with interests in the Victorian coast (marine and estuarine waters) and their associated status with respect to the *Native Title Act 1993* (Cth) (Native Title Act), the *Traditional Owner Settlement Act 2010* (Vic) (Settlement Act), and *Aboriginal Heritage Act 2006* (Vic) (Aboriginal Heritage Act). Some Traditional Owner groups also hold and manage land pursuant to the *Aboriginal Lands Act 1970* (Vic) and *Aboriginal Land (Lake Condah and Framlingham Forest) Act 1987* (Cth).

As this summary relies on the formal processes of recognition of Traditional Owner groups in Victoria it therefore may not provide a full description of the extent of the rights and interests asserted by some groups.

Gunditjmara

The Gunditjmara were recognised as holding native title on 30 March 2007 over various areas of Crown land along the coastal foreshore between Tyrendarra East and the South Australian border. The State of Victoria has also entered into a native title settlement agreement with the Gunditjmara, which established a Co-Operative Management Agreement over Budj Bim (Mount Eccles) National Park. Under this agreement, the state also transferred freehold title of Lake Condah Mission to Gunditj Mirring Traditional Owner Aboriginal Corporation (GMTOAC). Land at Lake Condah previously vested in the KerrupJmara Elders Aboriginal Corporation under the *Aboriginal Land (Lake Condah and Framlingham Forest) Act 1987* (Cth) is also currently held and managed by GMTOAC.

On 11 July 2011, the Gunditjmara and Eastern Maar Peoples were determined to jointly hold native title between the areas of Tyrendarra East and Yambuk. GMTOAC was appointed a Registered Aboriginal Party (RAP) on 28 May 2007 for the Gunditjmara native title determined area.

Eastern Maar

The Eastern Maar Traditional Owner group assert Traditional Owner rights and interests between Tyrendarra East and Anglesea. The Eastern Maar commenced negotiations with the State of Victoria under the Settlement Act on 2 November 2017, having met the state's threshold requirements.

As outlined above, the Gunditjmara and Eastern Maar Peoples jointly hold native title between Tyrendarra East and Yambuk. Eastern Maar Aboriginal Corporation (EMAC) shares RAP status with GMTOAC over this shared native title determined area.

Further, land in Framlingham Forest was vested in the Kirrae Whurrong Aboriginal Corporation under the *Aboriginal Land (Lake Condah and Framlingham Forest) Act 1987* (Cth) and in the Framlingham Aboriginal Trust under the *Aboriginal Lands Act 1970* (Vic)). It is currently held and managed by Kirrae Whurrong Aboriginal Corporation.

Wathaurung/Wadawurrung

The Wathaurung/Wadawurrung Traditional Owners assert rights and interests over the lands along the coast from Aireys Inlet to the Bellarine Peninsula and to the Werribee River, which flows into Port Phillip Bay. The Wathaurung Aboriginal Corporation (trading as Wadawurrung) was registered as RAP over this area, including the coastline, on 21 May 2009.

Wurundjeri

The Wurundjeri's traditional lands extend across Melbourne, from Mount Baw Baw in the east to Ballan in the west, which includes the Birrarung (Yarra River) Valley and the Maribyrnong River. The Wurundjeri Land and Compensation Cultural Heritage Council Aboriginal Corporation (Wurundjeri Council) is the appointed RAP over the land and waters between Ballan and Mount Baw Baw.

Bunurong/Boon Wurrung

The Bunurong/Boon Wurrung Traditional Owners assert rights and interests in south-central to southeastern Victoria, including the southeastern waters of Port Phillip Bay, the Mornington Peninsula, Western Port and along the coast from Phillip Island to Anderson Inlet and the Tarwin River basin.

The Bunurong Land Council Aboriginal Corporation was appointed RAP on 19 July 2017, over the land and waters (including coastal waters) between Carrum and Tarwin Lower. The Bunurong Land Council Aboriginal Corporation has cultural heritage responsibilities for the Mornington Peninsula, Western Port and part of south-west Gippsland.

Gunaikurnai

The Gunaikurnai Peoples are the Traditional Owners of western Gippsland. There are approximately 3000 Gunaikurnai people, and their territory includes the coastal and inland areas to the southern slopes of the Victorian Alps. The Gunaikurnai Peoples are made up of five major clans – this includes Brabralung, Brataualung, Brayakaulung, Krauatungalung and Tatungalung people.

In the 1970s, land at the Lake Tyers reserve was vested in the Lake Tyers Aboriginal Trust under the *Aboriginal Lands Act 1970* (Vic).

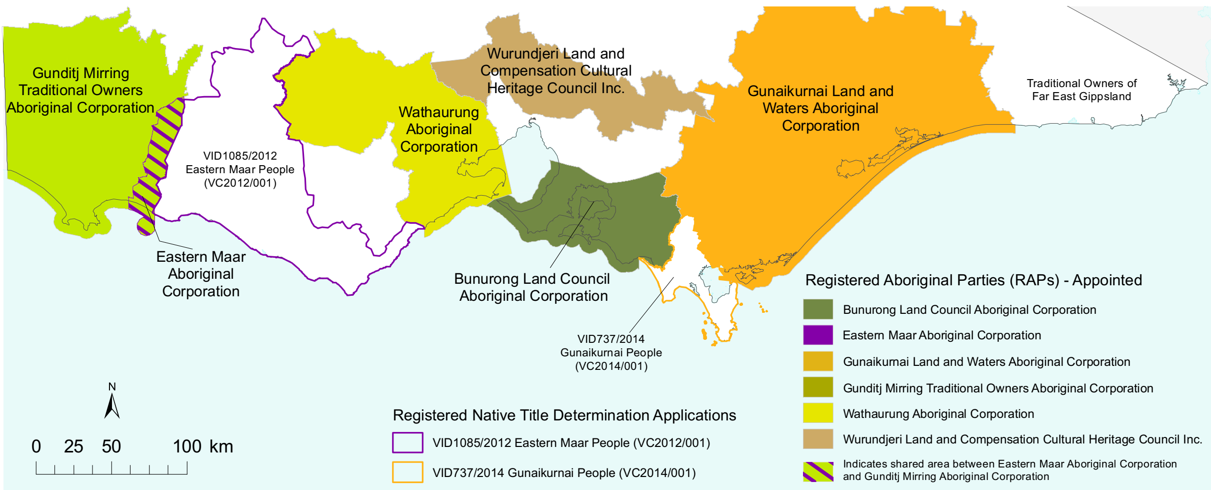
On 22 October 2010, the Gunaikurnai Peoples were recognised as native title holders for the western Gippsland area in the southeast of Victoria. On the same day, the State of Victoria entered into a settlement under the Settlement Act. Amongst other things, this established a joint management agreement between the Gunaikurnai and the State of Victoria over ten national parks and reserves, rights to access and use Crown land for traditional purposes, and funding in order for the Gunaikurnai to fulfil their obligations under the settlement.

In addition to this, the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) is the appointed RAP across the southeast coast of Victoria, from the Franklin River that flows into Corner Inlet, to the mouth of the Snowy River that flows into the Tasman Sea near Orbost. The Gunaikurnai Peoples also have a native title claim currently before the Federal Court over the land extending from the Tarwin River (Anderson Inlet) to Wilsons Promontory and Corner Inlet.

Traditional Owners of Far East Gippsland

The Traditional Owners of Far East Gippsland (the Bidwell, Monero/Ngarigo, Yuin and others) assert rights and interests in Far East Gippsland, extending east of the mouth of the Snowy River and across the New South Wales border to Green Cape. Traditional rights and interests in these areas have yet to be formally recognised under the Native Title Act, Settlement Act, or the Aboriginal Heritage Act.

Figure 7.1 Registered Aboriginal Parties with interests in Victorian marine waters and estuaries



7.3 Policies, strategies, projects or management plans of relevance

There are a number of provisions in the new *Marine and Coastal Act 2018* that support Traditional Owner rights and interests, including:

- to acknowledge Traditional Owner groups' knowledge, rights and aspirations for land and sea Country
- to engage with specified Aboriginal parties … in marine and coastal planning, management and protection.

The Marine and Coastal Act Transition Plan notes desired outcomes that include stronger links to cultural values in the planning and management of the marine and coastal environment.

Development of the Marine and Coastal Policy and Marine and Coastal Strategy offers opportunities to incorporate cultural values and the aspirations, rights and interests of Traditional Owner communities that are expressed in this chapter.

At a regional level, the Our Catchments our Communities partnership framework[7] provides a foundation for collaboration between catchment management authorities and Traditional Owner corporations. In terms of regional plans and reports, the Port Phillip Bay Environmental Management Plan, the State of the Bays report, regional coastal and marine management plans and regional catchment strategies provide a basis for understanding the state's priorities.

The foundational, consistent planning document for Victorian Traditional Owner groups, that sets out their aspirations and goals with respect to managing Country, is the Country Plan.[8] A Country Plan is a document that is prepared and approved by Traditional Owner Corporation groups, under self-determination principles. Where appropriate, Country Plans may include Sea Country plans that form a suitable basis to guide group directions and priorities for Sea Country (as advised by Elders and other knowledge holders for that Country) and further informed by the values and strategic directions expressed in this report.

The status of Country Plans and Sea Country Plans for the Victorian marine and coastal environment are summarised in table 7.2 below.

Table 7.2 Status of Country Plans and Sea Country Plans for Victorian Traditional Owner groups

Traditional Owner group	Prescribed Body Corporate, Traditional Owner group entity or RAP	Country Plan status	Sea Country plan status
Gunditjmara	Gunditj Mirring Traditional Owner Aboriginal Corporation	No[9]	Koonang Mirring (Sea Country) plan to be developed in 2019[10]
Eastern Maar	Eastern Maar Aboriginal Corporation	Yes[11]	Sea Country Plan to be developed in 2019
Wathaurung/ Wadawurrung	Wathaurung Aboriginal Corporation	No	Country Plan that incorporates Sea Country interests will be produced in 2019
Bunurong/ Boon Wurrung	Bunurong Land Council Aboriginal Corporation	No	Country Plan that incorporates Sea Country interests will be produced in 2019
Wurundjeri	Wurundjeri Land and Compensation Cultural Heritage Council Aboriginal Corporation	Yes	Country Plan currently under review and not publicly available
Gunaikurnai	Gunaikurnai Land and Waters Aboriginal Corporation	Yes[12]	Country Plan addition outlining the importance of sea birds will be produced in 2019

Other policies and strategies that require reference in consideration of Sea Country values, rights and aspirations of Traditional Owners include (chronologically):

- Victorian Aboriginal Fishing Strategy (State of Victoria 2012)
- Victorian Aboriginal Economic Strategy 2013-2020 (State of Victoria 2013)
- Victoria's Aboriginal Tourism Development Strategy 2013–2023 (State of Victoria 2014)
- Water for Victoria (chapter 6) (State of Victoria, DELWP 2016)
- Tharamba Bugheen Victorian Aboriginal Business Strategy 2017-2021 (State of Victoria 2017)
- Victorian Aquaculture Strategy 2017-2022 (State of Victoria 2017)
- Victorian Eel Fishery Management Plan (State of Victoria 2017)
- Biodiversity 2037 (chapter 8) (State of Victoria, DELWP 2017)
- A Pathway to Cultural Flows in Australia (National Cultural Flows Research Project, 2018)
- Victorian Aboriginal Affairs Framework 2018-2023 (State of Victoria 2018).

7.3.1 Native title and prescribed bodies corporates

Native title recognises the traditional rights and interests of Aboriginal and Torres Strait Islander peoples to land and waters. Under the Native Title Act, native title claimants can make an application to the Federal Court of Australia to have their native title recognised by Australian law.

Native title recognises a bundle of rights and interests over land or waters where Aboriginal people have practised and continue to practise their traditional laws and customs. Specific native title rights include the right to live and camp in an area, conduct ceremonies, the right to hunt, fish, collect food and build shelters, and to visit places of cultural significance. Recent court decisions have held that native title may also recognise a right to take resources for any purpose, including a commercial purpose.

If the Federal Court finds that native title rights and interests exist, the native title holding group must set up a Prescribed Body Corporate (PBC) to hold the rights and interests, as an agent, or in trust, for the group. A PBC must be incorporated under the *Corporations (Aboriginal and Torres Strait Islander) Act 2006* (Cth) and be registered by the National Native Title Tribunal.

PBCs have ongoing obligations under the Native Title Act and its associated legislation, including a requirement to consult and seek the consent of native title holders in relation to decision which may affect their native title rights and interests. All native title holders are entitled to join their PBC, vote in general meetings and stand as a director.

7.3.2 The Traditional Owner Settlement Act and Traditional Owner group entities

The *Traditional Owner Settlement Act 2010* is an alternative process which operates in Victoria to provide for an out-of-court settlement of native title. Under the act, the State government can enter into a settlement that recognises Traditional Owners having certain traditional rights and interests in Crown land. The group must meet the definition of 'traditional owner group' under the act, and satisfy the criteria set out in the Threshold Guidelines.

Under the act, a settlement package can include:

- a Recognition and Settlement Agreement to recognise a Traditional Owner group and certain Traditional Owner rights over Crown land
- a Land Agreement which provides for grants of land in freehold title for cultural or economic purposes, or as Aboriginal title to be jointly managed in partnership with the state
- a Land Use Activity Agreement which allows Traditional Owners to comment on or consent to certain activities on public land
- a Funding Agreement to enable Traditional Owner corporations to manage their obligations and undertake economic development activities
- a Natural Resource Agreement to recognise Traditional Owners' rights to take and use specific natural resources and provide input into the management of land and natural resources.

In return for entering into a settlement, Traditional Owners must agree to withdraw any native title claim, pursuant to the Native Title Act and not to make any future native title claims.

As part of the settlement process, groups must appoint a Traditional Owner Group Entity (TOGE) to represent them in relation to the recognised area, and to hold and manage the benefits of a settlement on behalf of the traditional owner group. All Traditional Owners are entitled to join their TOGE, vote in general meetings and stand as a director.

7.3.3 Victorian Aboriginal Heritage Council

The Victorian Aboriginal Heritage Council (VAHC) was created under the Aboriginal Heritage Act to ensure the preservation and protection of Victoria's Aboriginal cultural heritage.

The council's vision is of a community that understands and respects Aboriginal cultural heritage and the cultural responsibilities of Traditional Owners. The council recognises Traditional Owners as the primary guardians, keepers and knowledge holders of their heritage.

The council, which is made up of Traditional Owners appointed by the Minister for Aboriginal Affairs, plays an important role in the implementation of the Aboriginal Heritage Act. The principal functions of the council are to:

- make decisions on Registered Aboriginal Party (RAP) applications
- monitor operations of RAPs
- protect Ancestors' resting places and return Ancestors to Country
- act as custodian for secret or sacred Aboriginal objects in Victoria
- manage the Victorian Aboriginal Cultural Heritage Fund
- promote understanding and awareness of Aboriginal cultural heritage in Victoria
- report to the Minister annually and produce a State of Victoria's Aboriginal Cultural Heritage report every five years.

7.3.4 Registered Aboriginal Parties (RAPs)

Under the Aboriginal Heritage Act, RAPs play a key role in ensuring the preservation and protection of Victoria's rich Aboriginal cultural heritage. RAPs have a number of rights and responsibilities in relation to Aboriginal cultural heritage sites and objects located on public land.

The VAHC determines applications for registration as a RAP in accordance with the requirements of the Aboriginal Heritage Act. If an applicant is a registered PBC or TOGE for the area over which the application is made, the council must register the applicant as the RAP for that area.

RAPs are involved in preparation, evaluation and implementation of Cultural Heritage Management Plans (CHMPs). These plans set out measures and actions to be taken before, during and after a proposed activity in order to manage and protect Aboriginal cultural heritage in the activity area.

RAPs are one of the approval bodies for Cultural Heritage Permits under the Aboriginal Heritage Act.

7.3.5 Victorian Aboriginal Heritage Register

The Victorian Aboriginal Heritage Register holds all the information about known Aboriginal cultural heritage places and objects within Victoria, with their location and a detailed description.[13] RAPs amongst other groups and individuals, have access to the Victorian Aboriginal Heritage Register for the purpose of obtaining information relating to the area(s) over which the RAP is registered. RAPs have the power to authorise persons who wish to gain access to the register for the purpose of obtaining information relating to the area over which the RAP is registered. It should be noted the Victorian Aboriginal Heritage Register is not a complete register of all Aboriginal cultural heritage places and objects within Victoria.

The Aboriginal Cultural Heritage Register and Information System (ACHRIS) is a publicly available online tool that can be used to access the Victorian Aboriginal Heritage Register. Users can request further information about Aboriginal cultural heritage places and objects through ACHRIS.

RAPs can recommend that information on the register relating to Aboriginal cultural heritage or Aboriginal intangible heritage is sensitive Aboriginal heritage information. If approved, access to that information will be restricted unless approval from the relevant RAP is obtained. It is at the RAP's discretion whether to approve an application for access to sensitive Aboriginal heritage information.

Aboriginal intangible heritage is defined by the Aboriginal Heritage Act as any knowledge of, or expression of Aboriginal tradition, other than Aboriginal cultural heritage, and includes oral traditions, performing arts, stories, rituals, festivals, social practices, craft, visual arts and ecological knowledge. It does not include anything widely known to the public. RAPs, Registered Native Title Holders (including registered PBCs) and Traditional Owner Group Entities may nominate Aboriginal intangible heritage to be recorded on the register.

Registration of Aboriginal intangible heritage allows that heritage to become the subject of an Aboriginal intangible heritage agreement. For example, if a land manager such as Parks Victoria would like to utilise intangible heritage on the register as part of its Aboriginal cultural tour of a national park, it would need to enter into an Aboriginal intangible heritage agreement, which is then lodged with Aboriginal Victoria.

Some Aboriginal places and objects are of particular cultural heritage significance to Aboriginal people and the broader Victorian community. The Aboriginal Heritage Act allows the Minister for Aboriginal Affairs to make declarations for the protection of Aboriginal places or objects. Declaration provides specific measures for the protection and management of an Aboriginal place or object. For example, a declaration may restrict public access to an area.

7.4 Cultural values, rights and interests of Traditional Owners

7.4.1 The long harvest

The Aboriginal peoples of south-eastern Australia have long inhabited its coastal and marine environments. While estimates vary, it is safe to assume that the peoples of the area encompassed by modern-day Victoria have, with the benefit of some of the most enduring socio-cultural structures ever produced by humanity, lived here for many, many thousands of years. Indeed, the accounts of creation held by the peoples of the coastal and marine areas of modern Victoria still tell us of events within the landscape on what we now understand as a geological time scale.

From Cape Howe on the most eastern tip of the Victorian coastline to where the Glenelg River runs into Oxbow Lake, the Aboriginal peoples of the coastal and marine areas of Victoria identify today as Monero/Ngarigo, Bidwell, Yuin, Gunaikurnai, Boon Wurrung, Bunurong, Wurundjeri, Wathaurung/Wadawurrung, Eastern Maar and Gunditjmara. Evidence of their pre-colonial societies can be seen in the ethno-historical record created by the earliest colonial sources with whom they came into almost immediate contact after the establishment of the colony of New South Wales.

The earliest mention of Aboriginal people within the boundaries of modern-day Victoria comes from botanist Joseph Banks who saw fires inland from the coast as Cook's *Endeavour* sailed along the coastline at Cape Howe and at Twofold Bay.[14] Another involved a group of sailors who were shipwrecked on the Ninety Mile Beach and travelled through far east Gippsland on their way to Sydney. They described people they met west of modern-day Orbost as having whale blubber or shark oil through their hair and as wearing:

> … fish bones or kangaroo teeth, fastened with gum or glue to the hair of the temples and on the forehead. A piece of reed or bone is also wore through the septum, or cartilage, of the nose, which is pierced for the admission of this ornament.[15]

A century later in 1904, amateur anthropologist Alfred W Howitt described the people of the same area as the 'Guyangal-Yuin',[16] who included the 'Thauaira of east Malagoota Inlet'.[16]

The diaries and reports of early sources such as James Dawson, Francis Tuckfield and Charles Wightman Seivwright describe the coastal Wathaurung/Wadawurrung, Gulidjan, Gadubanud, Gunditjmara and other Maar speaking peoples of the Western Districts of Victoria while those of William Thomas, George Augustus Robinson and Alfred W Howitt describe the peoples of the Woiwurrung (including the Wurundjeri) the Boonwurrung and the Gunai/Kurnai.

The Scottish colonist who came in time to hold the title of Local Protector of Aborigines James Dawson provides some idea of the extent to which the people of Western Districts depended upon the coastal and marine environment for their survival and culture. Among the food animals harvested by the people of that district, he includes the 'gigantic crane, herons and swans, geese and ducks in great variety, cormorants, ibis, curlew, coot, water-hen, lapwings … and a great many kinds of sea fowls'.[17]

Of Aboriginal uses of other coastal and marine resources, Dawson writes further:

> Of fish, the eel is the favourite: but, besides it there are many varieties of fish in the lakes and rivers which are eaten by the natives. One in particular, called the tuurnpuurn, is reckoned a very great delicacy. It is caught plentifully, with the aide of long baskets, in the mouths of rivers during its passage to and from the sea, of which migration the natives are well aware.[17]

Dawson also noted the many middens spread along the coast in the Western Districts. Having seen similar middens in his native Scotland, he appreciated that these signs of human habitation were of a great age:

> Vast quantities of mollusca have been consumed from very remote periods by the natives occupying the country adjoining the sea coast; for opposite every reef of rocks affording shelter to shell fish, immense beds of shells of various sorts are to be seen in the sand-hills, in layers intermixed with pieces of charred wood, ashes, and stones having the marks of fire on them.[17]

The positioning of these middens in the landscape and the depth to which they were composed led Dawson to speculate about the degree to which the Aboriginal peoples of the region depended upon the coastal and marine areas for their survival:

> These immense mounds of shells being met with only near the sea, and nowhere in the interior, leads to the conclusion that the aborigines that fed on the mollusca and fish, never left the shore during the fishing season; and that, if they came from the interior, they never carried away any shell-fish with them, otherwise sea shells would be found in abundance at their old camping places in the bush, at a distance from the sea.[17]

Through correspondence with different sources, amateur ethnographer Robert Brough-Smyth also recorded species harvested within coastal and marine environments by the Aboriginal people of Victoria and elsewhere. Of the species he recorded as commonly harvested throughout the eastern coast, bream, herring, snapper, eel, conger eel, flounder, flathead, garfish, whiting, skate, stingray, dogfish and shark were all recorded.[18] Along with these, Brough-Smyth includes the gurnet, perch, trevally, sand mullet, fat mullet and sea trout in a list of fish species commonly harvested in Victoria.[18]

Of sea-mammals in Gippsland, he notes:

> The whale (Kaandha) and the porpoise (Kornon) are only procured when stranded. No efforts are made to catch them. The seal (Ngalercan) is killed on the beach.[18]

Informed by Rev John Bulmer at Lake Tyers Aboriginal Station, Brough-Smyth also recounted that the people of Gippsland harvested saltwater mussel, abalone (or mutton-fish), periwinkle, cockle (pipi), limpet and sea-cucumber.[18]

Bulmer himself wrote that:

> Fish formed a very important article of diet in the summer months. In Gippsland different fish were plentiful according to the seasons. At the beginning of the summer they were able to spear the flounder [Bothidae and Pleuronectidae] and the fat mullet [Mugilidae]. Just before and after the Lake opened to the sea (spring or winter) fish attempting to escape to sea were plentiful and many eels and mullet were obtained.[19]

Furthermore, the historical record contains reference to the different ways in which these foods were harvested. These ranged from gathering mussels,[17] wading for crayfish and crabs,[20] netting, spearing, trapping,[20] to line fishing with hooks made of wood and bone[18] and with bait wrapped in twine.[20]

From the journals of George Augustus Robinson, we know that the coastal people of Victoria utilised a number of different canoe constructions and travelled in them both in estuarine and coastal waters.[21] While recounting his five years in Australia, G H Haydon wrote of Aboriginal people in Gippsland using their canoes to travel at least two miles off the coast to a place called ‘Rabbit Island’.[21] Cahir, Clark and Clarke’s discussion of Aboriginal watercraft reveal that Aboriginal canoes were capable of an even longer range from the coast:

> Other writers (Gaughwin and Fullagar 1995) also recount how, in a later account (Howitt 1904), annual trips were made to Rabbit Island to collect mutton birds and their eggs. On this journey, the long route was taken from Port Welshpool passing Snake Island, across Corner Inlet and then along the Wilsons Promontory coast, a trip of some 20 kilometres.[22]

They go on to cite Thomas’s account of Boonwurrung people travelling by canoe to French Island.[23]

Islands along the coast also played an important part of Aboriginal peoples’ spiritual lives, being the focal point of many beliefs about the creation of the world and the afterlife. In the Western District, Dawson tells us of the island Deen Maar, also known as Lady Julia Percy Island (south of Yambuk and east of Port Fairy) and its significance in local Aboriginal beliefs:

> On the sea coast, opposite Deen Maar – now, unfortunately, called Julia Percy Island – there is a haunted cave called Tarn wirring, ‘road of the spirits,’ which the natives say, forms a passage between the mainland and the island. When anyone dies in the neighbourhood, the body is wrapped in grass and buried; and, if afterwards, grass is found at the mouth of the cave, it is proof that a good spirit called Puit puit chepetch, has removed the body and everything belonging to it through the cave to the island, and has conveyed its spirit to the clouds; and if a meteor is seen about the same time, it is believed to be fire taken up with it. Should fresh grass be found near the cave, when no recent burial has taken place, it indicates that someone has been murdered, and no person will venture near it till the grass decays or is removed.[24]

Furthermore, the ethno-historical record evidences that islands often fell under the same system of rights and interests that prevailed on the mainland. Howitt provides an example of this in relation to Snake Island in Gippsland, which he describes as a haven for the Brataulung people. He discusses an instance of elopement where the couple involved had, at first, hidden on Snake Island but had returned to face the family of the bride. After describing how the matter was settled, Howitt went on to write that 'Snake Island was the place of refuge for the Brataulung, not only in cases of elopement, but also when raids were made on them by other clans of the Kurnai'.[25]

Howitt and his fellow amateur anthropologist Lorimer Fison also reported that Raymond Island in Gippsland was the province of the men of the Tatungolūng people (whom Howitt and Fison recorded as the Būnjil Baul):

> The swan eggs laid upon this island were the property of the Būnjil Baul, and any stranger taking them without leave would have to fight. There was no other restriction as to game against any friendly Kŭrnai who might visit the island.[26]

7.4.2 In the beginning

Not surprisingly, the coastal and marine areas within contemporary Victoria were connected to cultural narratives of the Aboriginal peoples who lived and died within them for millennia before they came into contact with colonial Britain. One such narrative was that of the giant Lowan, whom the peoples of Gippsland assigned with having first led their ancestors into that country.

Howitt learned of the story of Löan from colonial Andrew Lang who, in turn, was told it by 'the oldest man in the Kutwut division of the Brataua clan, who lived on the Albert River'.[27] This man told of his people coming from the west where Löan, described by Lang as 'a non-natural man',[27] emerged from the Yarra River. The Kutwut man told of a 'Wurrunjerri' legend' that tells of Löan wandering 'from the Yarra River, following the migration of the swans, first to the inlets of Western Port and then to Corner Inlet, between Wilsons Promontory and the mainland, where he took up his abode.[27] Howitt added that, this 'is far within the country of the Kurnai, whose legend also speaks of him living there with his wife Löantuka, as the guardian of the Brataua clan'.[27]

Howitt also reports Kurnai creation narratives that speak to great flooding events which left the landscape permanently changed. In one of these, people interacted with the pelican ancestor being Bunjil Borun when 'a great flood which covered the land, and drowned people, excepting a man and two women'.[28] Bunjil Borun came upon the three survivors in his canoe and ferried the man and one of the women to the mainland, 'leaving the better looking one till last'. Becoming frightened by Bunjil Borun, the last woman 'placed a log rolled up in her rug by the fire as if she were asleep' to fool Bunjil Borun into thinking she was still there and then swam to the shore by herself. Upon discovering this, Bunjil Borun 'became very much enraged and began to paint himself ready for fighting with the man whose wife had played him this trick'. In the midst of doing so, he was seen by another Pelican who, upon 'seeing a queer-looking creature, half-black and half-white, struck at it with his beak and killed Bunjil Borun'.[28]

In another narrative, Bunjil himself, referred to as Munung-ngaua, or 'Great Father', was angered when the secrets of the Jerail initiation ceremony were given to the women of the Kurnai. This angered Bunjil and he responded by sending '… his fire, the aurora Australias, which filled the whole space between the earth and the sky'. As Howitt records, this drove men 'mad with fear' and they proceeded to spear each other, 'fathers killing their children, husbands their wives, and brethren each other'. Then the land was flooded by the sea and 'nearly all mankind was drowned'. The survivors became animal beings called 'Muk-kurnai' of whom some 'turned into animals, birds, reptiles, fishes and Tundun [son of Bunjil] and his wife became porpoises'. In the narrative presented by Howitt, 'Mungan [Bunjil] left the earth, and ascended to the sky where he still remains'.[29]

Mathews recorded a story told to him 'by some of the old Aboriginals of the Hopkins and Eumeralla rivers in western Victoria' which recounts the actions of Tyuron, the Eel Spearer who was 'a notable ancestor of the plovers'. In this account, Tyuron 'carried a spear on each shoulder when he went fishing … and frequented swamps and shallow streams where eels were plentiful, and never hunted for any other kind of food'. Tyuron is described as continually running up and down the lengths of swaps and river banks looking for eels and as singing out at intervals, 'Pittherit, pittherit'. As Mathews reports, this 'is why the plover still carries the point of a fish-spear on either shoulder, and likes to remain near water'. He also noted that the plover 'continues his old habit of running a little way and standing still, then running on again' and 'still sings his old song … *pittherit*.'[30]

Finally, there is also a narrative that records the flooding of Port Phillip Bay (known to the Boon Wurrung as 'Nairm') many thousands of years before the coming of the British. In this account, as told by a Boon Wurrung elder,[31] after many years of peace, the Boon Wurrung came into such conflict with the other Kulin peoples that they collectively ceased to look after country properly. This angered the sea and it rose, threatening to flood the land. Frightened, the people turned to Bundjil and promised to follow him once again. Bundjil stopped the sea from rising but not before much of Boon Wurrung country was flooded and Port Phillip Bay, whose true name was 'Nairm', had been created.[32]

7.4.3 From the Elders

Importantly, contemporary Aboriginal Victorians continue to utilise and harvest the resources of their country as they have done for countless years in the past. They and their extended families maintain regular camping sites along the length of the coast of Victoria in which they pass knowledge of the coastal and marine environment from generation to generation. Indeed, this interaction with the coast has always been a crucial source of physical and spiritual sustenance and vital to their identity as coastal people.

As one Gunaikurnai and Ngarigo elder recounted, when she was young, her family regularly camped along the coastline because, 'in those days, nobody could live without fishing'. She said that, among the species of fish they depended upon were bream, mullet, leatherjacket and flathead. She also remembered her family catching eels, both with fishing line and by spearing, which were a staple of their diet. She recounted that a member of her family was so proficient with eel spears that he would often feed large family gatherings from his spear fishing alone.

She further recounted that her family would often fish in the 'dusky' water, where the fresh water and the salt water mixed. She said they did this in places such as Mallacoota, the Bemm River and Gypsy Point near Genoa, where she would go as a child with her parents throughout each fishing season. The elder also recounted her family harvesting mussels at Mallacoota, Lakes Entrance and Metung and abalone (or mutton fish) at Marlo and from Cape Conron.

Along with line and spear fishing, her family would also cast nets from boats. She said further that the boys in her family would dive for crayfish and that often whales could be seen making their way along the coast past the Bemm River and Mallacoota travelling towards New SouthWales. In addition, she mentioned seeing sea lions along the beach at Cape Conron and spoke of the dolphins at Lakes Entrance.

All along the Victorian coast, the Aboriginal peoples have a strong traditional association with the coastline and utilise many of the same resources their ancestors relied upon for countless generations. An Eastern Maar elder recounted how his family have always fished the waters of the coast at Warrnambool and the mouth of the Hopkins River. Here they harvest species such as kingfish, salmon, mullet, eel and bream as well as the mussels whose shells form much of the ancient middens left behind by their ancestors.

The elder also spoke of the whale nursery nearby to Warrnambool and of how in recent years the whales were sung and danced back to within sight of the shoreline in a traditional ceremony. This speaks to the currency of traditional Aboriginal beliefs concerning the coastline in modern day Victoria and of the strong attachment to the coastal and marine environment that is still a feature of the lives of contemporary Traditional Owners.

The country of the coastal areas was, and continues to be, very important to the Aboriginal peoples of coastal Victoria. As well as medicines and bush food such as native cherries, heath berries, ferns (or 'burrawong' in Gippsland) and honey from both native and introduced bees, eggs were harvested from the birds living in these regions. A Gunaikurnai elder recounted that, when she was a girl, there used to be a big swamp, called Tosteree, on the other side of Nowa Nowa that her family used to fish as well. The women of her family would also take Swan eggs from nests in Tosteree swamp, but she was quick to note that they never took all of the eggs from any one nest. She said that, should this happen, the swans would never return to breed in that nest, so she and her family would always leave some eggs for the swans to rear to maintain the local population.

The coast also contains many sacred and significant sites for Victorian Aboriginal people. An Eastern Maar elder spoke of one such site, which was a cave associated with the law man Mawpaw. He said that Mawpaw could speak all of the languages of the area and that, because of this, it was he who had, in times gone by, organised safe passage through country for people of the region when they needed to move through the country of their neighbours. He also said that the cave ran underneath Warrnambool and was previously used by local Aboriginal people as both a refuge and a passage to the coast.

Drawing on the information received from interviews with Elders and other knowledge holders and the examination of the historical record, a summary table of resources, values and uses is provided in table 7.3.

Table 7.3 Sea Country resources and values

Category	Resource	Cultural uses	Contemporary context
Marine plants	Kelp Seaweed	Camouflage (seaweed's traditional use in seal hunting) Tool (kelp-based water carrier)	Cultural value exists in contemporary context for these resources, although there is limited application due to multiple policy, social and institutional barriers (including rights of access and use). Elders and other knowledge holders, however, continue to pass on cultural knowledge, practices and stories.
Marine animals	Birds e.g. mutton bird chicks and eggs, pelican (associated with dreaming stories) Fish e.g. bream, herring, snapper, eel, conger eel, flounder, flathead, garfish, leatherjacket, whiting, skate, stingray, dogfish, gurnet, perch, trevally, sand mullet, fat mullet, sea trout, kingfish, salmon Shark Seal (hunted), whale and dolphin (when stranded and associated with dreaming stories) Shellfish e.g. pipis, gastropods, turbo, oyster, mussel, elephant snail, limpet, abalone, crayfish/lobster, crab	Food for family, Elders, ceremonies and sharing Ornaments (operculums are used for shell necklaces) Ceremony Totems (with associated guidelines for conservation and management that are embedded in stories) Trade	
Landforms	Caves Dunes Estuaries Hunting areas Nearshore islands	Historical occupation Burials Cultural practice, ceremony/business Dreaming stories	
Cultural	Camp sites (permanent, seasonal) Massacre and abduction sites, other historic sites Middens, burials Practice places (men's business, women's business, birthing areas) Fishing rights Songlines Totemic species (including sea birds such as the pelican, short-finned eel) Travel routes Coloured ochre	Defined lores Dreaming stories Ceremony	

Note: This list is not comprehensive and should be considered only a summary of information extracted directly from interviews undertaken during the development of this chapter.

Top: Cape Schanck, Mornington Peninsula National Park (Bunurong/Boon Wurrung). Ceremony and other cultural practices were performed along the coast. The creator spirit Bunjil's cave is nearby. Photo: Ewa Kordupel

Middle Left: Bridgewater Bay (Gunditjmara) looking east. **Right:** Shelly Beach (Gunditjmara). Extensive shellfish middens under threat from wind and wave erosion and unplanned access. Photos: Rohan Henry

Bottom: Point Nepean National Park (Bunurong/Boon Wurrung mon-maar, a women's place of rights). The Port Phillip Heads (the location of the mouth of the Yarra River 10,000 years BP) has been an important meeting and ceremony place for the Kulin Nations over millennia. A waterfall at the earlier mouth of the Yarra River had red silcrete pillars on either side. This material was used in tool making. Photo: Rohan Henry

Top Left: Bridgewater Lakes Caves (Gunditjmara). Occupied from at least 11,000 years BP, associated with stories. An important meeting and camping place. **Right:** Bridgewater Lakes looking northwest from the caves. Photos: Rohan Henry

Bottom: Noble Rocks and Discovery Bay Marine National Park (Gunditjmara). An opportunity for a key partnership in Sea Country management. The shark washed up on the beach (broad-nose seven gill shark -Notorynchus cepedianus) was probably caught by fishers and left stranded. Photos: Rohan Henry

7.4.4 Going forward

This section begins by setting out some examples of threats to Aboriginal cultural values and environmental values more broadly and addresses the terms of reference for the assessment relating to threats to values and uses. The section ends by introducing the strategic framework as a pathway to go forward.

The Elders that contributed their time and knowledge to the creation of this report were in strong agreement that more should and could be done to protect and preserve the cultural and environment values of Victoria's coastal and marine environment. They identified a clear need for a greater Aboriginal and Traditional Owner voice within policy concerning this area.

A case in point is the fate of the middens at Moyjil (otherwise known as Ritchie Point in Warrnambool). While Traditional Owners had been involved in discussions with the shire council about how best to protect the site, they felt that the shire had not listened to them. The Traditional Owners had advised that any signage referring to Moyjil be placed some distance away from the site so that it would invite neither the curiosity of tourists nor the attention of vandals and, yet, the signs were placed directly in front of the midden site. Furthermore, not only was the site fenced off, fence posts were driven into the site, running horizontally around one of the ancient middens.

Victorian Traditional Owner Elders have also signalled that there should be more Traditional Owner involvement in the management and preservation of the coastal and marine environment. While marine sanctuaries were seen as a very positive development, Elders did identify a need for Traditional Owners to be allowed to continue to utilise the resources of these sanctuaries using their ancient knowledge of country to inform their harvesting of the species therein.

Elders identified the need to be able to be on country and pass on their knowledge to future generations. For example, an Eastern Maar elder indicated that he would like to have greater access to sanctuary areas in order to teach the young people how to harvest and husband resources. He said it was important that the young people be given the chance to learn about country on country. He said this with particular reference to the harvesting of abalone and other shell fish.

The Elders also noted further that over-fishing was a real problem, with tourists and non-Aboriginal locals taking undersize specimens of fish and abalone and stripping beaches of shellfish, such as pipis. To illustrate this, a Gunaikurnai/Ngarigo elder recounted a story of her family catching huge flathead but never keeping these large animals. She said that the larger flathead would always be thrown back so that they could continue breeding in order to keep the population healthy. This is in contrast to many of the current recreational anglers in Gippsland in recent years who, after filleting them, either nail the skeletons of these big fish to trees near boat ramps as an indication of how good the fishing is or take them to a taxidermist to be preserved and mounted as trophies.

She went on to say that there was too much over-fishing and that people come in groups now to one place and harvest as many shellfish as they can get at one time and then, having taken everything, move on to another spot. She said this meant that it took years for a place so affected to be renewed as there was not enough breeding stock left to repopulate it. This was echoed by an Eastern Maar elder who felt strongly that Traditional Owners should be paid to enforce fishing regulations and catch limits on their own country as they knew it best and would be the most effective agents in this regard.

In general, the Elders agreed that there should be more people to enforce the laws concerning over-fishing as these laws were proving ineffective without enforcement. They pointed out that the whole community, Aboriginal and non-Aboriginal, live off the food harvested from the coastal and marine environment and that everybody misses out due to illegal fishing practices. They said that people should live the right way and only take what they need, leaving what they don't so that the environment can continue to provide for them.

When asked about how coastal and marine environments can be protected and managed into the future, an Eastern Maar elder again repeated that it was most important that Traditional Owners had a real voice in discussions about how this was to occur. Amongst other things, he said:

> *We need a voice … where people will listen to us and understand what it means to us. [This is] for us and for non-indigenous people as well. We're living on Country and we've got a fair idea about what's in the Country.*

The threats outlined above are not adequately addressed in marine policy and planning at the moment for a variety of reasons. The following proposed strategic framework developed by the Federation addresses key barriers. It provides a pathway for Traditional Owners to develop and apply Indigenous knowledge and practice for Sea Country in partnership with other managers, to achieve significant ecological, economic and cultural outcomes.

7.5 Strategic framework

The Federation included the following 'strategic framework for healing Sea Country and culture through the application of knowledge and practice' as part of its report to VEAC. The framework articulates the measures that Traditional Owners say are needed to fill knowledge gaps and avoid threats to natural and cultural values. The terms of reference for VEAC's assessment clearly include these matters, but do not include the making of any recommendations. The proposed framework is therefore included in this report as a significant contribution to solving the issues underlying knowledge gaps and threats to cultural and natural values.

7.5.1 Purpose

The purpose of the Victorian Traditional Owner Sea Country strategic framework is to reinvigorate Traditional Owner-led cultural practices across all types of Sea Country, its tenure and communities; enabling Traditional Owners to heal Country and fulfil their rights and obligations to care for Country.

> **Vision:** *Victorian Traditional Owners actively identifying, restoring, protecting and enhancing sea country heritage, across generations. Young men and women will grow up observing their Elders healing Country and undertaking ceremonies. Their children and grandchildren will see culturally valuable plants, animals, flows and spirit return to Country and know their stories.*

Victorian Traditional Owners wish to emphasise the inter-generational nature of this change, the fact that managing Country is really about people and that trust must be given, placing authority in people's hands.

7.5.2 Enabling principles

The principles presented here have been drawn from interviews and discussion with Elders and other knowledge holders. These principles build on those in other work focused on facilitating Indigenous involvement in land management.[33]

> **Principle 1: Managing Country is a cultural responsibility** Traditional Owners lead the development and application of land and water management practices on Country; the responsibilities and authority of Traditional Owners are recognised and respected; Traditional Owners knowledge, practice and connection with Country will be respected and bring a cultural approach to planning and management.[34]

Traditional Owners need to be leading the planning from the beginning, not simply informed of the decisions at the end [of the planning process].[35]

> **Principle 2: Sea Country practice is living knowledge** Aboriginal knowledge is shared for continual learning and adaptive management. Traditional Owners will work together on each other's Country to heal Country and guide practice development. Knowledge and practice are shared.
>
> **Principle 3: Monitoring, evaluation and research support cultural objectives and enable adaptive learning** This will be used to build a body of evidence that allows Aboriginal knowledge and practice to occur and grow.
>
> **Principle 4: Country is managed holistically** Traditional Owners manage Country holistically to address multiple values and objectives, healing both Country and culture. Partnership arrangements and management objectives are tailored to each regional and cultural landscape context. These include analysis of the tenure, regulatory and operational arrangements to support the application of beneficial

Indigenous management practices, together with a process of learning to continuously improve planning, management and action.

Principle 5: Managing Country is healing There are substantial positive impacts to Traditional Owner wellbeing and confidence through providing access and authority to practice on Country.

7.5.3 Outcomes

Outcomes being sought through implementation of the strategic framework are:

Cultural and social benefits Traditional Owners contributing to resilient regional communities and healthy resilient cultural landscapes

Ecological benefits Traditional Owners and partners applying a holistic approach to managing the natural world, through Traditional Owner-led knowledge and practice

Economic benefits To be realised though natural resource management (NRM) services that are delivered through corporation NRM teams (supporting the rehabilitation and management of Country for all species and habitats). Also through the employment of Traditional Owner officers in compliance, information and education roles. Also exploring potential sustainable tourism opportunities (as part of settlement or under partnerships).

7.5.4 Objectives and program components

Traditional Owners are seeking to achieve some system-wide strategic and policy outcomes for the benefit of all Victorian Traditional Owner groups and their communities.

The strategic framework outlines four objectives and corresponding program components with possible actions that will enable Traditional Owners to lead the management of Sea Country according to the five principles described above and support them to meet their vision of healthy people restored to healthy Country.

Realising these objectives will require timeframes that accommodate the need to pass cultural knowledge across generations and for the restoration of Country. Furthermore, monitoring and evaluation of these objectives will need to be conducted using timeframes, methods and processes that are culturally appropriate.

Objective 1
Sea Country knowledge and practice is applied, continuously developed in learning forums and expressed in Country plans

Program component 1
Sharing the expertise: Country planning and restoring the knowledge system

Rationale

The colonial history has been particularly severe in its impact on Traditional Owner communities on the coast. Notwithstanding this, there are Elders and other knowledge holders in contemporary Victoria who are custodians of Sea Country knowledge and practice.

Traditional Owners approach land and water management with a holistic set of practices that link the management of conservation and productive values to the environmental and the cultural services upon which they depend.

Traditional Owners continue to pass on understanding of their Country/ies and the resources within from one generation to the next. Children and young people are taught by their Elders how to watch for the changing of the seasons by the activities of the animals and flowering of plants in the environment. They are trained to be sensitive to the interaction between weather, natural events, plants and animals and to use this sensitivity to predict seasonal change throughout the annual cycle.

Cultural norms encourage knowledge and practice to be shared with other Traditional Owners with authority and for that knowledge and practice to be further developed through adaptive management and passed on through the generations. All program components therefore must be undertaken in parallel with Traditional Owner-governed knowledge development and training. Traditional Owners will decide how consent to share knowledge is given. This is important to protect the influence and integrity of this strategic framework.

These practices will enable Traditional Owners to heal or restore 'sick' Country (cultural landscape systems and processes currently imbalanced) and work towards creating an environment where cultural practices can be applied once again to manage Country (creation and maintenance of resilient cultural landscape systems and processes).

The two-way connection[36] of Traditional Owner values and priorities for managing Country is expressed through Country Plans. This strategy component supports the development of Sea Country plans (or additions of existing Country Plans) for all coastal Traditional Owner groups.

Situational analysis

The excerpts of research notation below provide examples of the complexities involved in developing and applying practice to bring Country back to health.

Traditional Owners [need] greater access to this water (Merri Marine Sanctuary) in order to both harvest resources and to teach the young people about how to do so.[37]

…[This Sea Country is] for us and for non-Indigenous people as well. We're living on Country and we've got a fair idea about what's in the country.[37]

Country is not the same due to the introduced species [and changed fuel and fire patterns] and adapting this knowledge will take time.[38]

Looking after Sea Country means relearning and reconnection….it also means a holistic approach. Looking after Country is looking after ourselves as well.[5]

The Department of Environment Land Water and Planning (DELWP) has recently offered funding for Traditional Owner-led projects in marine and coastal management. This is to support provisions in the new Marine and Coastal Act, which acknowledge Traditional Owner groups' knowledge, rights and aspirations for land and sea country. The Federation has embarked on a series of on-Country co-design events with groups to develop sea country components to Country Plans and to apply and further develop Sea Country practice.

Possible actions

- Provide statutory authority to Country Plans in the new Marine and Coastal Policy
- Monitor and evaluate the process of resetting and healing through the application of cultural practices in different types of Country
- Develop partnerships with other knowledge holders and practitioners across themes and jurisdictions (e.g. Indigenous People's Learning Network, Traditional Owner Cultural Fire Knowledge Group)
- Seek opportunities to restore food, medicinal plants and fibre to Country through Traditional Owner-led practice
- Work with Traditional Owners to ensure institutional frameworks enable and facilitate Sea Country management practices across tenures
- Develop formal training programs at a School or Academy for upskilling people on topics including Indigenous land, fire and water.
- Invest in Traditional Owner-led research that seeks to restore fragmented 'sleeping' Sea Country knowledge and that builds a body of evidence of the environmental, social, economic and cultural benefits of Traditional Owner-led practice.

Objective 2

Traditional Owners harvest wild resources within sustainable limits for ceremony and sharing, and build additional resources for economic development

Program component 2

Sharing the resources: Active and sustainable management of Sea Country

Rationale

The importance of sea country places, plants and animals is recorded by early historians e.g. eels and pelicans are recorded in dreaming stories (refer to the ethno-historical narrative above).

The importance of animals and plants for food, fibre, sharing and ceremony continues in contemporary context, in land, water and seas now known as Victoria and in the understanding that much in the environment has changed as a result of recent anthropogenic forces (particularly over the last 250 years of the colonial period).

The excerpts of research notation below provide examples of the complexities involved in developing and applying practice to restore and protect cultural values and to harvest from natural resources again as cultural assets.

Cultural values as places

Aunty [Gunaikurnai and Ngarigo elder] said that that her family would often fish in the 'dusky water', where the fresh water and the salt water mixed. She did this in places such as Mallacoota, the Bemm River and Gypsy Point near Genoa.[39]

Aunty [Gunaikurnai and Ngarigo elder] said that that, when she was a girl, there used to be a big swamp, called Tosteree on the other side of Nowa Nowa that her family used to fish as well.[39]

Cultural values as animals and plants

Aunty [Gunaikurnai and Ngarigo elder] remembered catching eels, which were a staple of their diet.[39]

Uncle's [Wurundjeri elder] mum dived for mussels that grew on piers and pylons [at Brighton and other places]. Aunty [Wurundjeri elder] remembers collecting mussels and sharing them [amongst the families].[5]

Aunty [Gunaikurnai and Ngarigo elder] said that her family would harvest mussels at Mallacoota, Lakes Entrance and Metung and abalone (called mutton fish) at Marlo and from Cape Conran.[39]

[We] spoke about the area directly in front of us (from the mouth of the Hopkins River to the mouth of the Merri River (taking in Warrnambool Pier, Flume Beach and Granny's Grave Beach). Uncle said that his brother (now deceased) used to fish in that water regularly and caught many fish there. He said there were species such as kingfish, salmon, mullet and bream that were caught there but that the numbers of these species were dwindling as the bottom became silted and the water shallower.[37]

Cultural values as animals and plants cont...

Aunty [Gunaikurnai and Ngarigo elder] then spoke about some of the plants she and her family used to harvest as bushfood and medicine. She said that the best area for plants used for these purposes were found between Mallacoota and Orbost. She told me of a fern she called 'burrawong' which grows like a pineapple which can be eaten but only when boiled or heated. She also spoke of native cherry trees which grow in that region and of a plant which produces a purple and/or white fruit which only grows in that area.[37]

Aunty [Boon Wurrung elder] explained there were massive middens all around the coast show[ing] lots of [old] food sources.[40]

Bunurong Elders to this day collect shells and practice traditional shell making. A tradition handed down by parents. Mutton bird (chicks and eggs) were harvested at Phillip Island, Western Port, San Remo and the practice continues today on the Bass Strait Islands.[41]

Traditional methods

Aunty [Gunaikurnai and Ngarigo elder] has caught eels with nets although some members of the family had used fish spears…. made out of a sapling of the right length that wasn't too thick….He would then attach 3-4 wire prongs and fasten them to the end of the shaft with twine and wax.[39]

…..She said whenever her family all gathered together to camp, this cousin would come along with his spears on top of his car to fish for them all.[39]

Uncle [Easter Maar elder] said that he had grown up spearing eels in the Hopkins near Framlingham (fresh water) but had also used traditional nets and fish traps to catch them. He spoke of feeling around in the mud with his toes to find them.[37]

Indigenous management

…She noted that people shouldn't be allowed to harvest abalone too close to the shore as, when over fished, they simply move further out from the shoreline and become more difficult to catch.[39]

The women of her family would also take swan eggs from the nest at Tosteree swamp but was quick to note that they never took all the eggs from any one nest. Should this happen, the swans would never return to breed in that nest, so she and her family would leave some eggs for the swans to rear to maintain the local population.[39]

When speaking about catching flathead, she said that she can remember her family catching huge flathead but never keeping these large animals. She said that the larger flathead would always be thrown back so that they could continue breeding in order to keep the population healthy.[39]

We'll also need to include Kooyang [short-finned eel] and its migration from our Country through state, commonwealth and international waters to their breeding grounds.[42]

There's a connection to whales and the importance of resources in nearshore marine areas.[6]

Bunurong people had to abide by two cultural lores, Bunjil lore and Loo-ern lore (related to different parts of Country).[43]

Wadawurrung Lore [guides that] large fish are the leaders and lead the young [larger breeding stock will be preserved].4[4]

Aunty described letting large fish go in order to maintain and preserve the larger breeding stock for future generation (the fish species itself, as well as mob).[41]

Situational analysis

Before European settlement the Traditional Owner economy was based on the natural resources of Country, with heavy dependence on marine resources for the coastal Traditional Owner communities. There is acknowledgement of the changed natural environment and the policy and financial barriers that exist for Traditional Owners to be able to access the existing highly regulated system.

Whilst many commercial fisheries are under threat, some niche markets can be developed e.g. short-finned eels, mussels that may be developed under sustainable production systems that are founded on Traditional Owner knowledge and practice.

For those species and habitats under threat, a priority will be on healing Country, domestic (ex situ) conservation, production and compliance.

Sustainable tourism (whale sightseeing, visitors of cultural landscapes e.g. Budj Bim and marine national parks) will be explored.

The excerpts of research notation below provide examples of the changes in the environment as a result of recent anthropogenic forces.

I then asked Aunty [Gunaikurnai and Ngarigo elder] about how the coast was being treated by the broader community today. She said that there was too much over-fishing. She made a point of mentioning that she did not like to see places stripped of shellfish and noted that people come in groups now to one place and harvest as many shellfish as they can get at one time and then, having taken everything, leave and move on to another spot. She said this meant that it took years for a place so affected to be renewed as there was not enough breeding stock left to repopulate it.[39]

Uncle [Eastern Maar elder] noted further that over-fishing was a real problem in the area with tourists and non-Aboriginal locals taking undersize abalone and stripping beaches of pipis.[35]

Aunty [Wurundjeri elder] said…the [Port Phillip] Bay had changed so much…used to have mussels and periwinkles. Uncle (Wurundjeri elder] remembers his mum coming home with mussels…these days periwinkles are tiny at Rosebud …. Used to be very large…almost [golf ball sized].[5]

I asked Aunty [Gunaikurnai and Ngarigo elder] about the condition of the country now as opposed to how it was when she was a girl. She said that places like Mallacoota haven't got much bigger than they were when she was young, but she did note that the rivers there – the Genoa and the Wallagaraugh – flowed much more freely in her youth. She said that when she was young her family would travel by boat along the Wallagaraugh and that is was then deep and wide like the Snowy River (was), not shallow and sandy such as it is today. She said that she thought this is due to so much of the river being diverted and due to the damming of water further up the river near Mount Kosciusko. She said that, due to the interference in the waterways of the region, many of the smaller creeks that emerged from these two rivers simply did not run anymore. She said further that this also had an effect on the coastal swamps and estuarine environments which were now smaller and more saline than they historically used to be.[39]

I then asked Uncle [Eastern Maar elder] about the mouth of the Hopkins and how often it opened during the year. Uncle said that it rarely opened these days, but that it used to open quite regularly. Uncle believed that the mouth was closed often now because the Hopkins doesn't flow as it once did. He told me that too much water is being taken by irrigation and that the flow of the river was also disturbed due to development.[35]

Associated with the pipis is their key importance as a food source. Present impacts to this cultural resource include direct [negative] impacts to the fishery from professional fishers and [damage] to coastal middens and dune vegetation caused by fishers making their own access tracks [with quad bikes].[6]

Possible actions

On-Country NRM teams

Aunty [Gunaikurnai and Ngarigo elder] went on to say that Traditional Owners should also be employed to control pest animals within the coastal and marine areas such as deer, pigs and rabbits.[39]

We'll need scuba diving training for our younger people across all of the Victorian coast to sustain our involvement in sea country initiatives.[42]

- Management principles will be developed for coastal and marine reserves.
- Pilots will be undertaken to facilitate Traditional Owners to manage natural resources on Country as part of a greater holistic set of practices that link the management of resources within the context of the environment and the ecosystems upon which they depend.
- Traditional Owners will utilise their traditional knowledge and skills by acting as environmental monitors on their own country. This will provide conditions for the further development of knowledge and practice under Aboriginal governance and its respectful integration with western science. Traditional Owners will incorporate indicators, tools and measures for monitoring of cultural values and threatened species, into Reading Country[45] programs.
- Marine and coastal reserves will be placed under active management, in particularly habitat improvement (healing and managing Country) to complement current approaches to restore and conserve populations of species.

- Traditional Owners will be again able to harvest animals and plants that they consider to be traditional sources of food and materials. This can be most efficiently undertaken through a listing in the Natural Resource Agreement[46] (Take and Use Provisions or Agreed List) for each Traditional Owner group.
- Economic development outcomes will also be sought through the employment of Traditional Owner Officers in compliance, information and education roles.
- In terms of contract services, NRM services will be delivered through corporation NRM teams, supporting the rehabilitation and management of Country for all species and habitats, using traditional and scientific methods, including cultural fire, forest gardening, water (cultural flow) management and replanting.
- Potential cultural and sustainable tourism opportunities will also be explored as part of settlement[47] or post settlement, under partnerships. This may include guided cultural and biodiversity tours, bird and whale watching, and associated infrastructure development (vehicles, hides, track development, interpretive signage etc.).
- Traditional Owners will be identified and supported in the development of Aboriginal-owned businesses in aquaculture and other marine resource development that is built on cultural values and (sustainable) management principles.

Objective 3
Improved management of marine and coastal reserves and private land through the application of collaborative management to heal Country and build resilience in people and landscapes

Program component 3
Sharing the management: Holistic land and sea management for healthy Country and healthy people

Rationale

Collaborative management is an administrative and cultural process that strives for transparent and equitable agreement about natural resource management. This approach incorporates a variety of partners and roles working towards multiple environmental, social and cultural goals. Collaborative management approaches have successfully been applied in many different contexts around the world.[48] In Australia, a key example is in the establishment of Indigenous Protected Areas.

Partnership arrangements and management objectives need to be tailored to each regional and cultural landscape context. This includes analysis of the tenure, regulatory and operational arrangements to support beneficial Indigenous management practices, together with a process of learning to continuously improve planning, management and action.

Situational analysis

Institutional arrangements for the management of public land are complex and compartmentalised. The management objectives for a particular area or reserve may be too narrow to realise all the natural and cultural values inherent in that asset; this may result in unintended outcomes when other department or agency policies, research and programs are focused on, for example, threatened species protection, commercial production or recreation.

The excerpts of research notation below provide examples of the history of Traditional Owner management of Sea Country and our aspirations to improve management arrangements of what are now public land reserves in contemporary Victoria.

Aunty [Gunaikurnai and Ngarigo elder] stated that she would like to see more and bigger marine parks so that the environment did not suffer so much from over-use and over-fishing. She added that these parks should not exclude Traditional Owners, who should be allowed to harvest the resources therein using their traditional understanding of the species and the health of the environment to guide their impact upon it. She also pointed out that there should be provision made for Traditional Owners to be employed *looking after these marine parks as they could bring their understanding of the waterways and the environment to these positions. She noted further that Traditional Owners employed in this way should be able to work in pairs so that they could work together when inspecting catches and, if necessary, giving out fines and sanctions.*[39]

Initially, Uncle [Eastern Maar elder] spoke about Moyjil and the damage that was occurring to it. He said he had been involved in discussions with the shire council about how best to protect the site but felt that the shire had not listened to the advice of Maar Elders. Uncle also told me that he and other Traditional Owners had advised that any signage referring to Moyjil be placed some distance away from the site so that it would invite neither the curiosity of tourists nor the attention of vandals. Rather than following this advice, the council have placed the sign directly in front of the midden site. Furthermore, they have not only fenced off the area around the site, they have actually placed a fence into the site, running horizontally around one of the ancient middens…. Uncle complained that the people at Aboriginal Victoria, who were involved in the discussion of the site at each turn, also did not pay attention to the wishes of the Traditional Owners.[35]

When I asked Uncle [Eastern Maar elder] if there were other significant places and sites in the area he told me that there were many along the coast in this region. He spoke of one site which was a cave associated with the law man Mawpaw. He said that Mawpaw could speak all of the languages of the area and that, because of this, it was he who had, in times gone by, organised safe passage through country for people of the region when they needed to move through the country of their neighbours. He also said that the cave ran underneath Warrnambool and was previously used by local Aboriginal people as both a refuge and a passage to the coast. He said the cave entrance was somewhere nearby in the sand dunes but is now closed.[35]

Mawpaw's cave illustrates clearly how the people of the region negotiated access to the coast and how the freshwater people of the inland areas communicated with those of the saltwater/coastal areas. This would have also involved trade and marriage alliances in the pre-colonial and contact eras.[35]

I then asked Uncle [Eastern Maar elder] if there were any stories about whales in the area. He said that there was a whale nursery nearby but that there had been a time when nobody had seen a whale in years. He said that, one day, Peek Wurrung man had decided to try to sing the whales back to the coast. This man had performed a ceremony involving traditional dance and song and, after that, people began sighting whales from the beach again.[35]

Bunurong/Boon Wurrung people could call seals [considered as a deity/sacred association with a dreaming story].40 Women are skilled seal hunters. Bunurong women could swim up to seals and catch them easily. This shocked even the professional sealers of the early 1800s.[49]

Coastal and Aboriginal environments have changed. Aboriginal values have not. Environmental pressures dictate these cultural values require greater importance now and immediate protection.[49]

It would be good to work on the Budj Bim lava flow where it extends out under the ocean beyond Tyrendarra; and with that, the original river mouth [would] be covered (considered) as well.[42]

[Gunditjmara staff showed us]…the convincing ground, a place where Gunditjmara people were massacred by sealers over a dead whale that washed up on the beach. Between 70 and 200 people [were] killed. It was about keeping and preserving the site…aspirations to make a reflective, quiet site, honestly and accurately depict the site as a memorial space.[6]

Our sacred places need to be protected. This begins with rights to access and manage [these sites].[44]

Culturally respectful disposal of deceased animals, following Elders' advice, is also important e.g. a stranded whale was taken to the tip rather than buried on-site.[44]

All [agency partners] should receive cultural training before accessing sacred places.[44]

Possible actions

- Traditional Owners lead actions to identify, map, plan and implement cultural heritage protection and management in the coastal and marine environment
- Traditional Owners to enforce regulations and to issue warnings, fines and refer serious infringements to the appropriate authorities. They will have the power to restrict camping and natural resource extraction near sacred and significant sites on Country (see also objective 2 actions)

- Identify and progress a minimum of five pilots (as cultural landscapes) in a more collaborative, true partnership approach to both planning, resourcing and management
- Apply the full suite of Indigenous land and water management practices to heal and manage Country.

Objective 4

Institutional frameworks, operational and procedural pathways have been developed that enable Traditional Owners to undertake Sea Country management actions across all land tenures and according to their cultural obligations

Program component 4

Sharing the responsibilities: Two-way co-capacity building between agencies and Traditional Owner communities

Rationale

The new Marine and Coastal Act has provisions:

- To acknowledge Traditional Owner groups' knowledge, rights and aspirations for land and sea country; and
- To engage with specified Aboriginal parties … in marine and coastal planning, management and protection.

Despite the existence of supporting statements and mutual objectives in the act and in some government policies,[50] there remain numerous policy and regulatory constraints to Traditional Owners. This means that Traditional Owners currently have limited authority, resources and capacity to develop and apply cultural practices on Sea Country according to the principles described in this strategic framework.

Situational analysis

DELWP are currently supporting Traditional Owner groups as regional partners in coastal and marine management through the development of two pilot regional and strategic partnerships with the state (a provision under the new act).

Possible actions

- Identify and resource pilots over the next five years to showcase and test different institutional arrangements that enable Traditional Owners to lead practice and develop proof of concept on different Countries.
- Identify, establish and grow key partnerships with coastal land and sea management authorities.
- Identify regulatory barriers to practicing Traditional Owner-led Sea Country management and trial methods of removing these barriers in partnership with relevant agencies and stakeholders.

7.5.5 Next steps

Country is more than a place. The Indigenous relationship between people and Country is deep and intimate. From an Indigenous perspective, one belongs to Country and there is a reciprocal relationship that exists between people and Country.

VEAC considers that the proposed strategic framework as provided offers a way forward where Traditional Owners can further develop and apply Aboriginal knowledge and practice for Sea Country in a contemporary Victorian context. Through undertaking the framework's outlined program of work, Traditional Owner communities, along with the cultural landscapes and seascapes, can begin to be healed.

The actions outlined in the strategic framework can complement and support broader processes of reconciliation as well as leveraging significant environmental, social and economic benefits in regional Victoria.

7.6 References and notes

1. The authority to speak for Country and responsibility to care for Country in Victoria is vested in Traditional Owners.
2. https://www.iucn.org/theme/protected-areas/about/protected-area-categories (accessed January 2019).
3. https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed January 2019).
4. Transform the participation goal with Traditional Owners from 'involve' to 'collaborate' see: https://www.iap2.org.au/Tenant/C0000004/00000001/files/IAP2_Public_Participation_Spectrum.pdf (accessed January 2019).
5. Wurundjeri elder interviews, Abbotsford Convent, Melbourne, 21 January 2019.
6. Gunditjmara knowledge holder interviews and on-Country discussion 07 December 2019.
7. State of Victoria (undated) *Our catchments our communities. Integrated catchment management in Victoria 2016-2019*
8. Country includes all of the sentient and non-sentient parts of the world and the interactions between them, according to Aboriginal lore. Indigenous lore and life originates in and is governed by Country. Country must be respected. In a western conservation context, this is more aligned to a systems and resilience approach to active, adaptive management.
9. Gunditjmara interests and priorities for managing Country are currently described in the *Ngootyoong Gunditj Ngootyoong Mara South West Management Plan* (Parks Victoria, May 2015). See https://parkweb.vic.gov.au/__data/assets/pdf_file/0003/662763/NGNM-South-West-Management-Plan.pdf (accessed January 2019).
10. Gunditjmara and Eastern Maar interests and priorities for managing Sea Country are currently described in *The Kooyang Sea Country Plan (*Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation, 2004) See https://www.environment.gov.au/system/files/resources/4fc3aad8-47f4-4d90-b58e-bbadbd9e369d/files/kooyang-plan05.pdf (accessed January 2019).
11. Eastern Maar Aboriginal Corporation (2015) *Meerreengeeye ngakeepoorryeeyt* http://easternmaar.com.au/wp-content/uploads/2012/10/EM_CountryPlan_FINAL.pdf (accessed January 2019).
12. Gunaikurnai Land and Waters Aboriginal Corporation (2015) *Gunaikurnai Whole-Of-Country Plan* https://www.gunaikurnai.org/wp-content/uploads/gk_whole-of-country%20plan%20LR%20FINAL%20270815.pdf (accessed January 2019).
13. The Aboriginal Cultural Heritage Register and Information System (ACHRIS) contains only a relatively small proportion of the total heritage places and objects in Victoria.
14. The Diary of Sir Joseph Banks – April 20-21, 1770.
15. F. M. Bladen (ed.) (1895) *Historical records of New South Wales, vol. 3, 1796-1799*. Charles Potter, Government Printer, Sydney, p 762.
16. Howitt, A.W. (1904) *Native tribes of south-east Australia.* McMillan & Co, London, p 82.
17. Dawson, J. (1881) *The languages and customs of several tribes of Aborigines in the Western District of Victoria.* George Robertson, Melbourne, p 19.
18. Brough-Smyth, R. (1878) *Aborigines of Victoria with notes relating to the habits of the natives of other parts of Australia.* John Ferres, Government Printer: Melbourne, p 203-204.
19. Bulmer, J. (1855-1908 [1999]) *John Bulmer's Victorian recollection of Victorian Aboriginal life, 1855-1908. No 3.* Compiled by A. Campbell, edited by R Vanderwaal, Museum Victoria: Melbourne – cited from Cahir, F., Clark, I. D. and Clarke, A. (2018) *Aboriginal biocultural knowledge in south-eastern Australia: perspectives of early colonists.* CSIRO Publishing, Victoria.
20. Dawson, J. (1881) *The languages and customs of several tribes of Aborigines in the Western District of Victoria.* George Robertson, Melbourne, p 94-95.
21. Clark, I. D. (2014) *The journals of George Augustus Robinson, Chief Protector, Port Phillip Bay Aboriginal Protectorate, 1 January 1839 – 30 September 1852* (1st ed). Createspace, USA, p 629.
22. Cahir, F., Clark, I. D. and Clarke, A. (2018) *Aboriginal biocultural knowledge in south-eastern Australia: perspectives of early colonists.* CSIRO Publishing: Victoria.
23. Stephens, M (ed). (2014) *The journal of William Thomas, Assistant Protector of Port Phillip and Guardian of the Aborigines of Victoria 1839-1867, 4 vols.* Victorian Aboriginal Corporation for Languages, pp.131-2 – cited in Cahir, F., Clark, I. D. and Clarke, A. (2018) *Aboriginal biocultural knowledge in south-eastern Australia: perspectives of early colonists.* CSIRO Publishing, Victoria.
24. Dawson, J. (1881) *The languages and customs of several tribes of Aborigines in the Western District of Victoria.* George Robertson, Melbourne, p 52.
25. Howitt, A.W. (1904) *Native tribes of south-east Australia*. McMillan & Co, London, p 278.
26. Fison, L. and Howitt, A. W. (1880) *Kamilaroi and Kurnai: group-marriage and relationship, and marriage by elopement.* George Robertson, Melbourne.
27. Howitt, A.W. (1904) *Native tribes of south-east Australia.* McMillan & Co, London, p 134.
28. Howitt, A.W. (1904) *Native tribes of south-east Australia.* McMillan & Co, London, p 486.
29. Howitt, A.W. (1904) *Native tribes of south-east Australia.* McMillan & Co, London, p 493.
30. Mathews, R. H. (1904) The native tribes of Victoria and their languages. *Proceedings of the American Philosophical Society* 6 (175): 66.

31. Aunty Carolyn Briggs.
32. For Aunty Carolyn Briggs's full accounting of this narrative see https://cv.vic.gov.au/stories/aboriginal-culture/nyernila/boon-wurrung-the-filling-of-the-bay-the-time-of-chaos/.
33. Such as Parks Victoria's *Managing Country Together,* CFA's *Koori Inclusion Action Plan (2014-2019)* and DELWP's *Aboriginal Inclusion Plan 2016-2020.*
34. Noting 'Indigenous peoples have the right to practice and revitalize their cultural traditions and customs', Article 11.1 of the *UN Declaration on the Rights of Indigenous Peoples* https://www.humanrights.gov.au/publications/un-declaration-rights-indigenous-peoples-1 (accessed 04 Sep 2018).
35. Wadawurrung knowledge holder interview, February 2019.
36. Between Aboriginal and western world views.
37. Eastern Maar elder interview, Warrnambool, 09 December 2018.
38. NRM Committee, 31 May 2017.
39. Gunaikurnai and Ngarigo elder interview, Jeeralang, 25 November 2018.
40. Boon Wurrung elder interview, Melbourne, 21 January 2019.
41. Bunurong elder interview transcript, Frankston, December 2019. See also a link to Bunurong elder Bernice Condie on these practices: https://www.youtube.com/watch?v=Fm0BhC5Tgk8. (accessed 31 January 2019). Bernice's Aboriginal name is *moekatan* (meaning 'of the sea').
42. Gunditjmara knowledge holder, by email 05 October 2018.
43. Bunurong elder interview transcript, Frankston, December 2019. Lore is connected to a kinship system that includes responsibilities (through totems) for protection of culturally valued species, through rules associated with practice (guiding what could or couldn't be hunted to safeguard that species and its place in the natural world).
44. Wadawurrung knowledge holder comment, by email 21 February 2019.
45. Reading Country is a Traditional Owner-led program to identify, develop and/or refine key performance indicators and tools for measuring progress against Aboriginal cultural and natural resource outcomes including Traditional Owner wellbeing through connection to Country. The indicators will be used to measure progress against the relevant outcomes in Joint Management Plans or other natural resource management strategies and to measure the health of Country for partnership forums authorised under the Traditional Owner Settlement Act (the Natural Resource Agreement).
46. Provisions for the harvesting of natural resources are outlined in the Recognition and Settlement Agreement under the *Traditional Owner Settlement Amendment Act 2016.*
47. E.g. under the *Traditional Owner Settlement Amendment Act 2016* or through a Determination under the Native Title Act (Cth).
48. Under many guises, including the Indigenous Protected Area program in Australia. For example, see R. J. Fisher, Experiences, challenges and prospects for collaborative management of protected areas: an international perspective. In Louise B. Buck, Charles C. Geisler, John Schelhas and Eva Wollenberg (eds) (2001) *Biological diversity: balancing interests through adaptive collaborative management.* CRC Press, Boca Raton, Florida.
49. Bunurong elder interview transcript, Frankston, December 2019.
50. Such as Parks Victoria's *Managing Country Together,* CFA's *Koori Inclusion Action Plan (2014-2019)* and DELWP's *Aboriginal Inclusion Plan 2016-2020*.

8 Non-Aboriginal Heritage

This chapter provides an outline of the maritime heritage values associated with the European history of Victoria, and how they are managed and protected. Maritime archaeology focuses on the tangible evidence of seafaring history, including vessels, structures such as ports and lighthouses, and subsistence activities including fishing and whaling. Issues affecting Victoria's non-Aboriginal heritage are discussed, and existing and emerging uses and threats are canvassed.

KEY POINTS AT A GLANCE

- The sea had a central role in the early economic, social and physical development of Victoria by Europeans. Physical evidence of past dependence on the sea for transport of people, goods and information remains in numerous historic places and objects.
- Many sites in Victoria that are rich in non-Aboriginal heritage are also of significance to Aboriginal people – both pre- and post-contact with Europeans – but these values are not as well documented. The Shared Heritage Project in Victoria is identifying places with both Aboriginal and other heritage values.
- The permanent European settlement of Victoria followed agricultural development from the 1830s and quickly led to the establishment of maritime infrastructure, as sea transportation was much more reliable than inland travel. Investment in ports, harbours, shipping channels and navigation aids continued through the nineteenth and twentieth centuries.
- Defence, quarantine and recreation also drove extensive changes in the use and development of marine and coastal areas in the nineteenth and twentieth centuries.
- Historically significant places and objects in Victorian waters and on land are protected under the *Heritage Act 2017*. Shipwrecks and other underwater cultural heritage are also protected under complementary Commonwealth legislation.
- Many heritage values are not well known or documented. For example, shipwrecks are some of the most readily recognisable sites of maritime archaeology but fewer than half of the 780 shipwrecks along the Victorian coast have been located.
- Shipwrecks were often damaged by treasure hunting divers, but legislative protection and education – including through establishment of shipwreck trails – have promoted more benign forms of tourism.
- General threats to non-Aboriginal maritime heritage include degradation by natural forces, some of which (e.g. storm surges) will worsen with climate change.
- Increasing pressure for coastal and foreshore development is likely to lead to disturbance of undiscovered or undocumented heritage sites and objects.

The broad categories of threats to non-Aboriginal heritage are summarised and examples are provided for each threat in table 8.1; for more detail see the relevant section of this chapter. Discussion of threats in this chapter are threats to non-Aboriginal heritage. The threats that non-Aboriginal heritage might pose to other values are discussed in the relevant chapter.

Table 8.1 Summary of threats to non-Aboriginal heritage in Victoria

Threat class	Pathway/ outcome	Example (with section reference)
Climate change	Sea level rise	Maritime history sites are close to water and could be threatened with inundation due to rising sea levels (5.4.3)
	Ocean acidification	Corrosion of metal structures and objects (for example hulls of shipwrecks) will increase in more acidic oceans requiring more extensive use of sacrificial anodes (8.2.3)
	Increased storm frequency	Storm events (e.g. cyclones) can lead to water movement and sandblasting (8.2.3)
Physical	Anchor damage/ trampling	Commercial and recreational vessels may cause anchor damage to shipwrecks through dragging anchors or anchors dropped directly over wrecks (8.2.3)
	Removal/theft	Divers may cause damage through looting and souveniring (8.2.3)
	Decomposition/ corrosion	Penetration of the wreck by divers can increase corrosion through the build-up of oxygen pockets in confined spaces (8.2.3)
	Exposure	Corrosion of metal structures and objects is decreased by water depth and burial. Some fragile wrecks are reburied to assist with protection (8.2.3)
Biological	Marine borers, fungi, bacteria	Biological threats come predominantly through the consumption of timbers by marine borers, which appear to be increasing in range as oceans warm (8.2.3)
Community/ industry demand	Expansion of industry	Disturbance to the seabed through dredging, trawling, or other industries (e.g. oil and gas pipelines) can inadvertently disturb undiscovered wrecks (8.2.3)
	Demand for historical tourism	The promotion of wrecks through shipwreck trails could lead to increased looting and souveniring (8.2.2)
	Development/ obsolescence	Developments in SCUBA equipment have opened access to previously more difficult to reach wrecks in deeper waters, opening these sites to increased risk of looting and damage (8.2.3)
	Recreational access	As divers are the main users of underwater maritime heritage, wrecks in protected zones that are safe to dive are occasionally opened to experienced divers under permit (e.g. City of Launceston) (8.2.2)
	Safety risk	Shipwreck protected zones close wrecks that are unsafe to dive (e.g. *HMVS Cerberus*) (8.2.1)

8.1 Victoria's maritime history

Unless otherwise cited, the following is adapted from Barnard (2008)[1] with additional details taken from the Victorian Heritage Register.

8.1.1 Early navigation and settlement (1770-1830s)

Charting the coastline

The first documented encounter with the Victorian coast by Europeans was when Lieutenant Hicks spotted what is now known as Point Hicks in east Gippsland on April 19, 1770 onboard James Cook's *Endeavour*. It was not until 1797, when men from the *Sydney Cove* landed on Ninety Mile Beach, that the first recorded Europeans set foot in Victoria.

Subsequent sea-based surveys between 1797 and 1801 charted the Victorian coast including Western Port (so named because it was the westernmost port identified from Sydney Cove) and Port Phillip Bay (initially named Governor King's Bay, then subsequently renamed by King in honour of Admiral Arthur Phillip who led the First Fleet).

British settlements

The first British settlement in Victoria, established to prevent French rivals from claiming territory, was at Sullivan's Cove near Sorrento in 1803. Victoria's first maritime infrastructure, a gun battery, was constructed on shore. The short-lived settlement of some 467 people was moved to Tasmania (then Van Diemen's Land) in 1804. The site is one of few Australian early settlement sites that have survived and is included on the Victorian Heritage Register. Surviving archaeological evidence includes artefacts (e.g. bottles and leg irons), grave sites, and much of the pre-settlement landscape (i.e. enclosing headlands, old growth moonah woodland).

The second settlement was similarly established to guard against French invasion and also short lived. A small group of soldiers, convicts and explorers settled in Western Port at Settlement Point near Corinella between 1826 and 1828 and on Phillip Island near Rhyll. Batteries were established to guard the entrance to the bay, but when no threats emerged the group returned to Sydney.

Sealers and whalers

Whaling was one of the first export industries in Australian colonies. Shore-based stations were often established on remote coasts, making them the first sustained European presence in the area.[2]

Sullivan Bay, Port Phillip 1803, from a sketch by G.P. Harris, Surveyor

From the late eighteenth century, small groups of sealers based themselves in Sealers Cove on Wilsons Promontory and Phillip Island in Western Port. Others worked western Victoria from Port Fairy and Portland. Furs were shipped for sale to Sydney or overseas ports. Whalers also established bases at Port Fairy and Portland. Whale blubber was used for oil and whalebone in corsets. Due to rapid overexploitation of stocks, both sealing and whaling were short-lived industries in Victoria, ending in the 1830s and 1850s respectively.

Aboriginal encounters

During early European settlement, the south-eastern Australian Aboriginal populations were decimated by smallpox that spread from the Sydney Cove settlement around 1790 and then again in 1830. While some of the early European explorers and settlers in the Port Phillip District (as Victoria was known) had peaceful encounters with the local Aboriginal people, such encounters were more likely to involve hostility and violence leading to the deaths of many Aboriginal people.[3] The Convincing Ground near Portland is the site of the first documented massacre of Aboriginal people in 1833 or 1834 where it is estimated that up to 200 Aboriginal people were killed by European whalers.

8.1.2 Permanent settlements (1830s to 1851)

Spread of settlers

By the mid-1830s, land was becoming scarce in New South Wales and Van Diemen's Land (Tasmania). Pastoralists turned to Port Phillip District and settled in Portland and around Port Phillip Bay. By 1836 there were so many settlers in the district that an army captain, William Lonsdale, was sent to represent government. He was succeeded by Lieutenant-Governor Charles La Trobe. The establishment of maritime infrastructure including port-related government services were high priorities. The first customs office was set up on the Yarra and, between 1837 and 1840, customs houses were also established at Williamstown, Port Melbourne, Geelong and Portland. Customs duties regulated goods imported to and exported from the colony and provided an important source of government revenue.

Sea transportation was essential to the spread of European settlers across Port Phillip District. At a time when inland routes were undeveloped and dangerous, the sea provided a means of transport for people, goods and information both domestically and internationally. For example, building supplies such as timber and lime were harvested from the Mornington Peninsula and moved by sea to Melbourne. By 1839 the *Midlothian* was the first vessel to sail directly from Britain to Port Phillip Bay.

Ports and harbours

Three alternative landing sites existed in early Melbourne and each had its own challenges. The main settlement on the Yarra was favoured as there was a freshwater source, but sandbars and mudflats prevented larger vessels from entering. Gellibrand's Point (Williamstown) was close to deep water anchorages but lacked a freshwater source and was some distance from the main settlement. Sandridge (Port Melbourne) was closer to the main settlement but strong south-westerly winds often made the water too choppy for safe landings. Other early ports existed at Portland, Geelong and Albert Town (Port Albert).

Maritime safety

The first recorded shipwreck in what are now Victorian waters occurred in 1797 with the disappearance of the *Eliza* while salvaging cargo from the *Sydney Cove*. As shipping traffic increased with settlement, so too did the number of shipwrecks. The Port Phillip Heads were particularly treacherous. To counter the dangers of entering Port Phillip Bay, navigational buoys were established in 1837. By 1839, officially-licensed pilots were stationed at Shortlands Bluff (Queenscliff) to guide ships through the Heads. A stationary navigational light was installed in a wooden structure at Williamstown in 1840 (replaced by a bluestone lighthouse in 1849), and by 1843 the first sandstone lighthouse was completed at Queenscliff.

Quarantine

The risk of infectious diseases arriving in the colony with settlers led to the establishment of quarantine camps at Red Bluff (Point Ormond) in 1840 and Williamstown in 1841. More permanent arrangements were made for quarantine at Point Nepean in 1852. Graves and other remnants of these early quarantine sites are listed on the Victorian Heritage Inventory.

Recreation

Even in the early days of settlement, some residents had time to appreciate the sea. From the 1840s, surveyors set aside land for recreational purposes as towns were drawn up. In 1844 the foreshore at Geelong was reserved for the purpose of bathing. The Corio Bathing establishment opened in 1844. While there was a general rule that land within 100 feet (30.48 metres) of the high-water mark of the sea was not to be alienated from the Crown, some foreshores (e.g. at Brighton and Port Fairy) were granted to settlers. However, after 1870 all water frontages were withheld from sale and permanently reserved.

As men tended to bathe nude, bathing in public was prohibited between 6 am and 8 pm. Bathing establishments offered screened areas for men and women to bathe separately.

8.1.3 Gold rush to Federation (1851 to 1901)

Gold rush

Gold was discovered in Melbourne the same year as Victoria separated from the colony of New South Wales. This brought a massive influx of ships, for which the newly-independent government was ill equipped to deal. Gold rush immigration and trade stimulated the growth of existing ports and encouraged the development of other areas such as the Gippsland Lakes. Jetties and piers were also constructed at coastal locations including Frankston, Mornington, Portarlington, Hastings and Warrnambool to improve transportation of locally-produced products such as firewood, fish, meat and vegetables. Some of this development was carried out by private railway companies.

Ports and harbours

In the second half of the nineteenth century, the government invested substantially in port and harbour infrastructure. Much of the investment was intended to stimulate the economic development of the colony, particularly through the growth of agriculture and settlements. This work had substantial environmental impact, including the destruction of extensive wetlands.

The Yarra wharves were improved in the 1850s and 1860s with additional sheds and cranes. Constant dredging was required to keep the Yarra navigable for ships. By 1873, it was recommended to the government to do away with the 'repulsive aspect' of the area, including the swamp, through a program of drainage, reclamation and improvement. This led to the once difficult-to-navigate course of the lower Yarra being developed into a wide, deep canal along a direct course from the city to the river's mouth.[4]

The Melbourne Harbour Trust was established in 1877 to continue to improve access for shipping and cargo to Melbourne. Major public engineering works were commissioned including the creation of the Coode Canal on the Yarra and the completion of Victoria Dock in 1896. The Port Phillip Bay channels were widened and deepened in the late 1880s and early 1890s. Improvements were also made during this period to the ports of Geelong, Portland, Warrnambool, Port Fairy, Port Albert and Cunninghame (Lakes Entrance).

Developments in shipping also influenced maritime infrastructure. Iron-hulled sailing ships and then steamships gradually replaced wooden sailing vessels. Port Phillip jetties had to be lengthened and channels deepened and widened to accommodate more, and larger ships.

To facilitate ship repair, construction of a dry dock, the Alfred Graving Dock (which later became the State Shipbuilding Yard), began in 1856 at Williamstown. There were also private ship repair companies on the south bank of the Yarra and at Port Melbourne. Surviving evidence of early shipbuilding and repair industries can be seen in the Duke and Orr's dry dock (constructed in 1875 and rebuilt in 1901), the site of the Melbourne Maritime Museum and the barque *Polly Woodside*.

Maritime safety

Navigational aids continued to be added in Port Phillip Bay. A flagstaff that signalled the state of the tides through the Rip was erected at Point Lonsdale in 1852 and a lighthouse and signal master's quarters were added a few years later. The early buoys in the Bay were replaced by lights constructed on timber piles in the south and west channels and at

Polly Woodside

South Channel Pile, Port Phillip Bay. Photo: Robert Molloy

Williamstown. The south channel pile was relocated in 1998 and the Williamstown pile light now resides in the Melbourne Maritime Museum.

The development of navigational aids was often a response to maritime disasters. Australia's worst maritime disaster occurred in 1845 with the wrecking of the *Cataraqui* off King Island in Tasmania when some 400 people were drowned. This prompted the construction of Bass Strait lighthouses, the first of which was built at Cape Otway in 1848. However, the Cape Otway lighthouse couldn't prevent the wreck of the *Loch Ard* in 1878 on Mutton Bird Island. Some 52 of the 54 passengers and crew drowned. The wooden lighthouse on Gabo Island was built in response to the wreck of the *Monumental City* in 1853. In eastern Victoria, lighthouses were built at Cape Schanck and Wilsons Promontory in 1859. In western Victoria, harbour lights and/or lighthouses were built in Portland, Port Fairy and Warrnambool in the late 1850s. The intercolonial conference of Principle Marine Officers on the Colonies in 1873 led to the construction of further ocean lights along the coast, some of which still stand today (e.g. Cape Nelson lighthouse).

Despite the development of navigational aids, shipwrecks were still all too common in the nineteenth century. In 1857, four lifeboats were commissioned and installed at Port Fairy, Queenscliff, Portland and Warrnambool. Port Albert received one in 1859. After the wreck of the *Cheviot* in 1887, a jetty and lifeboat shed were built at Point Lonsdale to house an additional lifeboat at the Heads in 1891. An alternative to lifeboats were rockets or mortars. These devices fired rockets attached to lines of rope to stricken vessels. Survivors were then hauled to shore. Small, specifically-constructed sheds were necessary to house the equipment and to keep rockets or mortars secure and dry. While these sheds were built at most ports, examples of these sheds still exist at Port Fairy, Lakes Entrance and Port Campbell.

Defence

In response to the British involvement in the Crimean War, the British Secretary of State had advised the Australian colonies to put their harbours in a state of defence. The gold rushes had made Melbourne a busy and valuable trade port. This led to the construction of batteries at Williamstown and Emerald Hill (South Melbourne) in 1855. While advice to the Victorian government in 1858 indicated that coastal defence infrastructure would be most efficacious protecting the Heads, the associated cost and insufficient fire power of guns at the time led to the further strengthening of defences at Hobson's Bay.

In 1870, imperial forces withdrew from the colony and the Victorian government had full responsibility for defence. Subsequent improvements in military technology meant that protecting the Heads became more viable. Fortifications were developed at Queenscliff, Swan Island and South Channel Fort in 1879 and at Point Nepean in 1882. Further weapons developments meant that the second shoal fort at Pope's Eye was no longer needed, so work was discontinued after only the stone base (the annulus) was completed. After 1885 a second battery was built at Fort Franklin (near Portsea), and by 1890 Victoria was assessed as being the best defended commercial city in the British Empire.

Fort Queenscliff provided defences for the entrance to Port Phillip Bay. Engraving published in *The Australasian sketcher*, 1878. Source: State Library of Victoria

Recreation

Developments in railway infrastructure facilitated tourism at resort locations such as St Kilda and Brighton in the 1850s and 1860s. From the 1850s, 'excursion' steamers began carrying passengers between settlements around Port Phillip Bay and in 1872 the first regular first-class service was established between Queenscliff and Sorrento. The steamers carried holiday makers and day trippers to resort towns including St Kilda, Mordialloc, Mornington, Sorrento, Portsea and Queenscliff. Steamer traffic led to the development of coastal hotels and resorts including around the mineral springs at Clifton Springs in the 1880s.

Several sea baths were established in Port Phillip Bay in the nineteenth century including at St Kilda and Port Melbourne. Others were established outside of Port Phillip Bay at Portland and Warrnambool. Even after prohibitions on open bathing during daylight hours were relaxed, people still used sea baths as they offered diving platforms and protection from sharks. Swimming carnivals were held in the St Kilda baths in 1860s. In the 1870s, swimming clubs associated with baths in South Melbourne, Middle Park and St Kilda were formed. Bathing boxes were established around Port Phillip Bay in the late 1800s. These structures were initially designed to offer a discreet changing place and were usually constructed in connection with a beach resort home or hotel.

While much early enjoyment of the beach was passive, sailing regattas took place on Hobsons and Corio bays in the 1840s and 1850s. The first yacht club, the exclusive Victoria Yacht Club, formed in

1856 and later became the Royal Yacht Club of Victoria in the 1880s. Other yachting and sailing clubs followed. Competitive rowing began on the Yarra in the 1860s.

8.1.4 Early twentieth century (1901 to 1950s)

Ports and harbours

Even in the early twentieth century, much interstate travel was via the sea. This declined after World War Two (WWII) with improved rail connections, access to air travel and increased private car ownership. The development or redevelopment of major ports during this period was linked with the relocation of major industries and the growth of new ones. The Port of Melbourne continued to expand with additions to Victoria Dock between 1914 and 1920 enlarging its capacity. In 1925 the port entrance was widened to allow larger ships to enter. Disruption to international sea transport during WWII was a major impetus to develop local industries to support Victorian and Australian independence. A concurrent push for decentralisation led to further development of harbours and maritime infrastructure away from Melbourne, as the success of 'closer settlement' and 'soldier settlement' policies depended on the ability of farmers to get their products to market. Sea transport was an essential aspect of this.

Maritime safety

After Federation, the Commonwealth became responsible for ocean lights. In response to a review of existing lighthouses and navigational lights, further lighthouses were built at numerous locations, including around Wilsons Promontory.

Defence

After Federation, the Port Phillip ports passed into Commonwealth control. In 1914, fortifications were added near Point Lonsdale lighthouse. The first British shot fired in WWI came from Fort Nepean. A German steamer, the *SS Pfalz* had been given clearance to leave Portsea before Fort Nepean received the message that war had been declared. A shot was fired before the captain was convinced to stop. In WWII the first British shot was also fired from Fort Nepean when the Australian freighter *SS Woniora* neglected to identify itself entering the Heads. In response to the increasing threats of invasion during WWII the light building Caisson M (known as Chinaman's Hat) was constructed offshore at Port Phillip Heads to shelter naval equipment.

Diver on the SS Cambridge, a Brittish ship which hit a mine in 1942 and sank off Wilsons Promontory. Photo: Steve Cartlidge

Gabo Island lighthouse completed in 1862 now has a solar-powered electric light

Recreation

While early beach holiday-makers without their own summer retreats stayed at hotels, coffee palaces and guest houses, by the 1890s camping offered a cheaper way to holiday by the sea. Camp grounds opened at Dromana, Rosebud, Anglesea, Torquay and Lorne. By the late 1930s, there were 20 camping grounds between Mt Martha and Portsea alone. The growing popularity of camping coincided with the widespread personal use of cars between WWI and WWII, and as such, depended on adequate road access. Construction of the Great Ocean Road began in 1918 to open the western coast to tourists and holiday makers.

After 1917, mixed beach bathing was no longer prohibited and enclosed bathing was no longer mandatory. Foreshores were developed to accommodate public conveniences, kiosks, pavilions, changing rooms, carparks and playgrounds. The increasing use of beaches for swimming was accompanied by growth in the lifesaving movement. The first beach lifesaving clubs opened in 1912 at Elwood, Black Rock, Hampton, Middle Park and Brighton. Surf reels were installed on beaches after 1914. After the Victorian Surf Lifesaving Association formed in 1947, clubs gradually opened at numerous surf beaches.

By the 1930s, there was increasing recognition that intensive use of beaches and foreshores around Port Phillip Bay was leading to vegetation damage and removal, cliff erosion and storm inundation of low-lying suburbs. The then Public Works Department began a program of foreshore protection, which at one stage included a plan to construct a continuous rubble sea wall from Werribee to Frankston.

8.2 Maritime archaeology

8.2.1 Historical values

Victoria's history of development was intrinsically linked with the sea. The physical evidence of our past dependence on the sea for the transport of people, goods and information remains in numerous historical places and objects. Historic shipwrecks and places associated with maritime infrastructure are some of the most readily recognisable sites of maritime archaeology. Indeed, there are some 780 shipwrecks along the Victorian coast, but fewer than half of them have been located.[5,6] The maritime influence can also be seen in sites associated with post-contact Aboriginal association (e.g. Convincing Ground, Portland), cemeteries (e.g. Collins settlement graves site, Sorrento), places of historic events (e.g. Corinella settlement site), government and administration (e.g. Geelong first customs house), manufacturing (e.g. lime kiln complex, Limeburners Point), military (e.g. Fort Gellibrand, Williamstown), communications (e.g. Port Melbourne naval drill and former post office) and transport (e.g. Great Ocean Road; Duke and Orrs Dry Dock, South Wharf).[6]

These physical remnants of the past have historical, social, archaeological, technical, interpretive and scientific significance.[7] Places and objects of cultural heritage can enrich people's lives by providing an important sense of connection to community and landscape, to the past and to lived experiences. These historical records are important expressions of Australian identity and experience. Places of cultural heritage significance reflect community identity and past influences.

Legislative protection

In Victoria, the *Heritage Act 2017* provides for the protection and conservation of places and objects of cultural heritage to the state and for the registration, conservation and management of the places and objects.

Part 4 of the Heritage Act and the Heritage (Underwater Cultural Heritage) Regulations 2017 protect underwater cultural heritage including shipwrecks, shipwreck artefacts and sunken aircraft. All maritime heritage items that are 75 years or older are automatically protected and recorded on the Victorian Heritage Register. Younger heritage places and objects can also be registered if their significance justifies inclusion. The Commonwealth *Underwater Cultural Heritage Act 2018* provides complementary protections in Commonwealth waters to the edge of the continental shelf.

Both Victorian and Commonwealth shipwreck legislation provide for the declaration of protected zones around particularly significant or fragile historic shipwrecks. There are currently six shipwreck protected zones in Victorian waters and three shipwreck protected zones in adjacent Commonwealth waters (table 8.2). These zones are intended to protect highly significant wrecks and those that are at the greatest risk of deterioration or unauthorised interference. It is an offence to enter, anchor, fish, trawl or dive in a protected zone without a permit issued by Heritage Victoria.

Maritime heritage which occurs on land, including jetties and piers, navigation structures, ship building sites, maritime landscapes and maritime defence infrastructure are also protected under the *Heritage Act*.

Table 8.2 Shipwreck protected zones in or adjacent to Victorian state waters

	Shipwreck	Protected zone	Date zone declared	Permits currently granted?
State protected zones	*HMVS Cerberus* (1926)	Port Phillip Bay 0.5 hectares rectangle	1994	No – hull in imminent danger of collapse, risk of entrapment and drowning
	SS City of Launceston (1865)	Port Phillip Bay 250 metres radius	1982	No – fragile nature of site. Periodically open
	Clarence (1850)	Port Phillip Bay 100 metres radius	1986 re-gazetted 2009	No – wreck is currently part of in situ studies
	Joanna (1843)	Port Phillip Bay 100 metres radius	1990 re-gazetted 2009	No – currently buried under sand. When exposed, permits will again be issued
	Will O' the Wisp (1853)	Port Phillip Bay 50 metres radius	1993 re-gazetted 2009	No – rests in Commonwealth security area surrounding Swan Island
	William Salthouse (1841)	Port Phillip Bay 250 metres radius	1983 re-gazetted 2009	Yes
Commonwealth protected zones	*SS Alert* (1893)	off Mornington Peninsula 500 metres radius	2007	Yes
	PS Clonmel (1841)	off Nooramunga 50 metres radius	1996	No – currently buried under sand
	SS Glenelg (1900)	off Ninety Mile Beach 500 metres radius	2011	No

8.2.2 Current and emerging uses

Some of the most prominent maritime archaeological places and objects are associated with shipwrecks. Early public ideas surrounding these sites were associated with treasure and fortune, and many early wreck divers were focused on collecting valuable souvenirs.[8] More recently, there has been a shift away from treasure hunting to tourism. The mantra 'take only photos, leave only bubbles' is now widespread among wreck divers.[8] Legislative protection and an increased public awareness of the cultural and educational value of maritime archaeology has led to this shift in perception.

Citizen science, the participatory experience of recording and monitoring, has been part of maritime archaeology since the 1970s.[8] The Maritime Archaeological Association of Victoria formed in 1978. In Victoria, the existence of shipwrecks legislation, the current maritime archaeology program and its ongoing viability is a result of direct action on the part of an active community that lobbied persistently for legislation and followed up with ongoing support for the state's maritime programs. Through various citizen science projects, divers are encouraged to become involved in the protection and investigation of underwater sites. This involvement with historical resources is considered to help the broader public become aware of the competing needs to balance site access with preservation.

Historical or cultural tourism along the coast relies on Victoria's rich maritime history. For people to properly appreciate this heritage, appropriate storytelling and interpretation, often via experts, is necessary. Victoria's maritime heritage has been the subject of numerous touring exhibitions of artefacts,

Divers on the SS Queensland which sank in 1876 near Wilsons Promontory after a collision with another ship. Photo: Steve Cartlidge

waterproof publications, underwater and land-based shipwreck heritage trails, virtual dives and underwater wreck panoramas.

Shipwreck trails are particularly popular. Australia's first shipwreck trail was established in 1981 off Rottnest Island in Western Australia.[8] The first section of Victoria's historic shipwreck trail between Port Fairy and Moonlight Head was opened in 1990, with a second section between Port Fairy and the South Australian border opened three years later. While some have suggested that underwater shipwreck trails can alleviate pressure on sites that are too fragile to withstand heavy traffic, others have voiced opposing concerns that public promotion could lead to increased looting.[8] As divers are the main users of underwater maritime heritage,[9] wrecks in protected zones that are safe to dive are occasionally opened to experienced divers under permit (e.g. City of Launceston).[9] Technological advancements in both deep diving but also remote sensing is increasingly offering insight into unexplored wrecks.[10]

8.2.3 Threats

Submerged and buried maritime heritage exists in an environment that is conducive to the long-term preservation of a variety of materials, provided they are not disturbed. For this reason, it is important that wherever possible, maritime heritage resources are retained in their environment (in situ preservation).[11] It is also important that a site or object's relationship to history and contemporary society is maintained, often through documentation and interpretation.[10]

The main threats to maritime heritage are chemical, physical and biological. Chemical threats come from corrosion of metal structures and objects, which is decreased by water depth and burial.[12] Penetration of the wreck by divers can increase corrosion through the build-up of oxygen pockets in confined spaces.[13,9] At some sites, cathodic protection of metal wrecks and artefacts such as cannons and anchors is undertaken using a sacrificial anode of more easily corroding metal.[10,11]

Biological threats come predominantly through the consumption of timbers by marine borers, which appear to be increasing in range as oceans warm.[14]

Physical or mechanical damage to underwater sites occurs through of a range of processes. Storm events (e.g. cyclones) can lead to water movement and sandblasting. Disturbance to the seabed through dredging, trawling, or other industries (e.g. oil and gas pipelines) can inadvertently disturb undiscovered wrecks. Commercial and recreational vessels may cause anchor damage to shipwrecks through dragging anchors or anchors dropped directly over wrecks. Divers may cause damage inadvertently through poor fin technique, or intentionally through looting and souveniring.[13,14]

Many heritage values are not well known or documented. For example, fewer than half of the 780 shipwrecks along the Victorian coast have been located. Without knowing the location of these vessels significant heritage values remain unknown. To improve the location of shipwrecks there is a need for increased collaboration and sharing of survey data between maritime archaeologists and proponents of marine and coastal infrastructure. For example, multibeam sonar surveys undertaken for the Port Phillip Bay channel deepening helped identify the location of several heritage sites. Another example occurred in 2017, when routine seabed mapping being undertaken by CSIRO identified an unknown shipwreck, which was later confirmed to be the *Carlisle* that sunk southeast of Wilsons Promontory in 1890.

As maritime heritage is a limited and diminishing resource, several management interventions have been developed to protect these places and objects. In some instances, this may simply involve providing mooring points to mitigate anchor damage. Other interventions, such as protected zones, may be more controversial as they raise a conflict between protection and access. Physical site stabilisation to counter sand erosion has been conducted using plastic barriers, artificial seagrass mats and sand bags in conjunction with geotextile meshes or netting to encourage sediment deposition. In some cases, total reburial has been undertaken in conjunction. Rescue excavations are now a last resort where a highly valuable site is threatened by looting or sand erosion.[10,11]

Emerging threats

Increasing pressure for coastal and foreshore development is likely to lead to the disturbance of undiscovered or undocumented maritime heritage.[10]

Developments in SCUBA equipment have opened access to previously unreachable wrecks in deeper waters.10 While this has increased our knowledge and understanding of previously inaccessible heritage, it also opens these sites to increased risk of looting and damage.

Decreased funding for heritage organisations is a threat to the effective management of terrestrial and marine heritage.[10,6] An increasing amount of monitoring is conducted by volunteer and amateur archaeological divers. The liability and insurance costs for these diving groups is a barrier to such organised volunteer activity.[8]

8.3 References

1. Barnard, J. (2008) *Jetties and piers: a background history of maritime infrastructure in Victoria*. Heritage Council of Victoria, Melbourne.
2. Gibbs, M. (2006) Maritime archaeology at the land-sea interface. In: Staniforth, M. and Nash, M. (eds.) *Maritime archaeology: Australian approaches* pp 69 – 81. Springer, USA.
3. Broome, R. (2005) *Aboriginal Victorians: a history since 1800*. Allen and Unwin, Crows Nest.
4. Matthews, S. (2016) *The erasure of Melbourne's wetlands.* State Library of Victoria blog https://blogs.slv.vic.gov.au/such-was-life/the-erasure-of-melbournes-wetlands/
5. Mitchell, J. (2013) *Getting shipshape: evaluating shipwreck significance in Victoria.* Report prepared for Heritage Victoria.
6. Victorian Environmental Assessment Council (VEAC) (2015) *Historic places investigation. Draft proposals paper.* Victorian Environmental Assessment Council, Melbourne.
7. Coroneos, C. (2006) The ethics and values of marine archaeology. In: Staniforth, M. and Nash, M. (eds.) *Maritime archaeology: Australian approaches* pp 111-122. Springer, USA.
8. Souter, C. (2006) Cultural tourism and diver education. In: Staniforth, M. and Nash, M. (eds.) *Maritime archaeology: Australian approaches* pp 163 - 176. Springer, USA.
9. Department of Environment, Land, Water and Planning (DELWP) (2015) *A report on City of Launceston shipwreck open diving days 2015/16.* Department of Environment, Land, Water and Planning, Melbourne.
10. Anderson, R., Philippou, C. and Harvey, P. (2006) Innovative approaches in underwater cultural heritage management. In: Staniforth, M. and Nash, M. (eds.) Maritime archaeology: *Australian approaches* pp 137 – 150. Springer, USA.
11. Ortmann, N. (2009) *Exploring practitioners' attitudes towards in situ preservation and storage for underwater cultural heritage.* Thesis, Department of Archaeology, Flinders University.
12. MacLeod, I.D. and Harvey, P. (2015) Management of historic shipwrecks through a combination of significance and conservation assessments. *Conservation and Management of Archaeological Sites* 16: 245-267.
13. Viduka, A. (2006) Managing threats to underwater cultural heritage sites: The Yongala as a case study. *Heritage at Risk* 2006: 61-63.
14. Kingsley, S. (2016) Impacts on maritime cultural resources: assessing the invisible. *Environmental Practice* 18: 184-191.

9 Coastal Development

Coastal development involves altering the marine and coastal environment through the construction of commercial infrastructure (e.g. ports and commercial buildings), housing, recreation and tourism facilities, and structures that enable access to and protection from the marine environment (e.g. piers and boat ramps, seawalls and breakwaters). This chapter uses demographic data to contextualise the changing nature of coastal development and the demands of a growing population on the marine environment. The types of coastal infrastructure needed to support and protect coastal settlements and the impacts on the marine environment are discussed.

KEY POINTS AT A GLANCE

- Early coastal settlement was driven by access to safe harbours. More recently it has been influenced by increasing population and lifestyle factors such as the 'sea change' phenomenon.
- Demographic data provide context for assessing impacts of people on the marine environment and for planning future needs such as new boat ramps.
- Planning schemes protect visual aspects of coastal landscapes. Limiting development within township boundaries protects some natural and social values but puts increased pressure on others.
- There are more than 1000 coastal protection structures (e.g. sea walls) in Victoria with a replacement cost of about $700 million. Ageing and inadequately maintained structures are increasingly subject to climate change impacts and increased use by growing populations.
- While coastal protection structures protect approximately $10 billion dollars of built assets, they can alter the physical and ecological dynamics of coastal areas, alter settlement patterns for plants and animals and facilitate colonisation by marine pests.
- Beach renourishment protects and stabilises sandy beaches with lower environmental impacts than hard structures. However, it is costly and temporary.
- Rehabilitating habitats such as shellfish reefs and mangroves for coastal protection is an emerging activity at a local scale.
- Victoria has more than 400 boat launching sites, yacht clubs and marinas. These facilities provide access to the marine environment but create localised impacts.
- Demand for coastal access will increase with population growth. Crowding at boat ramps, conflict between users (e.g. boats and swimmers), noise and chemical pollution are all emerging concerns.
- Seawater is used for industrial purposes including cooling during energy generation, aquaculture and desalination.
- Oceans receive treated sewage effluent and industrial wastewater through outfalls. With population growth both the volume of discharge and extent of impact will increase.
- Climate change will increase the number of intense rainfall events and volume of stormwater. Impervious surfaces associated with coastal development also increase runoff. Stormwater carrying nutrients, sediments and pollutants threatens biodiversity and recreational uses of marine environments.
- Stormwater pollutants of emerging concern include endocrine-disrupting compounds, flame retardants, pesticides and microplastics. As these compounds are not systematically monitored, concentrations and the extent of impacts are unknown.
- Pressures associated with growing urban populations include increased volumes of stormwater, more intensive use and crowding at coastal access sites and increased demand for coastal protection structures.
- Climate change will increase pulses of stormwater, put pressure on ageing coastal infrastructure and ultimately impact on the feasibility of living in or developing some coastal locations.

The broad categories of threats to coastal development are summarised and examples are provided for each threat in table 9.1; for more detail see the relevant section of this chapter. Discussion of threats in this chapter are threats to coastal development. The threats that coastal development might pose to other values are discussed in other chapters.

Table 9.1 Summary of values and threats associated with coastal development in Victoria

Threat class	Pathway/outcome	Example (with section reference)
Climate change	Sea level rise	Rising seas will increase demand for coastal protection structures, which are costly to construct and maintain. They also impact the physical and ecological dynamics of coastal areas (9.4.1)
	Increased storm frequency	Storm damage and seawater inundation decrease the desirability of coastal living and increase demand for coastal protection structures (9.4.1)
Physical	Erosion	Residents and visitors expect that popular beaches will be protected and stabilised by ongoing sand replacement (beach renourishment). This is a temporary solution as sand movement is dynamic (9.4.3)
	Habitat loss/ degradation	While some habitat loss is a consequence of coastal development, it diminishes the features which attract people to coastal living. Existing residents may reject new coastal development (9.3.2)
Biological	Species loss/extinction	Local loss or extinction of species diminishes the features that people value in coastal locations (9.3)
Catchment processes	Beach closure	Algal blooms, a consequence of catchment-sourced nutrients, can lead to beach closures (10.2.3)
	Altered hydrological regimes	Decreased freshwater flows into estuaries leads to poor water quality, reduced amenity value and limits recreational uses (e.g. fishing) (9.5.2)
	Sedimentation	Sediments impact on aesthetic, recreational and ecological values and are vectors for transporting toxicants. In Port Phillip Bay, the Yarra catchment is a major source of sediments (9.7.6)
Pollution	Marine debris	Litter has negative impacts on visual amenity, reduces water quality and can kill or harm marine animals. Beaches are prominent locations for the accumulation of litter, and is a significant concern for the local community (9.7.6)
	Chemical/metal	Contaminants of emerging concern include endocrine-disrupting compounds, pharmaceuticals, flame retardants, pesticides and microplastics. Quantities and impacts are currently unknown (9.8.6)
	Nutrients	Water quality is degraded by excess phytoplankton growth (algal blooms) caused by nutrient influx (10.2.3)
Community/ industry demand	Expansion of industry	Existing ports are often in sensitive ecological locations. Habitat protection measures (e.g. Ramsar wetlands) may prevent the future expansion of industries in the area (9.6.1)
	Crowding	Overcrowding at popular locations particularly during peak times means people cannot launch their boat or find a car park (9.7.4)
	Recreational access	Popular locations, especially over summer or during events, may be subject to overcrowding, which impacts the ability of people to participate in their favoured activities (9.2.3)

9.1 Patterns of coastal development

Coastal development and the rate of change along Victoria's coastline can be considered in three stages. Early settlement of the coast (post contact with Aboriginal people) was influenced by availability of water, food and shelter, and safe harbours to support a seafaring nation. As settlements grew, the volume of trade increased, which necessitated growth in maritime infrastructure.[1,2]

The clearing of land for agriculture and the gold rush, together with increased use of rail and road for transport changed the character of coastal towns. Melbourne soon consolidated itself as Victoria's centre for commerce and urban development. Other coastal ports became regional trading centres and smaller coastal townships developed in strategic locations along the coast to meet the needs of the larger regional centres and Melbourne.

More recently, coastal development has been driven by increasing population, lifestyle choices and recreation, and facilitated by improved roads and reduced travel times.

Pressures from population growth and the effects of climate change, including sea level rise, storm surges and altered weather patterns, will drive new patterns of coastal development into the future.

Table 9.2 provides a chronological list of events that have shaped the use and management of Victoria's marine and coastal environment.

George Bass Coastal Walk is a cliff-top trail that stretches from the outskirts of San Remo to Kilcunda, linking these two coastal townships. Photo: Anna Kilborn

Table 9.2 Events that have shaped coastal development in Victoria[1,2,3]

Time	Event
1834	Edward Henty established a sheep run at Portland, which offered a natural harbour – other settlers soon followed. In 1835, Batman, Fawkner and others from Hobart established a settlement on the banks of the Yarra that became Melbourne
1851	Port Phillip District separated from New South Wales to become the colony of Victoria. Discovery of gold in the same year led to significant development of coastal infrastructure. Victoria's population increased from 75,000 people in 1851 to more than 500,000 within 10 years
1853	Construction of the railway from Geelong to Melbourne was part of extensive investment in railways and roads that helped transition the colony from coastal sea-faring to land based transport
1876	Koo-Wee-Rup Swamp Drainage Committee formed by local landowners – excavation of channels and drains opening up the area for agriculture, with lasting impacts on the ecology of Western Port
1879	Patterson Cut constructed to drain the Carrum Carrum Swamp, first for farming and then for development of Melbourne's southeast suburbs
1881	All unalienated land within one-and-a-half chains (30.18 metres) of waterways and the coast reserved by the government – this helped reduce development of private land to the water's edge
1889	Artificial entrance to Gippsland Lakes created, which helped open the Gippsland area for agriculture and later tourism
1890	South channel fort in Port Phillip Bay built as part of the colony's coastal defence – this artificial island now provides important habitat for birds and other marine animals and is a popular tourist attraction for recreational boating and diving
1928	Phillip Island Penguin Parade commenced with organised tours by local residents – today the parade has more than 700,000 visitors annually with flow-on benefits for the state and the island's economy
1930	Victoria's population reached 1 million
1932	Great Ocean Road officially opened – more than 3000 returned soldiers built the road from 1919 onwards - linking the isolated towns along Victoria's western coastline
1940	Phillip Island's first bridge built linking San Remo and Newhaven, helping open up the island for tourism and building of holiday homes. The current bridge was opened in 1969
1956	Breakwater at St Kilda built to create harbour for sailing events at Melbourne Olympics. The breakwater, which now hosts a colony of some 1400 little penguins, has become a popular tourist attraction
1963	Bells Beach annual surfing competition commenced, putting the Surf Coast on the world stage and driving tourism and development along this part of the coast
1965	Oil and gas discovered offshore in the Gippsland Basin, triggering development of the industry in Victoria – oil refineries, gas processing plants, pipelines and shipping facilities
1967	Prince Charles states that swimming at Elwood is like swimming in sewage, highlighting deteriorating water quality of Melbourne's waterways and beaches caused by urban and industrial pollution
1968	St Kilda Marina opened – first American style marina complex built in Victoria, providing a precedent for commercial funding of coastal infrastructure
1971	EPA Victoria created to regulate industry and reduce water pollution associated with industrial and urban development
1996	Port of Portland was sold by the State government, the first privatisation of port facilities in Australia. Significant private investment has continued to occur at other major ports, including $9.7 billion sale of a 50-year lease for the Port of Melbourne in 2016.
1996	Port Phillip Bay Environmental Study final report published, triggering improved stormwater management and implementation of water-sensitive urban design

2002	System of marine national parks and marine sanctuaries declared – recognising the significant biodiversity of the marine environment and the need to protect it from over development and exploitation
2008	Port Phillip Bay channel deepening commenced (completed in 2009) – maintaining Melbourne as one of Australia's major ports
2010	Buy back of Summerlands Housing Estate, Phillip Island completed for protection of the penguin rookery. This initially occurred against community protest, but has increased the success of the colony and associated tourism
2018	Marine and Coastal Act passed, which will facilitate improved management and approval processes for marine and coastal development

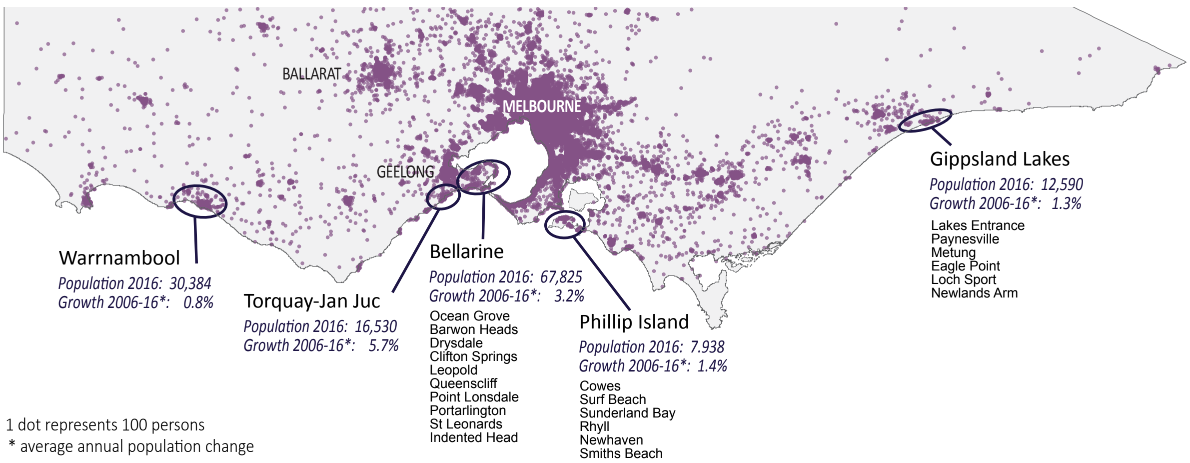
9.2 Coastal demographics

This section is based on an analysis of population and settlement along the Victorian coast prepared by the Land Use and Population Research group within DELWP .[4] The analysis highlights key relationships between coastal settlement patterns and proximity to urban centres, and implications of age profiles and occupancy rates in coastal townships. Information has been drawn from time series data for population and housing prepared by the Australian Bureau of Statistics, and government housing and economic data.

9.2.1 Population and settlement patterns

Figure 9.1, which maps population density, highlights the dominance of Melbourne and the radial nature of settlement along the coast and transport corridors. Locations of higher urban density along the coast coincide with operating ports that were established in the mid 1800s to service coastal trading and commercial fishing, including towns such as Portland, Port Fairy, Warrnambool, San Remo, Port Welshpool and Lakes Entrance.

Figure 9.1 Population concentration along the Victorian coast, 2016[4] Source: ABS census 2016



9.2.2 Age profiles of coastal populations

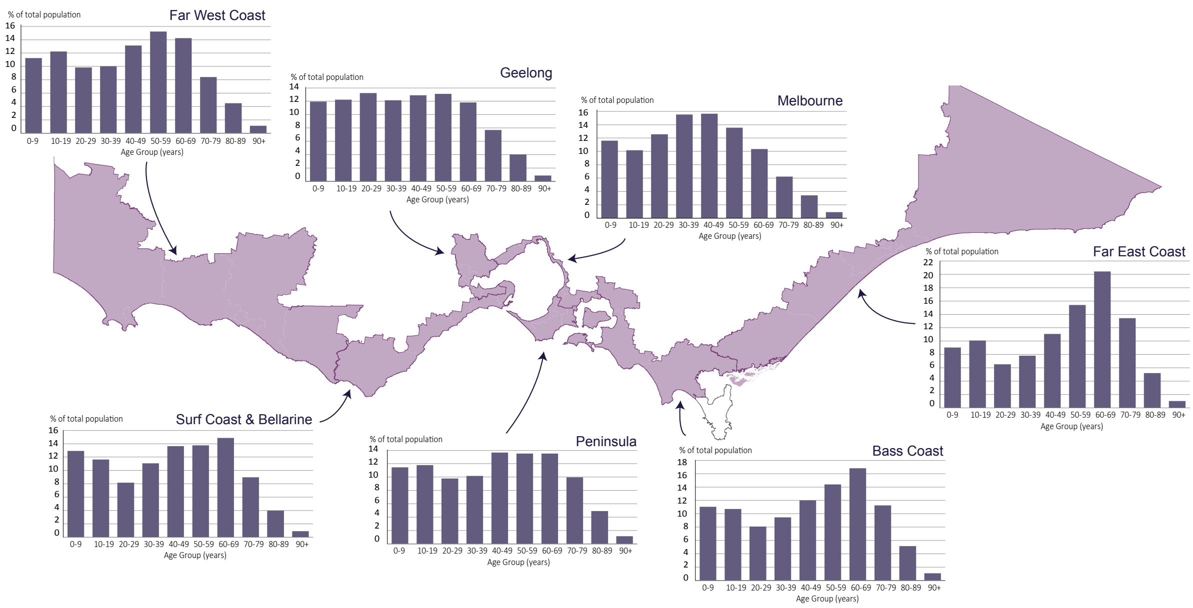
Understanding the age profiles of coastal communities – the number of people in different age brackets – provides context for investment in marine and coastal infrastructure. People at different stages in their lives have specific needs and interests in the marine and coastal environment and therefore value the marine and coastal environment differently. For example, people with young children may want access to safer swimming beaches, while people with mobility difficulties such as the elderly require ramps rather than stairs to access beaches.

Age profiles in coastal towns are influenced by migration and natural population increases. Migration includes movement at a variety of geographical scales: within a local area or region, to or from Melbourne, interstate, or overseas. Natural increase is the difference between the number of births and deaths in a population.

Some coastal areas display a much older age structure because of their attraction to retirees – Bass Coast and Far East Gippsland show this pattern distinctly with the highest proportion of their population being in the 60 to 69-year age category (figure 9.2). Some towns in East Gippsland, such as Loch Sport and Raymond Island recorded more than 30 per cent of their population aged 60 to 69 years in 2016. While these smaller coastal towns have high proportions in younger retirement age groups (60-69 years), people in the older age groups are more likely to move to centres where services are more accessible.

It is acknowledged that the age at which one becomes an older person is a notion that changes over time, so calculating the proportion of older persons based on a fixed age may provide an inaccurate indication of user needs and preferences.[5]

Figure 9.2 Age structure of Victorian coastal regions, aggregated Statistical Areas Level 2 (SA2), 2016[4]
Source: ABS Census 2016



9.2.3 Part-time coastal populations

A common characteristic of coastal settlements is the relatively high proportion of houses which are vacant during the year. These are usually holiday homes (beach houses), with non-residents visiting for various lengths of time. Typically, these dwellings will be inhabited during summer time and school holiday periods. There may also be considerable changes in levels of habitation between week days and weekends.

Because the ABS Census is conducted during winter time on a week night, the data on unoccupied dwellings can be used as a general proxy for holiday homes on the coast.

A total of 36,800 unoccupied dwellings were counted in Victorian coastal towns and cities (excluding Melbourne and Geelong) by the 2016 census. This represents an average winter vacancy rate of around 37 per cent. Although absolute numbers of dwellings – both occupied and unoccupied – have increased over the past 35 years, the proportion of unoccupied dwellings has remained reasonably consistent within the range of 35 to 40 per cent.

Coastal towns can experience a large difference between the size of their resident population and the size of the population at particular times of the day, week or year. While the count of unoccupied dwellings on census night gives some idea of the number of beach houses in these locations, it does not provide information about visitor populations. Where there is a large difference between resident and peak populations, stress can be placed on local services and facilities, many of which are funded by local authorities or staffed by volunteers.

The largest differences between resident and peak populations can reflect a particular event such as a festival or sporting event. For example, when the town of Lorne hosts the annual Pier to Pub swim in January, there can be an additional 20,000 visitors for the event. This represents a 20-fold increase over the resident population. On a hot weekend in summer, Lorne's population can increase 10-fold. Similarly, on a sunny day in January there will be long queues and waiting times for access to boat ramps around Port Phillip Bay, carparks at popular beaches will be overflowing, and space to spread out a towel on the beach will be at a premium. A summary of the potential impacts from these part-time and mobile populations is presented in table 9.3.

Table 9.3 Types of part-time and mobile populations and potential impacts

Type	Characteristic	Potential impacts
Weekenders	Overnight visitors utilising second homes or commercial accommodation on weekends – many getting away from congested and built-up urban environments	Creates demand for accommodation and services thereby creating local employment and wealth generation. Marine activities likely to be well within the existing capacity of facilities
Holidaymakers	Non-coastal residents on holidays increase coastal populations – many times higher than the resident population, especially during the summer holiday period (December-January)	May create congestion and stretch capacity of services and infrastructure but adds significantly to economy. Marine activities likely to be within the existing capacity of facilities
Daytrippers	Daytrippers to coast – higher numbers driven by warmer weather and suitable water conditions for activities such as swimming, surfing and boating	Creates road congestion and higher demand on services and infrastructure. Marine activities may exceed capacity of existing facilities. Popular beaches and boating areas will be crowded, with spillover to nearby beaches
Festival attendees	One-off events that attract thousands – includes participants and spectators	Local accommodation and infrastructure capacity may be stretched but can have major positive impacts on local economy. Popular beaches will be crowded, increasing impacts to intertidal zones, and creating spillover effects at nearby beaches
Seasonal workers	Includes hospitality workers, commercial fishers, life guards and other employees of seasonally dependent industries	Competing demand for tourist or temporary accommodation and for local services established to meet needs of resident population (trades and health services). Marine activities likely to be within the existing capacity of facilities.

Planning for coastal and marine areas is premised on the best use of public resources and should be undertaken in accordance with the public interest.[6] However, it is likely that public interest is perceived differently by resident and non-resident populations.[7]

Coastal research suggests that non-residents display a more general sense of concern with coastal development, whereas residents more familiar with the area are able to discriminate more localised values and threats. In most cases the concerns of both residents and non-residents were similar. However, the research highlights the need to explore areas of agreement and disagreement to better understand issues and to improve communication and messaging to both resident and non-resident populations.[8]

The Lorne Pier to Pub is an annual ocean swimming event that attracts thousands of competitors and swells the town's summer population. Photo: Like the world

Headlands at Flinders are protected from coastal development. Photo: Robert Molloy

9.3 Coastal landscapes

Victoria has some spectacular and well-recognised coastal landscapes that collectively provide significant social and economic benefits. They include the rugged wilderness of Wilsons Promontory and the Croajingolong coast, the unparalleled landscape of the Ninety Mile Beach and the iconic offshore rock formations of the Twelve Apostles and Bay of Islands in the Great Ocean Road region.[9]

The importance of coastal landscapes and the need for their recognition and protection from inappropriate coastal development has been acknowledged in the various versions of coastal strategies and regional coastal plans since 2002.[10]

9.3.1 Landscape components

Coastal landscapes are significant for their visual qualities including landform features, views, edges or contrasts, and for their predominantly natural or undeveloped character in which development is absent or clearly subordinate to natural landscape characteristics (table 9.4).

The *2005 Coastal Spaces Landscape Assessment Study*[9] commissioned as part of the Coastal Spaces Initiative, identified significant coastal landscapes and provided an implementation framework to assist agencies in managing development impacts to these landscapes. DELWP is currently reviewing the implementation and effectiveness of the framework in selected areas of Victoria. This includes work associated with the Great Ocean Road Action Plan and the Distinctive Areas and Landscapes work program (including Bass Coast, Bellarine Peninsula and Surf Coast).

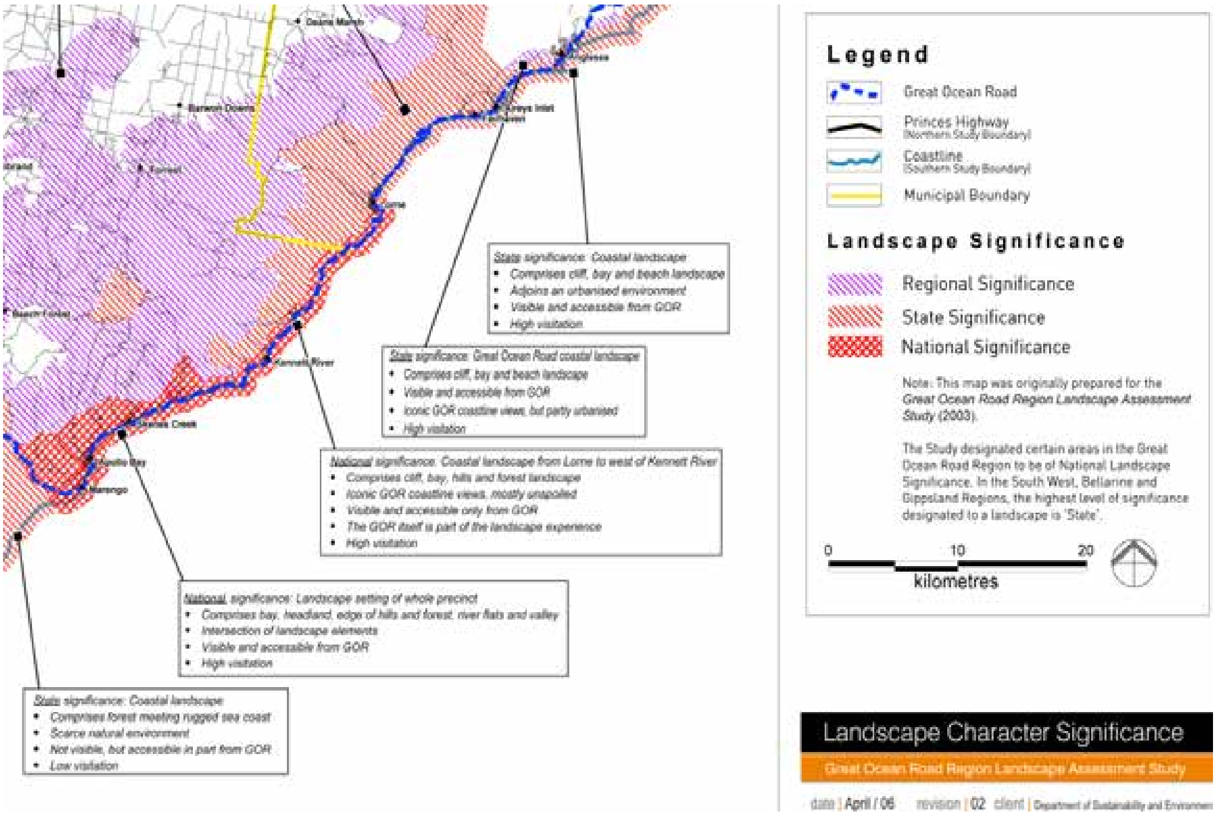
Table 9.4 Landscape components[9]

Landscape component	Description
Landform features	A topographical feature or landmark such as a headland that provides contrast with the surrounding landscape
Views	The viewpoint is open and publicly accessible; the view is a panorama, a broad prospect, or a linear view to a defined object or group of objects; and it offers a cohesive viewing experience
Edges or contrasts	The boundary between two landscape elements, for example, the coastline (the boundary between sea and land); the boundary between vegetation types or different landform types; a cliff or beach
Natural or undeveloped character	A landscape that is devoid of any development, or a landscape in which its natural characteristics visually predominate over any development that may be present

As part of the landscape assessment study, survey respondents were asked to identify those landscapes they would take a visitor to show and which they thought were scenic or beautiful. They also identified places where they believed the view was unattractive or spoiled. Other information used to rate the significance of landscapes included whether views were unique, iconic, cultural or popular. Collectively, this information was used to assess the significance of landscapes — of national, state, regional or local significance — along the Victorian coast.

The study provides landscape character significance in a series of maps together with details and specific guidelines based on the preferred character to be achieved for each area. Those landscapes that have either national, state or regional significance are protected through planning controls. Development must exhibit excellence in siting and design that complements the coastal landscape and maintains important public views, vista and sightlines.

Figure 9.3 Sample of map from the Coastal Spaces Landscape Assessment Study indicating landscapes that are of regional, state or national significance[9]

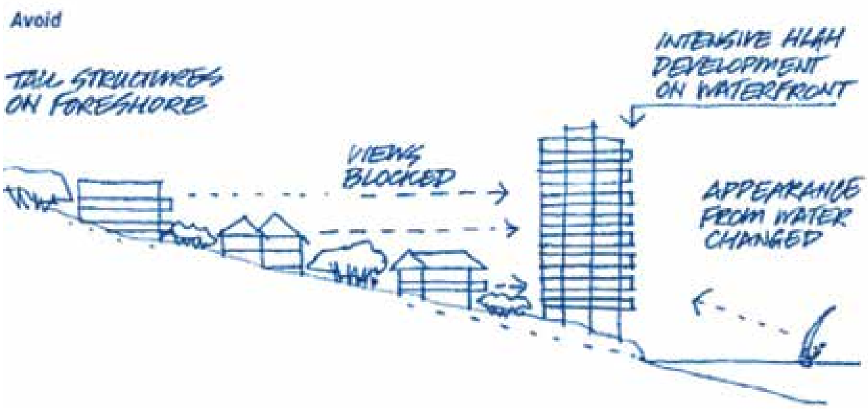


9.3.2 Protecting coastal landscapes

The implementation of significant landscape overlays and definition of settlement boundaries through planning schemes protects significant coastal landscapes from urban encroachment. As mentioned in section 9.3.1, DELWP is currently reviewing the implementation and effectiveness of these planning instruments.

The *Siting and Design Guidelines for Structures on the Victorian Coast* also help ensure sympathetic development that complements the surrounding landscape.[11] These guidelines are also being revised to ensure that they remain relevant and useful given the ongoing pressure of aging infrastructure, population growth and climate change. The revised guidelines will assist in creating places that are: accessible, safe, diverse, enjoyable, engaging, and accommodate people of different abilities, ages and cultures.

Figure 9.4 Sample illustration from Siting and Design Guidelines for Structures on the Victorian Coast[11]



9.3.3 Underwater seascapes

There is growing awareness and appreciation of underwater seascapes and of the plants and animals that inhabit these submerged terrains. For example, the 90-metre deep underwater canyon situated at the heads in Port Phillip Bay supports a spectacular garden of sponges, encrusting algae, soft corals, ascidians and anemone, and is highly valued by the diving community.[12]

Understanding where these unique underwater seascapes occur is dependent on access to remote sensing methods. These include multibeam echosounders and remotely-operated video cameras that can be used for mapping the seafloor and classifying the variety of plants and animals present.

Researchers at Deakin University have used these seabed mapping technologies to discover former coastal cliffs and limestone stacks at a depth of 60 metres some five kilometres offshore from the Twelve Apostles on Victoria's southwest coast.[13] Other mapping has identified valley-type features associated with old river courses that were submerged when sea levels rose some 6000 years ago.

9.4 Coastal protection

There are more than 200 kilometres of constructed breakwaters, seawalls and other built structures protecting coastal assets from the impacts of waves, storm surges and rising tides. Coastal protection is also provided by natural systems such as seagrass beds, mangroves and saltmarsh. Beaches also provide protection to coastal assets and in some locations are renourished to maintain this important function.

Coastal structures, which are subject to the natural processes of aging and the rigours of coastal environments, are also at risk from climate change impacts such as sea level rise, storm surge and altered wave and wind regimes. These processes are all occurring against a background of increased use of marine and coastal resources by a growing urban population with increased time for leisure and recreation.

Dorothy Houghton Walk was constructed to reduce cliff erosion at the site of Victoria's first settlement at Sullivan Bay, Sorrento. Photo: Robert Molloy

9.4.1 Engineered structures

Internationally, coastal development has resulted in significant lengths of the coast being engineered to provide protection for coastal assets. In some parts of America and Europe, over half of the shoreline has been reengineered and the impact to marine biodiversity and water quality has been significant.[14] At a statewide scale, Victoria has not reached these high rates of intervention; however, within Port Phillip Bay, the proportion of shoreline with engineered structures is significant (figure 9.6).

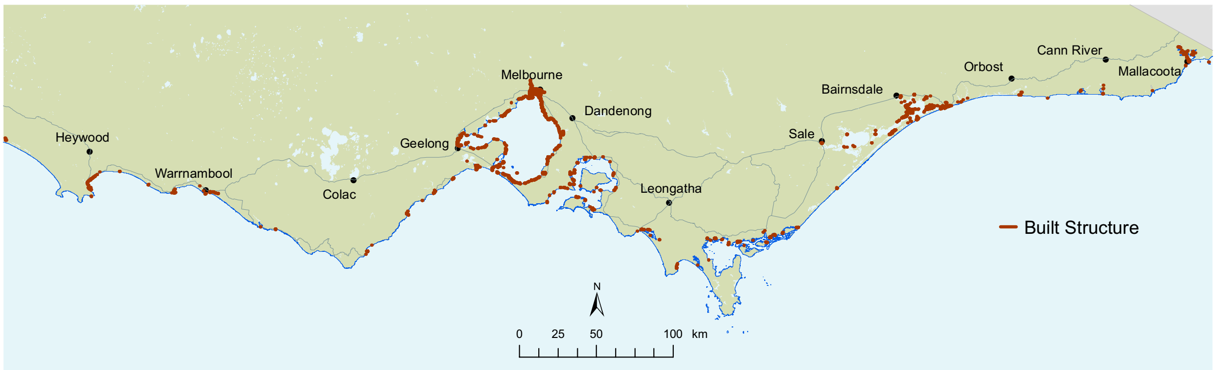
Engineered structures, including breakwaters, seawalls, revetments and groynes, can fix the shoreline in place, stabilise the underlying strata and prevent coastal processes and exposures that may be viewed as detrimental to the coast. However, these structures also alter the physical and ecological dynamics of coastal areas. They act as barriers to the natural movement of marine organisms and materials, alter settlement patterns for plants and animals, and provide additional substrate for colonisation by non-native species.[14,15]

The Victorian Auditor General reported in 2018 that coastal protection structures have an important role in protecting coastal assets now and into the future. A sea level rise of 0.8 metres by 2100 would put 48,000 residential buildings and more than 650 kilometres of roads and railways at risk of inundation. The replacement cost for these assets was estimated at more than $10 billion.[16] Summary data on coastal protection structures provided by DELWP is presented in table 9.5 and figure 9.5.

Table 9.5 Summary of coastal protection structures along Victorian coast – number of structures and cumulative length. Source: DELWP Coastal Assets and Values Project

Coastal protection structures	Number	Cumulative length (kilometres)
Breakwater	83	13.7
Groyne	355	10.9
Retaining wall	12	0.4
Revetment	396	73.9
Seawall	657	100.6
Wharf	80	27.6
Other	21	2.5
Total	**1604**	**229.6**

Figure 9.5 Locations of engineered coastal structures along the Victorian coastline. Source: DELWP Coastal assets database



Box 9.1 Living shorelines

At Portarlington on the Bellarine Peninsula, the City of Greater Geelong with the support of the local community are trialling an integrated living shoreline response to build coastal resilience. The Ramblers Road foreshore near Portarlington is very vulnerable to inundation and in recent years the foreshore and adjacent private properties have been significantly damaged during storm events. In response, local residents wanted the council to build a seawall. However, this solution was considered to be too expensive and unlikely to provide an optimal outcome for the broader community.[17]

The primary objective was to reduce inundation, stabilise the foreshore, dampen wave energy and accrete sand thereby broadening the beach. A combination of onshore and offshore works has been implemented. The foreshore has been reshaped and revegetated with swales to replicate former marsh areas, and the level of the shared path raised to provide an additional barrier. Structures to stabilise the shore have been installed and the beach renourished.

Offshore, an artificial reef has been installed to act as a breakwater. The modular design of the reef is made up of a series of steel cages filled with rock and shell which, over time, will be colonised by marine plants and animals. The project is being monitored to evaluate the success of the artificial reef from both a coastal protection and habitat improvement perspective.

The City of Greater Geelong's environmental engineer, Ralph Roob inspects the new offshore reef at Ramblers Road, Portarlington. Photo: City of Greater Geelong

9.4.2 Levee banks for coastal flood protection

Along parts of Victoria's coast earthen levees and embankments have been built up against the fringing mangroves and saltmarsh to protect low lying lands from inundation and to enable agricultural development. Coastal flooding of these areas can occur when storm surges combine with high tides, strong winds and high waves. Coastal hazard assessments, such as those done for Western Port, have identified where coastal levees and embankments (formal and informal) control the extent of inundation.[18,19]

9.4.3 Beach renourishment

Ongoing sand management and replacement (beach renourishment) provides an effective means to protect and stabilise sandy beaches and foreshores, which in turn protects coastal assets including built infrastructure.[20]

Beach renourishment is seen as an alternative to hard structures such as seawalls and has a comparatively lower environmental impact.[21] There is also a strong expectation by locals and visitors that actions be taken to maintain popular beaches.[22]

Beach renourishment can be undertaken through a variety of methods including dredging, sand relocation and the introduction of clean quarry sand. The additional sand provides a buffer against coastal erosion and widens the beach for improved community use. Renourishment is also used in combination with structures, either to enhance the effectiveness of the structures or to mitigate some of their adverse effects on sediment movement.[15,23]

Beach renourishment is a costly exercise and the results are usually temporary as eventually the sand will move on under the prevailing dynamic coastal processes. Cost estimates are highly dependent on the volume of sand required, the sand source and the transport distance.[21,24]

A technical review of beach renourishment programs being implemented by the then Department of Environment and Primary Industries found that it was vitally important for the protection of many beaches and foreshore areas around Port Phillip Bay.[20] The review referred to a cost-benefit analysis by AECOM[25] that suggested renourishment was a cost-effective means for protecting beaches and the many social and economic benefits that they provide.

In all, about 40 beaches around Port Phillip Bay have benefited from beach renourishment. DELWP is continuing to work with local land managers to enhance key beaches around Port Phillip Bay and elsewhere along the coast. In addition to these projects, DELWP is conducting beach monitoring with input from the community and local government.

9.5 Access to marine environments

An outcome of coastal development can be improved access to the marine environment through construction of marinas, piers and jetties, slipways, and boat ramps for launching and retrieving marine vessels. Victoria has more than 100 yacht clubs and marinas, and nearly 300 boat launching sites along the coast. While collectively these facilities provide a range of opportunities to access the marine environment, they also increase impacts to the marine environment in these local areas.

9.5.1 Piers and jetties

There are more than 80 public piers and jetties along the Victorian coast that provide a range of social, economic and environmental benefits. They often characterise coastal landscapes and townships, support tourism and recreation, and can generate economic activity in coastal towns.[21]

In addition to providing docking functions, piers and jetties are popular destinations for a range of recreational activities including short walks, sightseeing, fishing, swimming, snorkelling and diving. These structures are also home to a diverse range of marine plants and animals that can be observed by visitors who venture beneath the surface.

An indicative value of piers and jetties can be developed based on their construction cost, replacement cost and maintenance costs. Alternatively, they can be valued based on their contribution to social wellbeing and human health.

In addition to those piers and jetties managed by local port managers and councils, there are many that are privately built and maintained. These are usually of a smaller size and designed to meet the needs of small to medium sized boats. DELWP is responsible for issuing licences for private piers and jetties. Planning approval from the local council will also be required and sometimes several other approvals.

Coastal Action Plans prepared by the former regional coastal boards highlighted the need for a formalised policy to address and govern the current and future use and management of private piers and jetties.

9.5.2 Boat ramps and launching facilities

There are more than 260 sites along the Victorian coast that provide boat launching and retrieval facilities for trailerable vessels (figure 9.6). There are also additional sites where vessels can be launched along the many estuaries and rivers that connect with the ocean, such as those in the Gippsland Lakes.

Vessel traffic associated with boat ramps can have significant impacts on the local marine environment. Wakes and waves can disturb the sediment, engine noise disturb fish and other marine species, and accidental spills of fuel and other wastes can lead to contamination of the environment including seafood.

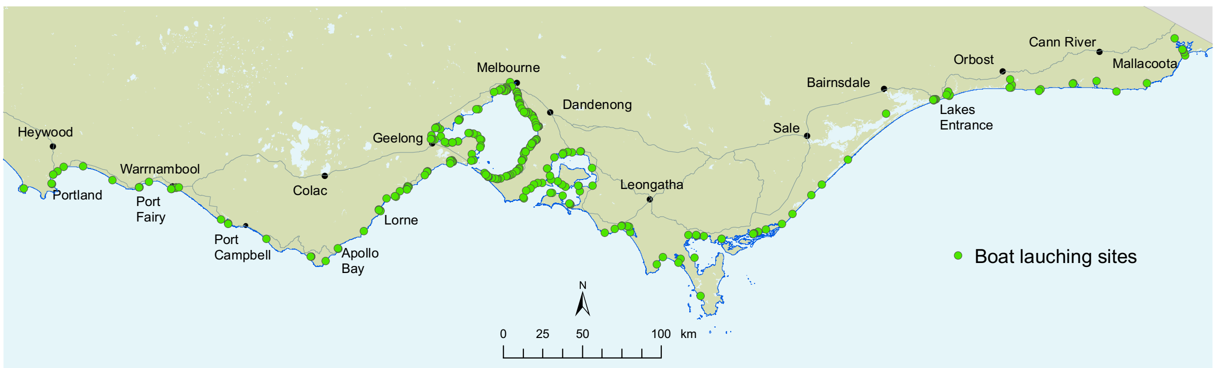
Boat ramp design is dependent on factors that affect the level of usage such as proximity to population centres and other launching facilities. The scale of a facility is also a means for limiting the number of boats and types of activities on a waterway. In New South Wales, the government's guidelines suggest that launching facilities should provide no more capacity than the desired level for the type of use, user experience and user safety agreed by local stakeholders.[26]

A survey of recreational fishers that use Port Phillip Bay and Western Port revealed that the main (30–40 per cent) reason for fishing in an area was attributed to access, either because it was easy to get to or it had good boat access.[27] In comparison, the prospect of catching target species was the second most common reason for choosing a location (21–29 per cent). The survey also revealed that fishers' level of satisfaction was reduced by limited access and crowding at boat ramps and associated facilities such as car/trailer parking.

St Kilda Pier is a popular tourist destination and well used for recreation and leisure. Photo: A Kilborn

Local piers and jetties at Port Franklin in Gippsland. Photo: R Molloy

Figure 9.6 Boat launching sites along the Victorian coast



The $1.23 million upgrade to the Rye boat ramp by the Mornington Peninsula Shire, completed in 2018, aims to reduce queue times and make the area safer for its users by making it easier, quicker and safer to get watercraft in and out of the water.

The Mallacoota Ocean Access Boat Ramp at Bastion Point, constructed in 2014 by East Gippsland Shire, improved launching facilities and ocean access for commercial and recreational craft. Ongoing operation and maintenance of the boat ramp is the responsibility of the council and is undertaken in accordance with conditions stipulated by DELWP through a coastal consent. This includes having appropriate procedures in place for safety, dredging, pollution and marine pests.[28]

9.5.3 Marinas

The following section draws on a heritage assessment report prepared in 2018 by Built Heritage Pty Ltd for the St Kilda Marina.[29] The St Kilda Marina, an early example of the American-style marina complex, was first mooted in 1961 and developed in stages from 1966 to 1970. It was conceived from scratch as a single cohesive development, with the intent to introduce high-end marina facilities to the latest American standards. This was a major innovation over earlier marinas, which tended to develop ad hoc over many years, with utilitarian intent and little (if any) architectural pretension.

Victoria's earliest marina-like developments were the so-called 'boat harbours' that developed around existing piers and breakwaters to provide safe mooring, invariably for local yachting clubs. Commercially-oriented marinas developed in parallel with those of the yacht clubs, with early examples appearing in hotspots for boating tourism such as Metung (1961), Williamstown (1965) and Patterson River (1964-66).

Following this initial burst of marina development in the 1960s, there was little further expansion until the 1980s. A second marina was built at Hastings, the Yaringa Boat Harbour upgraded, and Patterson River redeveloped to create the Runaway Bay Marina.

In the early 2000s, the completion of the Pier 35 project on the Yarra River at South Melbourne (1998-2000) ushered in a new era of marina development, characterised by luxury residential accommodation and high-end facilities such as helipads, restaurants and convention centres. Since then, there has been a boom of new marinas in Victoria, typified by the Anchorage Marina at Williamstown (2004), the Melbourne City Marina at Victoria Harbour, Docklands (2005), Marina YE at Yarra's Edge, Docklands (2006), the Martha Cove Marina (2006) and Hidden Harbour Marina (2008) both at Safety Beach, Portland Marina (2009) and Wyndham Harbour at Werribee South (2016).

Rye boat ramp, a popular access point to the southeastern area of Port Phillip Bay, was upgraded in 2018 at a cost of $1.23 million. Photo: R Molloy

Blairgowrie Yacht Squadron Marina includes components to enhance biodiversity and reduce its ecological impact – these include a wave attenuator instead of a breakwater, and relocation and attachment of sponges and ascidians to the marina's planking. Photo: R Molloy

An important aspect in the development of marinas is the environmental approval process. There have been some significant proposals that have been rejected based on the risk they pose to marine environments. A proposal to develop a marina at San Remo in Western Port was refused on the grounds that it would impact the significant intertidal and subtidal marine community protected by *Flora and Fauna Guarantee Action Statement #18*. An unacceptable impact to the seabed was predicted to occur during construction and operation.

9.5.4 Mooring grounds

Mooring grounds for yachts and small vessels are in relatively sheltered waters with low wave exposure, generally near the shore in bays or the fringes of main reaches in lakes and inlets. A mooring reduces the time needed to launch or retrieve a vessel, which for larger vessels such as keelboats is more complex. The other advantage of a mooring is that yachts can leave their mast erected. Mooring grounds are also easier to maintain compared to a jetty or boat ramp.

Swing moorings, the most common type of mooring used in Victoria, consist of an anchor (usually a concrete block or train wheel) to which is attached a heavy-gauge ground chain, an intermediate chain and a top ('riser') rope, with a large surface float.

Parks Victoria manage 58 mooring grounds in Port Phillip Bay and 26 mooring grounds in Western Port. In all there are 3158 registered moorings, which includes 860 that are managed by agents such as the Royal Geelong Yacht Club and Blairgowrie Yacht Squadron. There are also 35 seasonal moorings and 20 destination moorings at key locations around the bays. Gippsland Ports manages approximately 1000 berths and moorings across their five local ports. Similarly, local port managers at other locations manage the allocation and approval of moorings.

Boat owners are required to make application to the local port managers to install a new mooring or to transfer an existing mooring. For new moorings an authorised mooring tackle contractor is engaged by the boat owner to assess the suitability of the site and to complete a mooring report for approval. Once approved the mooring is installed and registered by the local port manager. Prior to transferring a mooring, the boat owner must arrange inspection of the mooring and assessment of suitability for continued use.

In granting a permit to use a mooring the boat owner agrees to maintain their boat in a seaworthy condition and ensure that all mooring lines, tackle and fittings are suitable and in good condition. Regular maintenance of both the boat and the mooring is needed to reduce the risk during storms of boats breaking their mooring and drifting, creating a hazard for other boats and the environment.

Inspections of mooring grounds by Parks Victoria indicates that a high proportion of moorings and boats are not complying with regulations. Issues include the use of moorings in overnight anchor only locations; boats present are different to the registered boats (and oversized for the mooring); mooring tackles in poor condition and at risk of failure; and boats in poor condition and at risk of sinking.

9.6 Industrial development

Industrial development along the Victorian coast includes development associated with ports, and infrastructure that supports urban areas such as sewage treatment outfalls and desalination plants. The physical and ecological characteristics of the marine environment influence the location of these facilities along the coast. Of interest is whether these facilities are sustainable given predicted sea level rise and storm surge, future industrial needs, potential conflict with other users and a better understanding of the community's appreciation of marine values.

9.6.1 Ports as sites for industrial development

Development of ports and harbours has involved large-scale engineering works, such as altering river courses, excavation of docks and building of wharfs, dredging of channels – deeper and wider – to improve navigation, and the building of breakwaters and training walls to create calmer waters.

For the Port of Melbourne, extensive areas of swampland in West Melbourne were drained, dredged and rebuilt from the 1870s to develop the port and associated industries. By the 1970s any trace of the wetlands and original course of the Yarra River had disappeared.[30]

The Hastings Port industrial area stretches along the northwest coast of Western Port from Hanns Inlet in the south to Watsons Inlet in the north. Much of this industrial land, which was developed in the 1960s and 70s, involved clearing of sensitive coastal habitat. At Long Island Point, levee banks were built around the seaward side of the mangroves and backfilled with soil from adjacent higher grounds where the steel works were built.

Since the late 1970s planning instruments covering industrial development in Western Port have recognised the sensitive nature of the marine and coastal environment and the need to ensure that any development provides appropriate protection to those environmental values. The sensitivity and importance of the area is reflected in its listing as a Ramsar wetland of international significance.

The marine and coastal environment of the ports and adjacent industrial areas in Portland and Geelong has also been substantially modified with significant impact to the marine environment through land reclamation, dredging and wharf construction.

9.6.2 Industrial use of seawater

Seawater has many industrial purposes. It is used as cooling water in electricity generation and oil refineries. Aquaculture farms and fish hatcheries use seawater as feed water for their ponds, with excess water being returned to the ocean. Previous uses have included the use of seawater to produce salt.

Newport Power Station is a gas-fired electricity generation peaking plant located in Newport on the banks of the Yarra River. The plant has a licence to extract seawater from the Yarra River estuary for cooling purposes and to return the warm water back to the river. Similarly, the former Shell oil refinery in Corio Bay has a licence to extract and return cooling water to the bay.

After initial attempts at evaporative salt production on French island in the 1870s, Cheetham Salt Pty Ltd built the Moolap saltworks in Geelong in 1888. The original salt marsh environment was modified to include large still evaporation ponds and a network of channels, levee banks and gates to control water levels. A second saltworks was built at Laverton in 1924 and a third at Avalon in 1951. Production of salt from seawater ceased at Laverton in 1990, Moolap in 2009 and Avalon shortly after.

9.6.3 Seawater desalination

Victoria currently has one seawater desalination plant, built at Wonthaggi and commissioned in 2012. The plant extracts seawater through an inlet structure 770 metres offshore. The brine is then discharged through an outlet 1100 metres offshore.

Factors that influenced the siting of the plant included having a shoreline site suitable for the construction of the desalination plant, access to relatively clean seawater and currents strong enough to disperse the brine with minimal impact to the surrounding environment. The original investigations for selection of a site identified six other potential locations at Torquay, Breamlea, Werribee, Carrum, Hastings and Crib Point. If an additional plant is required to produce additional drinking water for Melbourne these sites are likely to be considered again.

Long Island Point with oil and gas processing plant and wharf. Substantial areas of mangrove and saltmarsh were filled to create land for industrial use. Photo: R Molloy

Cheetham saltworks at Avalon, with Limeburners Bay in the foreground. Photo: R Molloy

The design, construction and operation of the Wonthaggi seawater desalination plant has taken into consideration the environmental values of the area. Monitoring programs are in place to ensure the discharge of the saline brine is rapidly diluted and having no observable effect. The operators provide reports on the outcomes of monitoring to DELWP and the EPA on an annual basis in accordance with the discharge licence.

The Victorian Desalination Plant Operational Marine Monitoring Program has four components:

- In-plant water quality – monitoring of plant processes and intake and discharge water quality (dissolved oxygen, conductivity, turbidity, pH and salinity)
- Diffuser performance – monitoring of salinity at sites on the seabed around the outlets and mixing zone (180 metres radius from outlets) and routine inspection of the two diffuser structures
- Marine ecology – quarterly monitoring of marine flora and fauna near the plant intakes and outlets to identify impacts on marine ecological communities

- Direct toxicity assessment – bioassays using early life stages of seven marine species to determine the concentration of discharge that has no toxic effect.

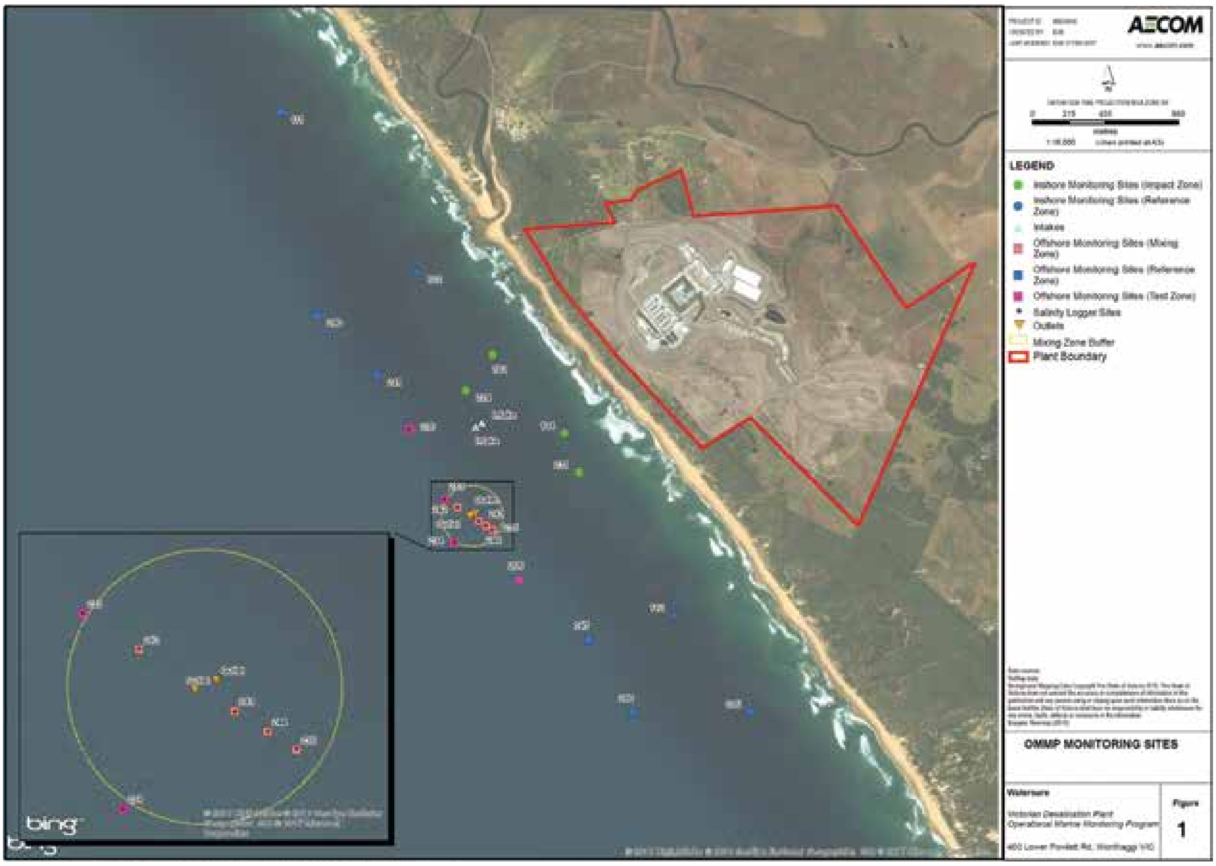
Direct toxicity assessments were used during design and commissioning of the plant to identify that a 30:1 discharge dilution is needed to ensure marine species are not impacted. The discharge includes the hypersaline brine from the desalination process with small volumes of cleaning solutions and biocides to reduce fouling of the internal pipework. Further direct assessment of toxicity is undertaken if the in-plant monitoring shows a substantial change in the quality of the discharge.

For the 2016-2017 supply period, the plant operated between March and June 2017, producing 46 gigalitres of drinking water. At full production the plant can draw in 1070 megalitres of seawater per day to produce 470 megalitres of freshwater and 600 megalitres of brine. If the plant was to run at full production for a year it could produce 170 gigalitres of drinking water (which is about one third of Melbourne's annual water consumption).

Results from the 2016-2017 monitoring detected possible ecological impacts to recruitment of sponge vases, forams, and spirorbid and serpulid polychaete worms near the discharge outlets. The scientists suggested that this is a minor impact but that it requires further monitoring to assess whether it will increase in size over time and with increased output from the plant. Of note, the actual dilution was less effective than that predicted by the hydrodynamic modelling conducted during the project design but was still within the licence requirements.[31]

The data and knowledge gained from the monitoring program, which includes potentially impacted and unimpacted reference sites, would be more valuable to the wider scientific community if it was incorporated into Victoria's broader marine knowledge framework.

Figure 9.7 Victorian Desalination Plant Operational Marine Monitoring Program sites[31]



9.6.4 Wastewater outfalls

Oceans are used as receiving waters for treated sewage effluent and other wastewater from industrial processes. The assumption is that with rapid dilution in the receiving waters, contaminants in the wastewater are at a low enough concentrations to have no toxic effect on marine plants and animals.

There are 16 ocean outfalls for discharge of treated wastewater from sewage treatment plants and two saline wastewater outfalls along the Victorian coast (table 9.6). Each of these discharges is licensed by the EPA under SEPP (Waters) clause 21. Where an outfall includes a mixing zone, the licence holder undertakes monitoring to assess the environmental impact of the discharge (SEPP (Waters) clause 23). The monitoring, undertaken annually by marine biologists for the water authorities, aims to assess what changes are happening to the biological communities near the discharge.

The largest wastewater discharge comes from Melbourne Water's Western Treatment Plant located at Werribee. The plant, which has been operating since the late 1890s, discharges about 420 megalitres per day of treated effluent to Port Phillip Bay through a series of drains at the shoreline.

The next largest discharge is at Boags Rocks on the Mornington Peninsula, where Melbourne Water's South Eastern Outfall discharges about 340 megalitres per day of treated effluent from the Eastern Treatment Plant located at Carrum. The Boags Rocks outfall also receives about 25 megalitres per day of treated effluent from two of South East Water's sewage treatment plants. Their treatment plant at Somers can discharge to the outfall, but currently recycles 100 per cent of the treated effluent.

Melbourne Water's South Eastern Outfall discharges treated effluent at Boags Rocks on the Mornington Peninsula

The discharge of treated effluent at Boags Rocks, which commenced in 1975, had a significant impact on the adjacent intertidal rock platforms through increased loads of nutrients and freshwater.[32,33,34] Improved treatment processes at the Eastern Treatment Plant implemented in 2007 and further upgrades in 2012 have reduced the visual and biological impact of the discharge. At Fingals Beach, some four kilometres east of the discharge, macroalgal communities are showing signs of recovery.[35]

As with the desalination plant marine monitoring, data from the biological surveys undertaken for outfalls would be more valuable if they were integrated into DELWP's marine knowledge framework.

Table 9.6 Wastewater treatment plant ocean discharges

Treatment plant	Owner	Outfall location	Volume (megalitres) discharged in 2016/17	Volume (megalitres) discharged in 2017/18
Portland	Wannon Water	Portland	1497	1361
Port Fairy	Wannon Water	Port Fairy	1048	915
Warrnambool	Wannon Water	Warrnambool	5728	5474
Apollo Bay	Barwon Water	Apollo Bay	462	467
Lorne	Barwon Water	Lorne	340	285
Anglesea	Barwon Water	Anglesea	336	263
Black Rock/Geelong	Barwon Water	Discharge 1.2km offshore	19,610	21,623
Western Treatment Plant (Werribee)	Melbourne Water	Shoreline discharge into Port Phillip Bay	164,074	151,755
Altona	City West Water	Discharge 0.5km offshore into Port Phillip Bay	3041	2347
Eastern Treatment Plant (Bangholme)	Melbourne Water	Shoreline discharge to Bass Strait at Boags Rocks	127,590	123,825
Mount Martha/Mornington	South East Water	Boags Rocks	6392	6097
Boneo/Rosebud	South East Water	Boags Rocks	3977	3241
Somers/Hastings	South East Water	Boags Rocks	0	0
Cowes	Western Port Water	Pyramid Rock	1129	1567
Wonthaggi/Cape Paterson/ Inverloch	South Gippsland Water	Offshore discharge into Bass Strait at Baxter's Beach	1310	1355
Toora	South Gippsland Water	Shoreline discharge into Corner Inlet	27	27
Foster	South Gippsland Water	Shoreline discharge into Corner Inlet	142	147
Welshpool/Port Welshpool	South Gippsland Water	Shoreline discharge into Corner Inlet	56	48
Leongatha Trade Waste (saline)	South Gippsland Water	Venus Bay	1007	not available
Regional Outfall System (ROS) Dutson Downs	Gippsland Water	Delray Beach	6143	6183
Saline Wastewater Outfall Pipeline (SWOP)	Gippsland Water	McGaurans Beach	9278	8771

9.7 Threats and limitations to coastal development

9.7.1 Coastal settlements

The limitations to growth of coastal settlements in Victoria is partly attributed to the significant area of national and other parks and reserves along the coast, and also to planning controls that have helped to keep residential development within township boundaries. Consequently, where populations are larger and access to coastal waters is available, pressures on the marine environment and resources will be greater.

Residential development has occurred along the entire eastern shoreline of Port Phillip Bay. Photo: R Molloy

9.7.2 Coastal landscapes

Visual impact of offshore structures

There are currently no significant offshore structures built within Victoria's coastal waters that would be considered to have a significant impact on coastal landscapes.

Most of the oil and gas production platforms in the Otway and Gippsland basins are in Commonwealth waters, with those on the horizon more clearly visible at night due to their lighting. The 'Star of the South' offshore wind farm (see section 13.4), which is in the early stages of planning, is proposed to be some 10 to 20 kilometres offshore from the Nooramunga Marine and Coastal Park in Gippsland. This is also outside Victoria's coastal waters but would be visible from the shore.

In Europe the trend in strategic planning for coastal areas is to introduce buffer zones to protect significant coastal landscapes from visual impacts associated with offshore developments such as wind farms.[36] Germany, Belgium and Netherlands have introduced 12 nautical mile (22.2 kilometres) exclusion zones for offshore wind farms. However, observer-based research suggests that offshore wind farms were a major focus of visual attention at distances up to 16 kilometres and noticeable to casual observers at distances of almost 29 kilometres.[36]

9.7.3 Coastal protection

Failing coastal protection structures

The Victorian Auditor-General reported in 2018 that there were more than 1000 coastal protection structures in place, and that these have a replacement cost of about $700 million.[16] The audit report suggested that many of these structures are not being maintained adequately, and that there are significant weaknesses in asset management practices and governance arrangements. A key recommendation was the need to invest in building a comprehensive inventory of coastal assets and the coastal protection structures in place to protect those assets, and to conduct research to better understand the risks to these structures from coastal processes.

It was estimated that between 20 and 30 per cent of coastal protection assets are in poor condition, and between 30 and 50 per cent are estimated to have less than 10 years' useful life remaining.[16]

There are many hotspots along the coast where existing coastal protection structures require significant repair or replacement, and other sites where new solutions are required. Examples include the repair of the seawall at Black Rock in Port Phillip Bay and replacement of the temporary sandbag seawall at Portsea front beach adjacent to the pier.

At Port Fairy, Moyne Shire Council have installed a low-level rock wall and sand trap fencing to prevent erosion exposing rubbish from the decommissioned landfill.[37] Other prominent places where coastal erosion and asset damage is a concern include: Inverloch at the Surf Lifesaving Club, Apollo Bay

Bluestone masonry seawall at Black Rock, constructed in the 1930s, has sustained significant storm damage. A rock revetment along the existing seawall is to be built to protect the historical bluestone seawall, promenade and adjacent cliffs from erosion. Photo: M Mitchell

Temporary sandbag seawall at Portsea front beach, to be replaced by a rock revetment. Photo: R Molloy

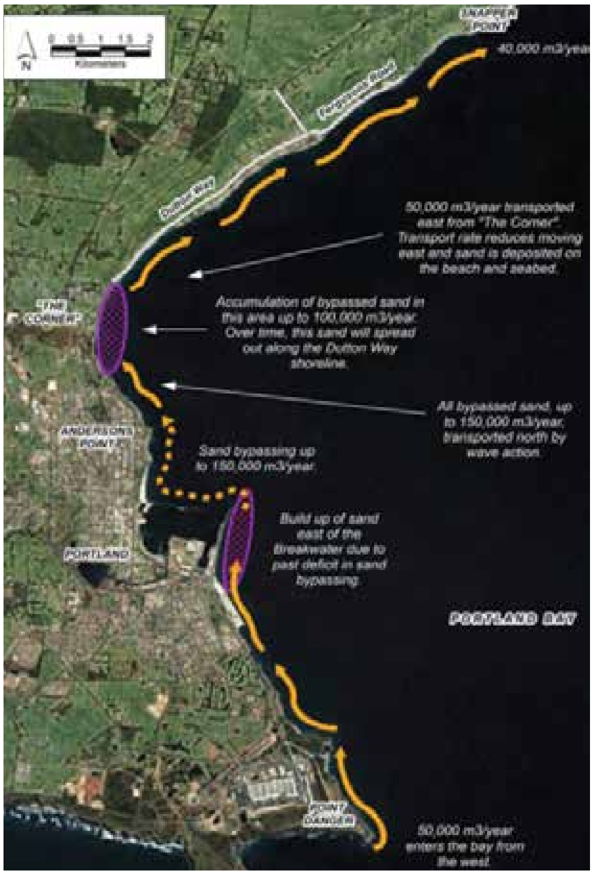
and Mounts Bay where the Great Ocean Road is at risk of collapse, and along the eastern side of Port Phillip Bay between Frankston and Mentone.[38,39,23]

In the Port Albert area of Corner Inlet large areas of low-lying coastal flats are protected from tidal influences by about 65 kilometres of levees. These levees are in various states of disrepair and require substantial investment to maintain their effectiveness. The ownership and condition of these levees together with decisions on coastal retreat under climate change adaptation plans will dictate the investment in future maintenance and repair of these coastal structures.[40]

Altered sediment budgets

At Portland, the construction of breakwaters for the port interrupted the south–to-north longshore transport of sand. This led to a loss of beach area and erosion of the foreshore in the Dutton Way area of Portland Bay. To mitigate this impact, a sand by-pass system was put in place, which has restored the natural sediment supply and halted ongoing erosion of the foreshore (figure 9.8).

Figure 9.8 Port of Portland sand by-passing operations[41]



9.7.4 Access to marine environments

Maintenance

As with other marine structures, piers and jetties are under constant physical stress from the marine environment. This combined with the wear and tear from users means that they require regular and often significant maintenance to maintain the level of service expected by their users. Local port managers, such as Parks Victoria, are under pressure to ensure that their limited budget is spent effectively on the maintenance of these assets. However, in some circumstances, the decision is made to decommission or remove structures that are no longer viable.[42]

Overcrowding

Consultation for the Rye Recreational Boating Plan highlighted issues associated with boat ramps in general. These include increased congestion on land and in the water, conflict between vessels and swimmers, increased littering, reduced water quality and increased dredging to maintain water depths adjacent to the facility.

Patterson River on the eastern side of Port Phillip Bay, has four two-lane boat ramps, boat washing facilities and room for 375 trailers in the carpark. It is one of the most popular boating and fishing gateways to Port Phillip Bay. On a good day 600 boats might use the ramp. However, the boat ramp area is known to suffer from congestion in peak boating and fishing periods, causing issues for boat-ramp users and the public (such as cyclists and pedestrians) alike. Options presented in the 2018 Patterson River draft concept plan include the construction of additional boat ramps and access points for non-powered vessels.[43]

Issues raised through the approval process for the Rye boat ramp upgrade was that increased use for jet skis would put local swimmers at increased risk of injury through collisions. The increased traffic may also impact the resident population of dolphins. To mitigate some of these issues, Marine Safety Victoria impose speed limits in nearshore areas and create exclusion zones to protect swimmers.

Moorings

Capacity for increasing the number of moorings is limited by local conditions, especially in popular boating areas such as Portsea, Sorrento, Williamstown, Werribee and Queenscliff. These more popular mooring grounds are closed (for expansion). However, there is capacity to increase the number of moorings in other grounds. Where mooring grounds are at capacity, port managers can maintain waiting lists. There is also the opportunity for private transfer of mooring permits, but this can encourage speculative behaviour and profiteering.

An issue of concern with increasing the number of moorings is the cumulative impact on the seabed and associated plants and animals.[44,45,46] The mooring chain, which is dragged repeatedly across the seabed through an arc around the anchor, creates a chain-scour that loosens sediment, removes plants and makes the area more vulnerable to erosion. In areas with seagrass, a distinctive circular blowout can be created by swing moorings (figure 9.11). Estimates for the size of blowouts range from 200 to 400 square metres depending on the length of chain.[44,46]

There has been a move to installing more environmentally-friendly moorings to reduce the impact on the seabed. However, the associated higher installation cost makes this option less favoured.[47] The simplest method for limiting adverse effects of swing moorings on significant seabed habitats and organisms is to restrict them to less sensitive locations, such as areas of muddy or sandy sediment.[48]

In some locations the higher cost of land-based storage, in comparison to the annual mooring charge, has resulted in moorings being used for permanent storage of boats. Without regular maintenance these boats can become unseaworthy, posing a threat to other boats and the environment.

Figure 9.9 Aerial photography showing seagrass blowouts caused by moorings at Flinders Pier. Source: DELWP

9.7.5 Industrial development

Expansion of industrial areas at coastal locations is limited by increased recognition of the sensitive nature of these areas and requirements for environmental conservation. See chapter 12 for discussion of threats to port development.

9.7.6 Urban pollution

Stormwater runoff, particularly from urban areas, is a threat to the values in coastal waters and to public health, because it carries sediments, nutrients, toxicants, pathogens and litter.

Toxicants

The science knowledge synthesis for the Port Phillip Bay Environmental Management Plan concluded that toxicants such as metals and organochlorine pesticides are generally below guideline levels in the bay.[49] However, increased levels are found in a few localised areas, including Hobsons and Corio Bays and at the mouth of creeks and drains, such as Mordialloc and Kananook Creeks.

Nutrients

Increased nutrient loads to coastal waters increase the risk of more frequent and intense algal blooms. Water quality modelling for Port Phillip Bay has shown that when nitrogen loads from the Western Treatment Plant move clockwise around the bay and combine with stormwater from the Yarra River and other major drains, algal blooms can occur in Hobsons Bay and along the eastern beaches.[50] Similarly, increased loads of nutrients flowing into the Gippsland Lakes from agricultural areas increases the risk of algal blooms, some of which can be toxic.

Sediments

Sediments can have a significant impact on aesthetic, recreational and ecological values, and they are vectors for transporting toxicants. Water quality modelling for Port Phillip Bay showed that the Yarra catchment is a major source of sediments, with annual loads closely correlated to rainfall (i.e. loads are higher in wetter years). The split between urban and rural sources is about 50/50 despite the area of rural land in the catchment being twice that of urban land. Modelling highlighted the need for improved management within catchments (urban and rural) to reduce sediment loads and their associated toxicants from entering coastal waters, especially in periods of high rainfall.[50]

Litter

Litter, which is any solid or liquid domestic or commercial waste that is deposited inappropriately, has negative impacts on visual amenity, reduces water quality and can kill or harm marine animals. According to research undertaken in the 1990s, about 95 per cent of litter found on beaches in Port Phillip Bay had been transported from suburban streets through the stormwater system.[51]

Litter traps have been installed at key points within the drainage system to collect litter, but their effectiveness is limited by their design and frequency of cleaning.

Microplastics

Microplastics, small pieces (less than 5 millimetres in diameter) of plastic that come from broken-down plastic litter or from raw plastic manufacturing materials, are being washed off properties and roads into drains and waterways that then discharge into the marine environment. Microplastics can be eaten by marine animals, with subsequent impacts on their health.[52,53] Microplastics also include small

Floating litter trap on the Yarra River in the Docklands precinct. Photo: A Kilborn

Microplastics, which includes plastic resin pellets ('nurdles') caught in a surface trawl in Port Phillip Bay. Photo: A Kilborn

Urban stormwater drain at Elwood Beach. Photo: R Molloy

synthetic fibres from the breakdown of woven cloth, which result from washing clothes.

The Clean Bay Blueprint project (2017-2020) aims to prepare Port Phillip Bay's first catchment-to-coast microplastic litter profile. The project, which includes monthly microplastic trawls in the Yarra and Maribyrnong rivers, is showing the pervasiveness of plastics in urban water catchments and reflecting their ubiquitous use, mobility and extreme persistence. Based on results from the first 60 trawl surveys, it is estimated that more than 800 million litter items flow into Port Phillip Bay annually from the surface waters of the two rivers, of which 74 per cent of items are microplastics.[54]

Pathogens

Pathogens, which are found in urban drainage, can impact recreational use and aquaculture, but are generally localised and short-term in nature. However, the potential public health implications of pathogens and public expectations for swimming and collecting shellfish mean that this is a significant issue that requires ongoing management by the EPA, councils and water companies.

9.8 Trends and projections in coastal development

9.8.1 Coastal settlements

Growing townships

There has been an increasing trend in the population of people living along the coast within two hours' drive of Melbourne. Populations in coastal towns such as Torquay and Ocean Grove west of Melbourne, and Dromana on the Mornington Peninsula have been growing at a faster rate than towns further in distance from Melbourne. This contrasts with coastal towns in the far east and far west, which recorded declining populations in 2016-17.[4]

During the past ten years there has been rapid growth in non-coastal centres such as Bendigo and Ballarat and non-coastal suburbs of Melbourne and Geelong. As a result, the coastal population of Victoria in 2017 formed a slightly smaller proportion of Victoria's overall population (13.9 per cent) than it did a decade earlier (14.7 per cent).

Comparison with coastal areas in other states shows that between 2006 and 2016, Victoria had lower rates of growth. However, the 'sea change' phenomenon of people locating from urban areas to the coast is likely to continue. Community attitudes and behavioural research conducted in 2018 indicated that thirteen per cent of respondents are considering making a move to the coast in the next five years. This was a significant increase on the 2011 survey figure of seven per cent.[55]

Changing age structures

Where a population is dominated by retirees, it is likely that there will be a higher number of deaths compared to births. In contrast, an area such as the Bellarine Peninsula that was traditionally a retirement location has increasingly become a place of residence for workers that commute to Geelong or Melbourne. More couples and young families have been attracted to centres such as Torquay, which has resulted in population growth through natural increase as well as net immigration.

This change in age profile has implications for marine and coastal management. Younger retirees are more likely to make greater use of coastal assets, such as boating facilities. They are also likely to be more environmentally conscious and have more time to invest in activities associated with caring for the marine environment.[56, 57]

9.8.2 Coastal landscapes

It is expected that coastal development will continue to occur in designated areas consistent with maintaining settlement character and protection of coastal values. However, as coastal settlements become more developed there will be increased pressure on councils to move township boundaries, which could impact coastal landscapes.

9.8.3 Coastal protection

As indicated by the Auditor-General[16] between 30-50 per cent of coastal protection assets will need replacing in the next 10 years. With increased sea level and frequency of storm events there will be an increase in demand from local communities for new coastal protection assets, especially in those areas highlighted through coastal hazard assessments.[58]

Ecological engineering

There is an increasing recognition that the design, construction methods and materials used for coastal protection structures can mitigate ecological impacts associated with traditional structures.[59] By utilising designs that allow overtopping or penetration of water, sediments and organic matter, these structures are better suited to support marine life. In addition, the seeding of these structures with native species can reduce the likelihood of rapid colonisation of non-native species, which in turn can reduce the range expansion of these pest species.[14]

'Living shorelines' is a concept that has been popularised by environmental groups and regulatory agencies in the USA as an attempt to incorporate natural habitats into coastal protection structures.[15] The use of natural elements, such as oyster reefs and wood to protect shorelines from erosion, help to maintain ecological connectivity by minimising loss and fragmentation of habitats.[14]

At locations in Port Phillip Bay, researchers are trialling mussel reefs and mangroves to see how well they protect shorelines. For the mangrove a 'hybrid' approach is being trialled, involving planting the mangroves within concrete cultivars that attenuate waves, accrete sediment and provide the right conditions for mangroves to grow.[60]

9.8.4 Access to marine environments

Piers and jetties

Many of the piers and jetties at popular locations along the coast provide access and facilities for charter fishing and sightseeing boats, and recreational and commercial scuba diving companies. Demand for these services and facilities will continue to increase with population growth.

Boat ramps

Continued growth in boat ownership and episodes of crowding at existing boat ramps will drive proposals for upgrading of existing ramps and construction of new ramps. There will also be a need to increase the size and number of associated car parks, launching and retrieval piers beside boat ramps and dredged areas for boats waiting to access the ramps.

The Mornington Peninsula Shire's Rye recreational boating plan[61] suggested demand for boat ramp facilities would increase by as much as 25 per cent more than existing levels within the next 15-20 years. This is due to population growth inside and outside the shire, improved road infrastructure (therefore better access to Rye facilities), the popularity of the Rye boat ramp in terms of its location in Port Phillip Bay, and the limited capacity of other boat launching facilities.

9.8.5 Industrial development

The dependence of manufacturing businesses on close proximity to sea ports is less relevant than it once was. Together with the decline in heavy industries such as steel works and oil refineries in Victoria, this has reduced the need for expansion of industrial areas along Victoria's coast. For those coastal areas where industrial development has occurred it is likely that additional development will occur within the existing areas rather than expanding outwards and along the seaward boundary.

An exception to these trends is the development of marine industrial precincts for businesses associated with the manufacturing, maintenance and heavy servicing of vessels and marine equipment. These businesses gain a competitive advantage from direct access to the coast. The Mornington Peninsula Marine Precincts Strategy suggested development of marine industrial precincts at Crib Point and Hastings in Western Port.[62]

Industrial development associated with a second container port in Port Phillip Bay will most likely occur on the landward side of the port and outside of sensitive environmental areas. However, there is concern that if the Port of Hastings is expanded, sensitive coastal and marine environments to the north of the current facilities would need to be developed.[63]

The use of ocean outfalls for the discharge of wastewater is likely to come under increasing scrutiny by local communities. When constructed, many of these outfalls were located in relatively remote locations. With increased urban growth some of these outfalls are in areas that are increasingly used for fishing and collection of shellfish. This is increasing the human health risk associated with eating seafood from these locations.

9.8.6 Urban pollution

Modelling of climate change suggests that there will be more years with less rainfall, but more intense rainfall events over summer. This will result in higher storm event-related flows to coastal waters, bringing increased loads of nutrients, sediments and other pollutants at times of the year when more people use coastal waters.

While the presence and sources of nutrients and sediments in Port Phillip Bay are well described and the impacts of litter on key values have been identified, there are numerous contaminants of emerging concern.[49] These include endocrine-disrupting compounds (EDCs), pharmaceuticals, flame retardants, pesticides (other than organochlorines) and microplastics. These pollutants have not been monitored in marine waters in a systematic way, and in many instances their impacts on marine life have not been well characterised.

Similarly, as urban populations increase, it is expected that litter flowing to the marine environment will continue to increase unless measures are taken to reduce consumption, change littering behaviours and avoid transfer through urban drainage systems.

Results from the National Litter Index for 2017/18 indicate a reduction in littering at the national scale of about 10 per cent since the previous survey in 2016/17. However, in Victoria results indicate an increase in the number and volume of litter (22 per cent increase for beaches in 2017/18 compared to 2016/17).[64] For those states and territories that have introduced policy changes such as container deposit schemes and bans on single-use lightweight polyethylene bags, the results show a significant reduction of these items in the litter stream.

People's concern for litter and marine debris on beaches is continuing to drive a strong community response. One example has been the formation of Beach Patrol, which is a chain of volunteer community groups each defined by suburb, post code and t-shirt colour. After starting in Middle Park in 2009, there are now 30 Beach Patrol groups operating around Port Phillip Bay and beyond with groups on the Bellarine Peninsula and at Warrnambool.[65]

Beach Patrol operates on a simple model. Volunteers sign up on the Beach Patrol website to become members of their selected group and pledge one hour per month of their time for beach cleaning. This cleaning is done either at the discretion of the member or as a part of organised monthly group cleans. After each session the volume of rubbish collected and volunteer hours is recorded for cumulative reporting. Groups also participate in quantitative litter surveys to build knowledge on the types of litter and volumes accumulating on beaches.

Other organisations, such as Tangaroa Blue Foundation, are providing support to communities, organisations, agencies and schools including training, clean up materials and logistical support, educational resources and analysis of the marine debris they are collecting. Their Australian Marine Debris Initiative provides valuable data on the types and amounts of marine debris impacting beaches and the success of communities in reducing the impact of marine debris.

Similarly, other groups such as the Dolphin Research Institute, Marine Mammal Foundation, Port Phillip EcoCentre and the Bellarine Catchment Network are continuing to work with schools and local communities to improve stewardship values for the marine environment that collectively mitigate the impacts of coastal development.

Port Melbourne 3207 is one of a chain of volunteer Beach Patrol groups working to improve the condition of local beaches through routine collection of litter. Photo: R Molloy

Wet sand fence installed at Inverloch to reduce erosion in front of life saving club. Photo: A Kilborn

9.9 References

1. Barnard, J. (2008) *Jetties and piers: a background history of the maritime infrastructure in Victoria.* Published by the Heritage Council of Victoria, East Melbourne. http://livinghistories.net.au/our-work/commissioned-histories/
2. Smyth, C. (2014) *The coast is unclear: an uncertain future for nature along the Victorian coast.* Report prepared for the Victorian National Parks Association, Melbourne.
3. Land Conservation Council (LCC) (1993) *Marine and coastal special investigation. Descriptive report.* Land Conservation Council, Melbourne.
4. McKenzie, F. (2018) *Coastal demographics in Victoria.* Background research paper prepared by Land Use and Population Research Branch, Department of Environment, Land, Water and Planning. Melbourne
5. d'Albis, H. and Collard, F. (2013) Age groups and the measure of population aging. *Demographic Research* 29: Article 23: 617-640. Available at: http://www.demographic-research.org/Volumes/Vol29/23/
6. Bozeman, B. (2007) *Public values and public interest: counterbalancing economic individualism.* Georgetown University Press.
7. Strickland-Munro, J., Kobryn, H., Brown, G. and Moore, S.A. (2016) Marine spatial planning for the future: using Public Participation GIS (PPGIS) to inform the human dimension for large marine parks. *Marine Policy* 73: 15e26.
8. Munro, J., Pearce, J., Brown, G., Kobryn, H. and Moore, S.A. (2017) Identifying 'public values' for marine and coastal planning: are residents and non-residents really so different? *Ocean & Coastal Management* 148: 9-21.
9. Planisphere (2006) 2005 *Coastal Spaces landscape assessment study – protection and management of Victoria's coastal landscapes – State overview report.* Prepared for Department of Sustainability and Environment.
10. Victorian Coastal Council (VCC) (2014) Victorian Coastal Strategy 2014, published by Victorian Coastal Council, East Melbourne. http://www.vcc.vic.gov.au/page/victorian-coastal-strategy-2014
11. Victorian Coastal Council (VCC) (1998) *Siting and design guidelines for structures on the Victorian coast.* Prepared by Tract Consultants Pty Ltd and Chris Dance Land Design Pty Ltd for the Victorian Coastal Council http://www.vcc.vic.gov.au/assets/media/files/sitingdesignguidelines.pdf
12. Commissioner for Environmental Sustainability Victoria (CESV) (2016) *State of the Bays 2016*. https://www.ces.vic.gov.au/sites/default/files/publication-documents/State%20of%20the%20Bays%202016.pdf
13. Bezore, R., Kennedy, D.M. and Ierodiaconou, D. (2016) The drowned Apostles: the longevity of sea stacks over eustatic cycles. *Journal of Coastal Research* Special Issue No. 75.
14. Bishop, M.J., Mayer-Pinto, M., Airoldi, L., Firth, L.B., Morris, R.L., Loke, L.H.L., Hawkins, S.J., Naylor, L.A., Coleman, R.A., Chee, S.Y. and Dafforn, K.A. (2017) Effects of ocean sprawl on ecological connectivity: impacts and solutions. *Experimental Marine Biology and Ecology* 492: 7–30.
15. Nordstrom, K.F. (2014) Living with shore protection structures: a review. *Estuarine, Coastal and Shelf Science* 150: 11-23
16. Victorian Auditor-General's Office (VAGO) (2018) *Protecting Victoria's coastal assets.* Victorian Government Printer, Melbourne.
17. Roob, R. (2017) *Living shoreline response to building coastal resilience*. Presentation at Connecting Coastal Champions Forum, 23 November 2017, Central Coastal Board, Melbourne.
18. Water Technology (2014) *Western Port local coastal hazard assessment: Report 1 (R01) – summary report.* Prepared by Water Technology Pty Ltd for Melbourne Water.
19. Melbourne Water (2017) *Planning for sea level rise, guidelines – Port Phillip and Westernport region.* Available at: https://www.planning.vic.gov.au/__data/assets/pdf_file/0016/103039/Planning-for-sea-level-rise-guidelines.pdf
20. Cardno (2015) Technical review: Port Phillip Bay beaches and foreshore program. Prepared for Department of Environment and Primary Industries by Cardno Victoria Pty Ltd.
21. Kirkpatrick, S. (2012) The economic value of natural and built coastal assets, part 2: built coastal assets. Australian Climate Change Adaptation Research Network for Settlements and Infrastructure (ACCARNSI) discussion paper – Node 1 Coastal Settlements.
22. Dominguez-Tejo, E., Metternicht, G., Johnston E.L. and Hedge, L. (2018) Exploring the social dimension of sandy beaches through predictive modelling. Environmental Management 214: 379–407.
23. GHD (2018) Apollo Bay – coastal protection study. Prepared for Department of Environment, Land, Water and Planning. https://engage.vic.gov.au/apollo-bay-and-marengo-erosion/ghd-report-apollo-bay-coastal-protection-study
24. Cardno (2016) *Sandringham sand management scoping study – final report.* Prepared for Department of Environment, Land, Water and Planning by Cardno Victoria Pty Ltd.
25. AECOM Australia Pty Ltd (2011) *Cost-Benefit Analysis of Port Phillip Beach Renourishment.* Report prepared for the Department of Sustainability and Environment.
26. New South Wales Roads and Maritime Services (2015) *New South Wales boat ramp facility guidelines.* https://www.rms.nsw.gov.au/documents/maritime/projects/better-boating-program/nsw-boat-ramp-facility-guidelines.pdf
27. Knuckey, I., Brooks, K., Koopman, M. and Jenkins, G. (2017) *The social drivers and implications of an ecological risk assessment of both recreational and commercial fishing – a case study from Port Phillip Bay.* Fishwell Consulting, 2017. FRDC Project No 2014/207.
28. Ethos NRM (2018) *Mallacoota ocean access boat ramp at Bastion Point: independent compliance audit of environmental management plan 2017 operation and maintenance.* Prepared for East Gippsland Shire. https://www.eastgippsland.vic.gov.

au/files/assets/public/documents/operations_directorate/egsc_bastion_point_environmental_management_plant_operation_and_maintenance_audit_2017_v2_1.pdf

29. Built Heritage Pty Ltd (2018) *St Kilda marine heritage assessment. Final report.* Prepared for City of Port Phillip: Available at: http://www.portphillip.vic.gov.au/default/Built%20Heritage%20-%20St%20Kilda%20Marina%20heritage%20Report.pdf
30. Matthews, S. (2016) *The erasure of Melbourne's wetlands.* State Library Victoria Blog. https://blogs.slv.vic.gov.au/such-was-life/the-erasure-of-melbournes-wetlands/
31. AECOM Australia Pty Ltd (2017) *Victorian desalination plant operational marine monitoring program, supply period 5 report - 2016-2017.* Prepared for Watersure.
32. Manning, P.F. (1979) *The biological effects of the discharge of secondary treated sewage effluent at Boags Rocks, Gunnamatta Beach, Victoria.* Honours thesis. Latrobe University, Melbourne.
33. Brown,V.B., Davies, S.A. and Synnot, R.N. (1990) Long-term monitoring of the effects of treated sewage effluent on the intertidal macroalgal community near Cape Schanck, Victoria, Australia. *Botancia Marina* 33: 85-98.
34. Newell, B., Molloy, R. and Fox, D. (1999) *Environmental impact assessment and review of effluent disposal options for Eastern Treatment Plant. Final report.* Prepared for Melbourne Water Corporation by CSIRO Environmental Projects Office.
35. Chidgey, S., Crockett, P. and Fulton, S. (2017) *Boags Rocks marine environmental monitoring program. Quantitative intertidal ecosystem indicator monitoring 2001-2017.* Results and effects. Report to Melbourne Water by CEE Environmental Scientist and Engineers, Cheltenham, Victoria.
36. Sullivan, R.S., Kirchler, L.B., Cothren, J. and Winters, S.L. (2013) Offshore wind turbine visibility and visual impact threshold distances. *Environmental Practices* 15(1): 33-49.
37. Moyne Shire Council (2018) *Port Fairy coastal climate change adaptation plan.* http://www.moyne.vic.gov.au/Our-Community/Environment/Defend-Port-Fairy
38. Miller, R. and Preiss, B. (2019) *Oceans rising: can we save our collapsing coastline?* The Age 12 January 2019. https://www.theage.com.au/national/victoria/oceans-rising-can-we-save-our-collapsing-coastline-20190111-p50qvy.html
39. Rosengren, N. and Miner, T. (2018) *Mounts Bay, Marengo – is backshore sand renourishment a viable option for managing coastal hazard risk?* Prepared for Department of Environment, Land, Water and Planning, Victoria.
40. West Gippsland Catchment Management Authority (2012) *Regional catchment strategy 2013-2019.*
41. Worley Parsons Services Pty Ltd (2014) *Port of Portland sand bypass project: environmental management plan*, prepared for Port of Portland. http://www.portofportland.com.au/images/stories/environment/Dredging/Sand_Bypassing_EMP.pdf
42. Parks Victoria (2016) *Safety and environmental management plan – Port Phillip, Western Port and Port Campbell, 2016* Second edition.
43. Department of Environment, Land, Water and Planning (DELWP) (2018) *Draft Patterson River concept plan.* https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.vic-engage.files/9215/2539/8608/2018_05_04_draft_Concept_Plan.pdf
44. Walker, D.I., Lukatelich, R.J., Bastyan, G. and McComb, A.J. (1989) Effect of boat moorings on seagrass beds near Perth, Western Australia. *Aquatic Botany* 36: 69–77.
45. Herbert, R.J.H., Crowe, T.P., Bray, S. and Sheader, M. (2009) Disturbance of intertidal soft sediment assemblages caused by swinging boat moorings. *Hydrobiologia* 625: 105 116.
46. Demers, M.C.A., Davis, A.R. and Knott N.A. (2013) A comparison of the impact of 'seagrass-friendly' boat moorings systems on *Posidonia australis. Marine Environmental Research* 83: 54-62.
47. Bowman, L. (2008) *Seagrass friendly boat moorings: feasibility assessment.* Department of Primary Industries, Fisheries Conservation & Aquaculture, Port Stephens Fisheries Centre.
48. Morrisey, D., Cameron, M. and Newcombe, E. (2018) *Effects of moorings on different types of marine habitat.* Marlborough District Council. Cawthron Report No. 3098.
49. Barbee, N., Longmore, A., Townsend, K. Pettigrove, V. and Swearer, S. (2016) *Science knowledge synthesis of nutrient cycling, marine pests and pollutants: informing the development of the new Port Phillip Bay environmental management plan.* CAPIM Technical Report No. 60, Centre for Aquatic Pollution Identification and Management, University of Melbourne, Victoria, Australia.
50. Jacobs and HydroNumerics (2015) *Integrated modelling for the development of the new Port Phillip Bay environmental management plan: model refinements and calibration report*. Report to Melbourne Water, Melbourne.
51. Melbourne Water (1993) *Backyard to bay, tagged litter report.* Prepared by Melbourne Water and Melbourne Parks and Waterways.
52. Duckett, P.E. and Repaci, V. (2015) Marine plastic pollution: using community science to address a global problem. *Marine and Freshwater Research* 66: 665–673
53. Maillard, K., Sgardelis, P., Ng, Y., Kearney, Y., Franchi, E., Charko, F., Blake, N. and Lee, R. (2013) *Nurdle soup? Preliminary investigation of 'nurdles' in Port Phillip Bay October 2013.* A Port Phillip Baykeeper report to Port Phillip EcoCentre Inc.
54. Charko, F., Blake, N., Kowalczyk, N., Johnstone, C., Seymore, A. and Quek, Y. (2018) *Microplastics in the Maribyrnong and Yarra rivers, Melbourne, Australia.* Report by Port Phillip EcoCentre. https://ecocentre.com/cleanbayblueprint

55. Ipsos (2019) *Wave 5 – Marine and coastal community attitudes and behaviours research 2018, draft report.* Prepared for the Department of Environment, Land, Water and Planning by Ipsos-Eureka Social Research Institute, Melbourne.
56. Morrison, P.S. and Beer, B. (2017) Consumption and environmental awareness: demographics of the European experience. *Socioeconomic Environmental Policies and Evaluations in Regional Science, New Frontiers in Regional Science: Asian Perspectives* 24 DOI 10.1007/978-981-10-0099-7_5
57. Volunteering Australia (2015) Key facts and statistics about volunteering in Australia
58. Spatial Vision (2017) *Victorian coastal hazard assessment 2017: a second-pass statewide assessment of erosion and inundation hazards resulting from future climate change scenarios to inform the Victorian coastal monitoring program*. Report prepared for Department of Environment, Land, Water and Planning, Melbourne.
59. Strain, E.M.A., Morris, R.L., Bishop, M.J., Tanner, E., Steinberg, P., Swearer, S.E., MacLeod, C. and Alexander, K.A. (2019) Building blue infrastructure: assessing the key environmental issues and priority areas for ecological engineering initiatives in Australia's metropolitan embayments. *Journal of Environmental Management* 230: 488–496.
60. Morris, R.L., Konlechner, T.M., Ghisalberti, M., Swearer, S.E. (2018) From grey to green: efficacy of eco-engineering solutions for nature-based coastal defence. *Global Change Biology* 24-5: 1827-1842.
61. Mornington Peninsula Shire (2013) *Rye recreational boating precinct plan. Final report.* Insight Leisure Planning.
62. AECOM Australia Pty Ltd (2015) Mornington Peninsula marine precincts strategy. Prepared for Mornington Peninsula Shire Council. https://www.mornpen.vic.gov.au/files/assets/public/new-website-documents/about-us/strategies-amp-plans/docs/marine_precinct_strategy_-_final_-_adopted_by_council_23_march_2015.pdf
63. Infrastructure Victoria (2017) *Advice on securing Victoria's ports capacity.* Prepared by Infrastructure Victoria for the Victorian government. http://www.infrastructurevictoria.com.au/
64. Keep Australia Beautiful National Association (KBA) (2018) National Report 2017 – 2018 National Litter Index. http://kab.org.au/wp-content/uploads/2019/03/2019_NLI17_18_EPORT.pdf
65. Beach Patrol (2019) *Beach Patrol*, what we do. https://www.beachpatrol.com.au/About-Us

10 Tourism and Recreation

This chapter provides a summary of Victoria's marine-related tourism and recreation together with a discussion of the threats and emerging uses. Tourism involves people travelling to, and staying in, places outside their usual environment for short periods of time typically for leisure or business, while recreation is made up of the activities people pursue in their free time. There is a strong connection between tourism and recreation, as many of the activities undertaken by tourists could be described as recreation. Recreation, sporting activities and events also contribute to regional tourism. As Victoria continues to experience population growth and urban densification, the marine environment will be visited by more people, in more places, for tourism and recreation.

KEY POINTS AT A GLANCE

- Marine tourism is a large and growing part of Victoria's tourism sector. It is strongly dependent on marine natural values such as popular or appealing ('charismatic') animals and pristine landscapes.
- Growing or emerging tourism sectors include Indigenous, nature-based and adventure tourism.
- Ecotourism is ecologically sustainable tourism with a focus on increasing environmental and cultural awareness. Popular activities include swimming with and viewing marine mammals, surfing and paddling. Compared with more traditional tourism, ecotourism has a lesser environmental impact.
- Victoria's most popular marine and coastal visitor destinations are the Twelve Apostles on the Great Ocean Road and the Penguin Parade on Phillip Island.
- Recreation in the marine environment includes activities beside, on and in the water, all providing significant health benefits. Popular in-water recreational activities include swimming, surfing, diving and snorkelling.
- Active recreation (e.g. boating) is more likely to have negative environmental impacts than passive recreation (e.g. bird watching) as it requires a greater level of infrastructure.
- Most on-water activities include boats of some sort. In Victoria, there are more than 400,000 licensed boat operators and more than 200,000 licensed vessels. Threats from boating include pollution, localised biodiversity impacts of access structures (e.g. boat ramps) and disturbance to biodiversity.
- Boat-based tourism is a growing industry and includes dive boats, fishing charters, scenic cruising boats and yachts. Mostly small to medium-sized boats are involved, so impacts and risks of marine pollution are minor.
- Marine mammals (whales, dolphins and seals) are the focus of a number of air, land and sea-based tourism businesses. To manage the disturbance impacts on the animals, a combination of regulations, permits and exclusion zones are in place.
- Artificial reefs, including sunken ships, are growing in popularity for diving and improving recreational values.
- Citizen science and community-based projects are important recreational activities that raise the awareness of environmental values and encourage marine stewardship.
- Urban population growth interacting with climate change generates a complex mix of threats to tourism and recreation. These include overcrowding and conflict between users, climate change impacts to natural (e.g. beaches) and built (e.g. boat ramps) assets and decreased water quality.
- There is limited knowledge on current visitor numbers at a finer scale. These data are needed to inform infrastructure priorities.
- Cooperation and a shared vision across the local community, tourism industry and government are necessary to sustain the appeal of tourist destinations.

The broad categories of threats to recreation and tourism are summarised and examples are provided for each threat in table 10.1; for more detail see the relevant section of this chapter. Discussion of threats in this chapter are threats to tourism and recreation. The threats that tourism and recreation might pose to other values are discussed in other chapters.

Table 10.1 Summary of threats to values associated with tourism and recreation in Victoria

Threat class	Pathway/outcome	Example (with section reference)
Climate change	Altered oceanography	Changes to currents (e.g. Leeuwin Current has weakened) impacts on targeted fish species that rely on pelagic transport of larvae and adults (e.g. King George whiting) (6.4.7)
	Sea level rise	Rising sea levels may impact on boat launching infrastructure (e.g. ramps and jetties) that are close to current sea levels (12.3.1)
	Increased storm frequency	Boat-based tourism may become increasingly unpredictable due to changing weather patterns, leading to cancellations and losses for tour operators (10.1.3)
Physical	Erosion	Increased investment needed to meet expectations that popular beaches will be protected and stabilised by ongoing sand replacement (beach renourishment) (9.4.3)
	Altered flow and depth	If bays and inlets become too shallow due to sedimentation, boats will be unable to launch unless dredging is undertaken (9.7.6)
Biological	Loss or avoidance of charismatic fauna	Tour and recreational vessels interact with marine mammals, especially in Port Phillip Bay. If not adequately managed, marine mammals may move elsewhere (10.1.3)
	Nuisance species	Over abundance of some species can lead to a loss in diversity of marine species reducing the appeal of a location. For example urchin barrens can reduce the appeal for snorkelling (10.1.3 and 6.5.1)
Catchment processes	Runoff and sedimentation	Diving requires clear water, which can be degraded by excess sediment that reduces water clarity (10.2.3)
Pollution	Marine debris	Build-up of seaweed, litter and marine debris can reduce the appeal of a beach, reduce visitation rates and lead to economic losses for local businesses dependent on tourists (10.2.3)
	Poor water quality	Water quality can be degraded by pathogens and litter from local drains, impacting on in-water activities (e.g. swimming) (10.2.3)
Community/ industry demand	Expansion of industry	Increased visitation rates at popular tourism destinations can have negative impacts on the visitor experience, resulting in reduced visitor numbers and spending (10.1.3)
	Crowding	Overcrowding at popular locations can lead to reduced visitor numbers, threatening local businesses (10.1.3)
	Recreational access	Conflict between water users, such as jet skis and speed boats and swimmers, can lead to reduced appeal of some locations (10.2.3)

10.1 Marine tourism

Tourism is defined as the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited.[1] Marine and coastal tourism are two distinct forms of tourism that are nonetheless very closely related. Marine tourism is totally connected to, and dependent on, the sea and the marine environment, whereas coastal tourism is generally associated with land-based activities that are linked to a coastal location.

Marine and coastal tourism are amongst the oldest forms of tourism and the largest segment of the tourism industry. While marine tourism activities take place in the sea, the supporting facilities and infrastructure are usually found on land and near urban populations. There is also an inverse relationship between distance from shore and the intensity of use. The concentration and diversity of tourism activities is far greater in waters adjacent to the shore and urban settlements. Consequently, the potential for conflict with other marine activities is greatest in these nearshore areas.[2]

For Victoria, tourism is a significant contributor to the economy, contributing some $25 billion in gross state product and employing more than 214,500 people in 2017-18.[3] Of the twelve tourism regions in Victoria, six include coastal areas: Great Ocean Road, Geelong and the Bellarine, Melbourne, Mornington Peninsula, Phillip Island and Gippsland (table 10.2).

Table 10.2 Regional tourism summaries for year ending September 2018 (source: Tourism Research Australia)[3]

Tourism region	Gross regional product from tourism ($ million)	Annual average growth % (2012-17)	Tourism employment (jobs)	Day trippers *domestic* (million)	Overnight visitors *domestic* (million)	Overnight visitors *international*
Great Ocean Road (to South Australia border)	994	3.7	11,200	2.9	2.2	219,000
Geelong and the Bellarine	783	5.3	8,100	3.8	1.3	53,000
Melbourne	15,700	6.2	119,800	18.8	9.9	2,900,000
Mornington Peninsula	849	6.0	9,000	5.6	1.8	61,000
Phillip Island (and Bass Coast)	407	1.6	4,400	1.5	0.9	50,000
Gippsland	785	2.9	8,900	3.3	2.0	75,000

The coastal tourism regions (excluding Melbourne), which contribute about 15 per cent of the gross state product, have a strong dependence on the natural values of the marine and coastal environment for attracting visitors and tourism investment. However, at a regional scale it is difficult to separate out how much of this tourism is marine related. For example, tourists may visit a region to attend a music festival, visit a market or play golf, none of which occur in the marine environment. There may also be overlap of people visiting a region to undertake multiple activities. For example, people attending a music festival may take the opportunity to visit the beach or go surfing.

Visitor survey information can be used to indicate differences in popularity between regions (and areas within larger regions) for different types of activities and types of visitors (day trippers verses overnight domestic or international visitors) (table 10.3). For example, of the 2.1 million annual visitors to the Surf

Coast Shire, which extends from Torquay to Lorne, about 71 per cent visit the beach, 12 per cent go surfing and 4 per cent go fishing. Visitor data for the Gippsland Lakes region show that going to the beach is less significant (26 per cent) in comparison to survey results for the Surf Coast Shire, and that fishing is a significantly more popular activity (15 per cent)

Table 10.3 Selected activity data for Surf Coast Shire, South Gippsland Shire and the Gippsland Lakes region from the National Visitor Survey and the International Visitor Survey, 2017-18 (Source: Tourism Research Australia)

	Number of visitors	Favourite activities (%)				
		Go to beach	Sightseeing	Go surfing	Fishing	Bushwalking
Surf Coast Shire						
Day trippers - domestic	1,133,000	69	26	11	4	7
Overnight visitors - domestic	945,000	73	36	12	4	23
Overnight visitors - international	50,300	90	89	20	6	53
South Gippsland Shire						
Day trippers - domestic	505,000	27	36	0	3	20
Overnight visitors - domestic	472,000	48	29	5	4	37
Overnight visitors - international	22,500	78	92	15	6	76
Gippsland Lakes region						
Day trippers - domestic	496,000	6	21	0	11	9
Overnight visitors - domestic	777,000	36	31	2	18	21
Overnight visitors - international	39,800	86	90	11	13	62

Notes: Figures highlighted in **red** are considered below reliable thresholds and should be interpreted with caution. Activities are undertaken in the nominated destination for domestic overnight and daytrips; however for international overnight visitors, activities could be undertaken anywhere on the entire trip.

10.1.1 Current marine tourism

Tourist destinations

Tourist destinations are generally built on a range of attractions, both natural and artificial. For example, Phillip Island, which can be described as a tourist destination, provides a range of attractions. Tourists can visit a sanctuary for koalas, take a boat ride out to view seals, have a meal at a local seafood restaurant and then finish off the day at the evening penguin parade. In turn, the tourist requires a range of services such as transport, accommodation and food outlets, all of which contribute directly and indirectly to the local economy.

Victoria's top coastal attractions are the Twelve Apostles on the Great Ocean Road (2.7 million visitors in 2017-18) and the Penguin Parade on Phillip Island (1.4 million visitors in 2017-18).[4]

The Regional Tourism Infrastructure Fund, administered by Regional Development Victoria, has supported investment in infrastructure at key visitor attractions such as the Great Ocean Road and the Penguin Parade at Phillip Island Nature Park and the development of the Shipwreck Coast Master Plan.

Marine ecotourism

Ecotourism is defined as ecologically sustainable tourism with a primary focus on experiencing natural areas that fosters environmental and cultural understanding, appreciation and conservation.[5] It can be considered as a niche within the broader nature-based tourism sector. Ecotourism generally involves limited visitor numbers in remote or unique natural areas, higher expenditure by the visitor, and an emphasis on sustainability and minimal environmental impact.[6]

Ecotourism creates benefits for the environment and residents of the destination. There is a significant return to the customer through a higher perception of satisfaction associated with the 'feel good' element and 'caring' for nature. Other perceived benefits for the customer include the sense of excitement and adventure, and environmental knowledge gained from the experience.[7]

A key value of ecotourism is that it provides visitors with an improved understanding and appreciation of the natural environment. This leads to a more caring visitor who supports conservation efforts and is more likely to adopt behaviours in the wider community that have positive outcomes for the environment.[8,9]

The ECO Certification Program, developed by Ecotourism Australia addresses the need to identify genuine nature and ecotourism operators. The three-level certification program assures travellers that certified products are backed by a strong, well managed commitment to sustainable practices and provide high quality nature-based tourism experiences.

Ecotourism Australia lists 52 ECO certified tourism operators in Victoria's terrestrial and marine environments. Those operating in the marine environment include dolphin swims and other marine wildlife viewing, surf schools, paddling and coastal walking tours.

A tour operator licence is required from Parks Victoria for businesses conducting an organised tour or recreational activity for profit on public land, which includes the marine environment. Fees payable consist of a fixed component and a variable component based on visitor numbers. Those operators demonstrating good compliance history can apply for a longer three-year licence term. Operators with Nature Tourism or Australian Tourism Accreditation Program are eligible for a five-year licence, and operators with Ecotourism or Advanced Ecotourism certification are eligible for a ten-year licence. Parks Victoria reported that in 2017-18, there were 496 licensed tour operators across the state.

Stretching for 243 kilometres, the Great Ocean Road, with its magnificent views of the Twelve Apostles, is regarded as one of the world's iconic coastal drives, while also linking the numerous tourism townships and destinations along the coast

Ecotourism operators cater for domestic and international tourists visiting southern Port Phillip Bay. Photo: Polperro Dolphin Swims, Blairgowrie

Marine mammal tourism industry

Marine mammal tourism in Victoria is well established and is an important tourist attraction. In 2008 (the most recent figures available) tourist expenditure associated with marine mammal tourism was estimated at more than $4 million.[10] Activities include:

- land-based viewing of whales on the west coast from Logans Beach at Warrnambool through to Portland
- air and sea-based viewing of whales
- tour vessel-based swimming with and viewing of dolphins at the southern end of Port Phillip Bay
- vessel-based viewing of dolphins in the Gippsland Lakes
- boat cruises, sea kayak tours, swimming or scuba diving with seals at the various colonies and haul out sites along the coast.

Whale and seal watching tours where operators seek to approach closer than the prescribed minimum distances, and dolphin swim tours require permits to be issued under the Wildlife Act. There are currently:

- four swim with dolphin permits for Port Phillip Bay (maximum allowed by a determination made under the Wildlife Act)
- seven whale watching (vessel) permits
- one whale watching (aircraft) permit
- five seal tour permits.

There are also likely to be several other tourism operators who offer activities similar to swimming with seals, whale watching or visiting seal colonies but who do not hold a permit under the Wildlife Act. No permit is required if operators intend to remain beyond the minimum approach distances, or to interact with seals outside designated seal breeding colonies.

The Wildlife (Marine Mammals) Regulations 2009 set out requirements that must be followed by permit holders for whale, seal and dolphin watching and swim tours. The regulations also set requirements for the public to follow, including minimum approach distances by vessels, aircraft and swimmers, and set penalties for breaches of these regulations.

The only area where dolphin swim tours are permitted to operate is Port Phillip Bay. The permitted area is all the bay waters that are more than 100 metres seaward of the low water mark, excluding aquaculture reserves and the Ticonderoga Bay Sanctuary Zone that runs parallel to the coast from Portsea to Point Nepean.

An exclusion zone for vessels has been established to provide protection of calving whales offshore from Logans Beach near Warrnambool, for the period from June to end of October.

Commercial tour boat industry

Commercial tour boats, charter vessels and car and passenger ferries are an important component of the marine and coastal tourism industry, often providing unique views and access to a marine environment not easily seen by tourists. The range of vessels and businesses include the dive boat operators, fishing charters and scenic cruising boats and yachts.

Dive boats that operate out of Queenscliff, Portsea and Sorrento provide access to the many shipwrecks and spectacular reefs at and near the entrance to Port Phillip Bay. Similar services are provided from Geelong for Corio Bay and the western side of Port Phillip Bay, Flinders for Western Port, and San Remo for locations around Phillip Island.

Scenic cruise ferry, Port Melbourne. Photo: A Kilborn

Tourists at Cowes, Phillip Island waiting to board the Western Port ferry. Photo: R Molloy

Cruising boats and yachts for sightseeing operate out of most local ports along the coast, offering a range of craft from large multideck luxury boats, to catamaran sailing and rigid-hulled inflatable boats, all providing a range of experiences for tourists.

Ferry services along the Victorian coast have had a long history of meeting the needs of tourists since the late 1800s. In the early days the ferry trip was as much a part of the vacation as the end destination.[11] Current ferry services include the car and passenger ferry service from Queenscliff to Sorrento and passenger ferry from Melbourne to Portarlington in Port Phillip Bay, and passenger ferry from Stony Point to Tankerton to Cowes in Western Port. Smaller ferries and water taxis operate in other locations such as the Yarra River, Hobsons Bay and Gippsland Lakes.

The potential for tour boat-related environmental impacts is generally a product of the overall size and type of vessel and its predominant area of operation. Most tourism operators tend to use vessels of the small to medium size category. In this group, environmental impacts resulting from accidents tend to be relatively minor.[12]

Visiting cruise ships dock at Station Pier, Port Melbourne. Photo: A Kilborn

Rye beach during the busy summer period, January 2019. Photo: R Molloy

Vessels used for commercial purposes must have appropriate certification for seaworthiness, operations and safety management systems (see Australian Maritime Safety Authority regarding certification requirements). In addition to ensuring safety, many of the operators provide commentary and education on the marine environment, local wildlife, coastal features and other points of interest. This can be of significant value for building awareness and appreciation of marine values.

Fishing charters

A Victorian parliamentary inquiry was conducted into the management of the fishing charter industry in Victoria in 2002. The parliamentary committee recognised that the fishing charter industry was an important and growing industry, making a significant contribution to tourism across Victoria. Issues of concern included sustainable fishing practices, business management, safety and service standards. Recommendations included registration of charter vessels, a voluntary accreditation program and the use of voluntary catch and effort logbooks.[13]

There is currently no government agency that records the number of charter boat operators in Victoria. In 2002 it was estimated that there were between 80 and 130 businesses using boats to conduct fishing charter trips. These businesses operate from most coastal towns, with a concentration around Port Phillip Bay and Western Port. The services provided cater for experienced fishers targeting key species through to novices wanting an enjoyable day fishing.

In most circumstances, the charter operator assists the customers to catch fish by taking them to areas where the chances of catching fish are high, and by teaching the customer the best fishing techniques for target species. Most operators educate their clients on aspects such as fishing regulations, licensing requirements, fish stock sustainability, fishing etiquette, and will encourage clients to return some of the legally retainable catch to the sea. However, there is no obligation for operators to provide this education service.[13]

Fishing charter operators participate in the industry in varying degrees, ranging from those who are almost full time to those who intersperse their fishing charter activities with other boat-based activities such as conducting tours and maintaining marine physical infrastructure.

The main social benefit of the industry is the enjoyment of an active outdoor experience being provided to recreational anglers that would not otherwise be available to them. There is also a direct and indirect benefit to local economies through employment, equipment and vessel maintenance and travel expenses incurred by anglers.

Cruise ships

Victoria has three terminals servicing cruise ships: Melbourne, Geelong and Portland. Each of these terminals feature varying services, from meet, greet and farewell programs to shuttle services and other transportation, day excursions and dedicated berths. Most arrivals occur during the summer season.

Station Pier in Port Melbourne is the main destination point for cruise ships in Victoria. The pier, in addition to hosting more than 100 cruise ships that visit Melbourne per year, also hosts the Spirit of Tasmania ferries that run twice daily between Melbourne and Devonport in Tasmania.

Victoria captures a small proportion (7 per cent in 2016/17) of the Australian cruise ship industry, which is nationally worth $5.3 billion.[14] Some of the smaller luxury cruise ships (about 30,000 to 60,000 gross tonnage, carrying 600 to 1200 passengers) occasionally visit the ports of Geelong and Portland to give passengers access to regional tourist attractions. Cruise ships will also anchor in Western Port offshore from Cowes where passengers can be tendered ashore to visit local tourist attractions such as the Penguin Parade.

Beach-based tourism

Victoria has some 560 ocean beaches and 132 beaches around Port Phillip Bay. *Beaches of the Victorian coast and Port Phillip Bay*,[15] a guide to Victorian beaches, provides a description of each beach emphasising its physical characteristics. This description includes details on the location, access, facilities, dimensions and the character of the beach and surf zone. The guide also provides comment on the suitability of the beach for swimming, surfing and fishing, with emphasis on the natural hazards.

In addition to the physical characteristics, the popularity of a beach is dependent on proximity to urban populations, knowledge and awareness of its qualities, and suitability to meet the needs of broad cross-section of the community. In Victoria, more than half the beaches are accessible by sealed road and less than 10 per cent are patrolled by life savers.

Heritage tourism

In Victoria, heritage tourism generally focuses on the built environment, and aims to provide tourists with experiences based on stories about historic sites, places or people.[6] Heritage tourism can be considered as part of the broader category of cultural tourism, which includes the performing arts, festivals, museums and art galleries, as well as historic sites. Indigenous tourism is a specific form of tourism that combines aspects of ecotourism and heritage tourism and is best discussed as a discrete part of the tourism sector. Maritime heritage sites along the coast, such as lighthouses and shipwrecks, can be an attraction or used to characterise a tourist destination.

10.1.2 Future marine tourism

The Victorian Visitor Economy Strategy (prepared in 2016) sets out the government's plan for increasing the number of tourists visiting Victoria and the amount they spend on tourism and other travel-related activities. Of the nine priorities in the strategy the three most relevant to the marine environment are: building on the potential of regional and rural Victoria, investing in better tourism infrastructure, and improving access for visitors through an integrated transport network. Regional tourism boards are in place to assist in delivery of the strategy and to support region-specific objectives including destination management plans.[16]

The strategy recognises that there are further opportunities to develop distinct regional products in areas such as Indigenous tourism, nature-based tourism and adventure tourism. There are also links with investment in recreational fishing and the development of community-owned Indigenous tourism businesses that leverage local land and cultural assets. Also relevant is investment in improved access to marine and coastal natural assets, which in turn enable private investment in new tourist products and services.[16]

Tourism destinations

For Phillip Island and the Bass Coast, projections are for visitor numbers to increase by about four per cent annually, reaching some four million visitors per year by 2035. Similar projections of growth are expected on the Mornington Peninsula. However, to ensure that facilities and local businesses can cope with this growth, local councils have identified the need to put in place strategies to increase visitation rates outside of peak periods.

One project being considered to improve the tourist experience and strengthen coastal destinations during the off-peak period is a car ferry between Stony Point and Cowes. When combined with the existing Queenscliff to Sorrento ferry service it would create a tourist driving route linking the Great Ocean Road, Bellarine Peninsula, Mornington Peninsula, Phillip Island and the Bass Coast.[17]

The Shipwreck Coast Master Plan has been developed for a 28-kilometre stretch along Victoria's south-west coast, from Princetown to the Bay of Islands, incorporating the Twelve Apostles, Port Campbell and the Blowhole.[18] Commitments have been made for a range of tourism experiences including a world-class lookout at the Twelve Apostles, a lookout over the Blowhole, pedestrian bridge over Campbell's Creek in Port Campbell and enhanced telecommunications to support digital interpretation.

Marine ecotourism

The number of licences Parks Victoria has issued for tour operators across the state has been increasing at about 7 per cent annually for the past ten years. Most licences are for land-based activities such as bush walking, bus tours and bird watching.

The Victorian Visitor Economy Strategy supports further development of nature-based tourism, with emphasis on developing regional destinations. However, the strategy makes no direct reference to marine-based tourism or ecotourism.

There is no evidence to suggest that current growth rates in ecotourism will decline soon. Rather, it is more likely to outgrow more traditional tourism that is associated with higher rates of environmental degradation, which will increasingly be viewed negatively in the market place. For some destinations, ecotourism can provide a more sustainable alternative.[7]

Marine mammal tourism industry

It is expected that the popularity of marine mammal tourism will continue and that swimming with dolphins and seals will be key attractions for tourists. The Wildlife (Marine Mammals) Regulations 2009, which set out requirements that must be followed by permit holders for whale, seal and dolphin watching and swim tours, are being revised. The new regulations are likely to largely retain the current rules for permit holders, but will be updated to enable the adoption of more modern data collection and reporting methods. Collected information will support more effective monitoring of visitor numbers, and potential impacts on, marine mammals and future management of the industry. The new regulations are also likely to provide increased flexibility to respond to dynamic populations of marine mammals and the ways they use areas of land and water.

Burrunan dolphins in Port Phillip Bay. Photo: Marine Mammal Foundation

Commercial tour boat industry

The outlook for the Australian marine sightseeing tours industry is positive with revenue expected to rise by three to four per cent annually. This assumes continued access to the international tourist market, stable fuel prices and the ability to accommodate environmental requirements.[19]

Fishing charters

The fishing charter industry is likely to continue to grow in line with population growth and in response to initiatives that encourage recreational fishing. However, there is currently no agency overseeing the industry and therefore no indications of projected growth or changes that may occur. Statistics on marine vessel certification, as compiled by the Australian Maritime Safety Authority, do not provide an indication of the size or spatial extent of the fishing charter industry.

Cruise ships

The Australian cruise ship industry is increasing at about 15 per cent annually.[14] In 2017-18 there were 109 ship visits to Melbourne with more than 330,000 passengers and crew. This is a significant increase in comparison to ten years ago when there were 44 ship visits and 108,000 passengers and crew.[20]

It is expected that regional port authorities and local councils will continue to encourage and promote cruise ship visits. The Mornington Peninsula Marine Precincts Strategy highlighted the need for upgrading some jetties to allow easier and safer alighting of cruise ship passengers.[21]

Beach-based tourism

Overall data on beach visitor numbers and potential growth in beach-based tourism are limited. It is expected that beach-based tourism will continue to increase. Where overcrowding and poor conditions are reducing visitor experience and satisfaction levels, tourists are likely to look for other beaches that meet their needs. This may result in spillover to nearby beaches or regions.

Tourism visitor numbers and overnight stays indicate continued growth in visitor numbers to coastal regions. Similarly, Life Saving Victoria annual beach use numbers for patrolled beaches indicate steady growth in numbers using patrolled beaches. However, the community attitudes and behavioural research conducted in 2018 showed that in comparison to similar research undertaken in 2011, visitation rates to beaches have declined.

In 2011, 84 per cent of respondents reported making a day trip to the coast in the last 12 months. This figure was 77 per cent in 2018. However, these differences may be attributed to the 2018 survey being conducted in September following the winter period when visitation rates are normally lower, whereas the 2011 survey was conducted in April.

Heritage tourism

Among shipwreck divers, there has been a shift away from treasure hunting to tourism. The mantra 'take only photos, leave only bubbles' is now widespread among wreck divers. Legislative protection and an increased public awareness of the cultural and educational value of maritime archaeology has led to this shift in perception.

Citizen science, the participatory experience of recording and monitoring, has been part of maritime archaeology since the 1970s and is a growing area.

As divers are the main users of underwater maritime heritage, wrecks in protected zones that are safe to dive are occasionally opened to experienced divers under permit (e.g. *City of Launceston*). Technological advancement in both deep diving and remote sensing is increasingly offering insight into unexplored wrecks (see section 8.2.2).

10.1.3 Threats to marine tourism

Tourist destinations

The success of a tourist destination, measured in visitor numbers and contribution to economic activity, is dependent on both the comparative advantage and competitive advantage of a place. Comparative advantage relates to the inherited resources such as good weather, expansive sandy beaches and abundant wildlife, whereas competitive advantage relates to created items such as tourism products and services, transport networks, accommodation and retail services that can satisfy the needs of tourists. Tourist destinations that can maintain both a comparative and competitive advantage will be more successful in attracting visitors and sustaining economic activity.[22]

Tourist destinations are on a continuum of development; from early days, when a place is relatively unknown and there is a strong reliance on inherited resources, through to a maturity, where a place's competitive advantage is at risk of decline. This decline is reflected in reductions in visitor numbers, tourism business profitability and local economic activity. Another indication of a tourist destination's point of decline is where residents lose interest in tourism and oppose further investment in maintaining or developing new infrastructure that might attract and sustain new tourists.[23]

Researchers worked with focus group participants in the Coffs Harbour region of New South Wales to better understand what was needed to maintain a coastal tourist destination.[23] They found that the three key elements were:

- tourism infrastructure maintained and updated to sustain the destination's appeal
- tourism industry and government agencies cooperating as a driving force to sustain the destination
- local community having a shared vision for the future of tourism in the area.

Marine ecotourism

Impacts associated with climate change are likely to affect individual ecotourism activities, for example increased frequency of storms leading to cancellations. However, the effect on the broader ecotourism industry will be minor in comparison to more traditional tourism operations that rely on coastal infrastructure that is not easily adapted for climate change impacts. Ecotourism operators generally work with and within the constraints of the natural environment and can more readily adapt their product to changing conditions.

Since increased visitation will result in incremental environmental damage, simply to minimise impacts is not considered to be sufficient. If the industry is to be sustainable, there can be no net environmental deterioration. Active management, which requires resources, is needed. Ecotourism, and nature-based tourism more generally, has a responsibility to contribute to the management of the natural resources on which it is dependent.[24]

Where and when environmental impacts from increased visitation occur, typical management responses may involve limiting the number of visitors, operators, periods for visiting, and tightening of environmental controls. The industry is concerned to address the risk that the environmental impact is wrongly attributed to the tourism activities, when other pressures such as catchment runoff may be contributing factors.[12]

Marine mammal tourism industry

Managing the impacts of human interactions with marine mammals is crucial to maintaining a sustainable marine mammal tourism industry, as well as producer profit, consumer benefits and the non-use benefits.[10] There is a significant level of interaction between tour and recreational vessels and marine mammals, especially in confined waters such as Port Phillip Bay, which if not adequately managed have long-term population consequences. Regulations must be enforced to manage both tourism and non-tourism related human interactions with marine mammals.

Commercial tour boat industry

As with most tourism businesses, the key threat to the commercial tour boat industry is loss of income associated with reductions in passenger numbers and reduced profitability through increased operating costs. Reductions in passenger numbers can be caused by a range of factors including seasonal variations and bad weather, increased competition, poor marketing, changes in perceived value, reduced transport connectivity and access to markets. There are also many regulations and fees that have been put in place to ensure safety and

Australian fur seals in Port Phillip Bay. Photo: Marine Mammal Foundation

environmental management controls are appropriate. Alterations to these can affect the business and the services they provide to tourists.

Fishing charters

Threats to fishing charters include reduced access to locations, changes in abundance of target species, increased, operational costs, regulatory burden and reduced demand for services.

Cruise ships

Public perception of an industry can prevent its successful expansion. Consultation for the proposed Station Pier redevelopment project identified that residents were concerned about the associated road traffic congestion and parking when ships were in port. Water pollution from the ships was also raised. In general, there were strong positive feelings towards the pier as a working port, and most people liked seeing the ships coming and going and saw the pier as a significant attraction for the area.[25]

Cruise ships require piers and other visitor facilities and tourism opportunities for passengers to be maintained to a high standard. If not, the cruise shipping companies may remove regional ports from their cruise schedules.[14]

Beach-based tourism

Issues that affect the use and level of satisfaction with beaches are perceived threats associated with pollution, water quality, beach erosion and loss of space, overcrowding and anti-social behaviour.

The build-up of seaweed, litter and marine debris can reduce the appeal of a beach, reduce visitation rates and lead to economic losses for local businesses dependent on tourists. A study that applied a travel cost model showed that visitors to beaches in Southern California, USA would be willing to incur $12.91 ($US) in additional costs per trip if each of the beaches had 25 per cent less litter.[26] This translated into a total willingness to pay of $30 million ($US) for action to reduce litter and marine debris by 25 per cent on Californian beaches.

Bayside councils, such as Frankston and Port Phillip, recognise that beaches are a major tourist attraction and that to maintain their value beaches need to be clean: that is have clear water, sandy beaches and be free of litter. Councils use mechanical beach cleaning and manual pick up methods on a regular basis and following storms to keep beaches clean.[27] Resident satisfaction with beach cleaning in the City of Port Phillip has ranged from 92 to 96 per cent over the past five years.[28]

Coastal erosion and higher tides are reducing beach space, which can lead to overcrowding and diminish the overall appeal of affected beaches. For example, at Portsea front beach, a previously popular part of the beach has been washed away, leaving no space for laying out a towel and sitting and relaxing. Beach renourishment, as discussed in section 9.4.4, can be used to increase the width of a beach to improve its recreational value and attractiveness for tourists.

Preference surveys of beach users can be used to identify the acceptable limit beyond which the satisfaction level with a beach is unacceptable due to overcrowding. Survey results for a popular beach in one of Taiwan's national parks found that visitors enjoy beach space of at least 22 square metres (this equates to having a three to four metre separation from other beach users).[29] Working back from this number and the total area of beach, managers were able to calculate the acceptable carrying capacity of the beach. Equivalent data for Victorian beaches have not been identified, but are likely to vary depending on the beach, with people using Melbourne's inner city beaches likely to be more tolerant of overcrowding.

A 2014 survey of New South Wales residents found that over half of the respondents (58 per cent) considered anti-social behaviour as a key threat to the social benefits of beaches.[30] Others suggest that many beach activities are generally accepted and uncontentious as long as they are conducted within complex, unwritten models of appropriate behaviour.[31] However, these unwritten rules of behaviour in public places are evolving and may be confounding to people not exposed to them from an early age. Knowledge of these rules is also likely to vary across different cultural and ethnic groups.

Heritage tourism

Any process that leads to the loss of heritage values, such as physical, chemical or biological damage (see section 8.2.3) can lead to a reduction in heritage tourism.

10.2 Marine recreation

Recreation is defined as the activities people pursue within their leisure time, separate to activities that are necessary for their survival, such as paid employment. The marine and coastal environment provides diverse settings and opportunities for people to pursue recreational activities. Recreation, whether it be on-water, in-water or beside water, is an important social value as it contributes to physical and mental wellbeing.

Recreational activities are often categorised as 'passive' or low-intensity recreation, and 'active' or high-intensity recreation. This division is somewhat arbitrary, and the categories overlap. The division can reflect the potential for impact of the activity on natural environments or the degree to which special facilities need to be provided (e.g. sailing), rather than the level of physical activity involved. In this assessment 'sport', which is defined as a structured and competitive activity, is incorporated in the discussion of recreation.

Research commissioned by DELWP identified that coastal areas are an important part of the lives of most Victorians.[31] Of those surveyed, 77 per cent had made at least one day trip to the coast in the past year, with the average number of day trips being 16. Of those who visited the coast, the most commonly reported activities were walking/hiking, swimming, nature appreciation, sunbathing/relaxing on the beach and fishing. Nineteen per cent of the respondents said they just enjoyed being on the coast.

10.2.1 Current marine recreation

Nature-based outdoor activities

Nature-based outdoor activity is defined as people's activities and experiences in natural or semi-natural environments, whatever the motivation. The natural environment is central to the nature-based outdoor activity, not incidental to it. Nature-based tourism is tourism based on the natural attractions of an area.

Examples include birdwatching, photography, kayaking, hiking, hunting, fishing, and visiting parks.

In Victoria, around $7.4 billion is spent each year on nature-based outdoor activities, with much of this directed to regional towns. There is also added benefit in avoided healthcare system cost of at least $265 million a year, and $455 million in other recreation benefits.[32] However, it is difficult to split out how much of this is associated with marine-related activities.

Recreational boating

Recreational boating is a popular activity in Victoria. There are more than 400,000 people licensed to operate marine vessels. There are more than 200,000 registered boats, mostly less than eight metres in length, and more than 20,000 of these are personal watercraft, which includes jet skis. It is estimated there are a further 350,000 paddle craft such as kayaks, canoes and paddle boards.[33]

Recreational boating infrastructure includes a range of on-water storage and launch and retrieval facilities, including berths, moorings, jetties and boat ramps. The three former regional coastal boards established hierarchies of boating facilities and associated levels of service, which then informed investment decisions. Sustainable boating activity relies on safe navigation and a dredging regime that minimises environmental disturbance. Maintenance dredging around local ports and boat ramps is the responsibility of local port managers such as Parks Victoria and Gippsland Ports.

Research undertaken for Transport Safety Victoria indicated that the most common purpose of boating was to go fishing (64 per cent), followed by 'water skiing/wakeboarding/knee boarding etc.' (18 per cent) or 'touring/cruising' (17 per cent). Half cabin and open boat operators were both more likely to say their main purpose was fishing (86 per cent and 68 per cent respectively), while cabin cruiser (50 per cent), personal watercraft (47 per cent), trailer sailor (66 per cent) and yacht (keelboat) (61 per cent) operators were all more likely to say their main purpose was cruising.[34] The main reasons given for using jet skis was, 'thrill seeking and speed', while a similar proportion said it was a 'family craft', and a third said they had changed from a boat to a jet ski. Research participants revealed both family and emotional reasons for boating, including quality family time, building life skills for their children, relaxation and adventure.

For the majority, the most common waterway for boating was bays/inlets (53 per cent), followed by those who used inland waters (42 per cent) with open coast waters used by 5 per cent. For those who answered bays/inlets, trips commenced most commonly on Port Phillip Bay (57 per cent), followed by Gippsland Lakes (12 per cent) and then Western Port (11 per cent). For those whose boat was stored on land, the main reason given as to why they launched at the water body they mentioned was that it was closest to where they live (37 per cent); while almost one-third said, 'it provides best access to where I want to use my boat'.

In the qualitative research, there was a strong view that Port Phillip Bay was an underutilised resource that lacks many of the facilities that make other Australian locations great places to boat. This includes adequate launching and mooring facilities, and marinas to provide a pleasant destination for cruises. Those who boated elsewhere (particularly in Gippsland or on Lake Eildon) were typically more satisfied with the facilities available. Many boaters who predominately use Port Phillip Bay felt that the government was not providing enough infrastructure in return for their licence and registration fees.[34]

Sailing

Australia is known throughout the world as a country with a long history of prowess and participation in sailing. It is a sport in which Australia excels at all levels and formats.[35] Victoria has the highest rate of participation in club racing and regattas (figure 10.1).

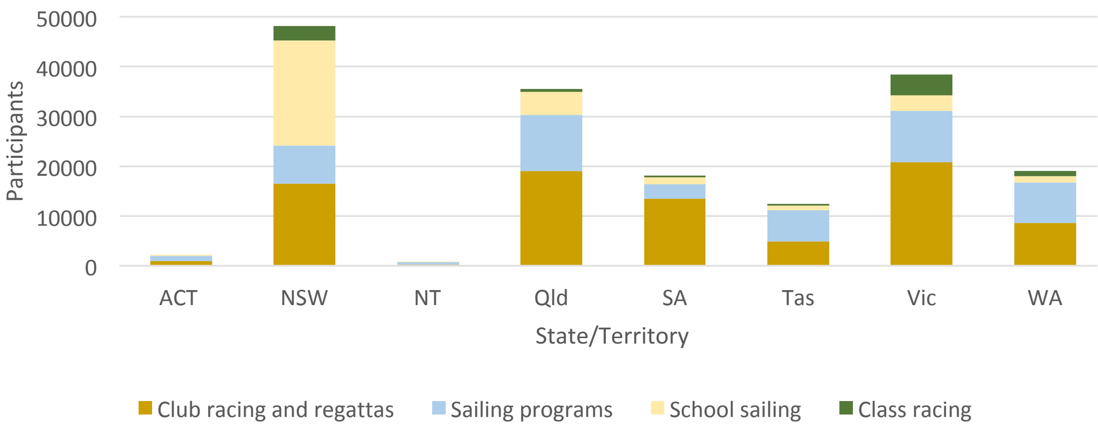
Australian Sailing is the governing body for the sport and is responsible for the administration, promotion and development of sailing. As a member-based organisation, they represent the interests and provide services and support to more than 360 clubs across Australia as well as more than 160 accredited Discover Sailing Centres.

There are 87 clubs in Victoria, with a combined membership of more than 30,000. Sailing participation rates are significantly higher than club memberships through learn-to-sail programs and casual sailing by non-members (figure 10.1).

Much of the sailing in Victoria occurs within Port Phillip Bay and Western Port and is mainly for off-the-beach yachts. However, there are significant numbers of keelboats, which are more likely to venture out along the open coast. These larger yachts are more dependent on facilities provided by yacht clubs such as access to boat ramps for launching, wet berths and moorings for storage, and slipway facilities and hardstand for maintenance.

Boats moored at St Kilda, Port Phillip Bay, February 2017. Photo: R Molloy

Figure 10.1 Participants in competition and sailing programs in 2017. Source: Australian Sailing 2017[35]



For most clubs the off-the-beach sailing season starts in October and finishes in April, with races occurring on weekends. Courses for sailing are set out in the waters offshore from the clubhouse. The layout for courses varies depending on the space available, wind direction and race requirements, and the class of yacht. Sailors will use the beach adjacent to the clubhouse for rigging their yachts, prior to entering the water for off-shore sailing.

The larger clubs such as Sandringham Yacht Club meet the needs of both keelboats and off-the-beach sailors through world class facilities and racing in formats to suit all levels of competition. Their sailing calendar, which runs all-year round, includes racing of regular laid and fixed mark courses, long distance races and more social twilight races during summer.

Clubs have a significant role in promoting marine safety. They operate their own patrol boats that primarily assist club members during races but will also come to the rescue of other vessels in trouble. Clubs work with local community groups through:

- opening their facilities for use by local groups
- running school sailing programs
- offering scholarships for children from disadvantaged families and schools
- running sailability programs for disability groups, schools and individuals.

Yachts used in the 'Tackers' introductory sailing program at Blairgowrie Yacht Squadron. Photo: R Molloy

Surf lifesaving carnival at Lorne, December 2018

Many clubs take turns in hosting specialist events such as state, national and international championships for individual classes. They also host special regattas and races over greater distances or around prominent land marks. This includes events such as:

- 'Around French Island Race' hosted by Warneet Motor Yacht Club
- 'Pelican Race Geelong' hosted by Geelong Trailable Yacht Club
- 'Around Sunday Island Race' hosted by Port Albert Yacht Club
- 'C.H. Robinson - Marlay Point Overnight Race' hosted by Gippsland Lakes Yacht Club.

The various championships and special events and regattas that clubs host provide significant economic value for the clubs and coastal towns where these events are held.

Swimming

Swimming and, specifically, swimming in seawater has long been recognised for its health benefits. These benefits are associated with the chemical composition of seawater, water temperate, buoyancy, physical exercise and restorative effects of contact with nature. Victorian beaches provide a range of opportunities for swimmers of all standards and preferences.

There are more than 40 organised ocean swimming events, mainly held over the summer period (see events list at http://oceanfit.com.au). They include events such as the Lorne Pier to Pub, Portsea Swim Classic, San Remo Channel Challenge and the Spirited Away Winter Solstice Swim at St Kilda held in June. Race distances range from 200 metres to 10 kilometres, catering for a range of ages and capabilities. There are also about 20 organised triathlon events that include ocean swims.

Life Saving Victoria has an important role in supporting swimming in Victoria. Its vision is that all Victorians will enjoy our aquatic environment after learning water safety, swimming and resuscitation. In 2017-18 they reported that volunteer lifesavers and lifeguards performed 659 rescues, attended 1806 first aid incidents and conducted 118,667 preventative actions to help keep more than 2.9 million visitors to Victorian beaches safe. All those numbers were an increase on the previous season and highlight the contribution to safety and wellbeing provided by the 57 lifesaving clubs and their 34,111 volunteers.[36]

Surfing

Victoria offers a range of surf breaks catering to all standards of surfers and all levels of risk. Those beaches that are easily accessed and within two hours of Melbourne are the most popular. They include Torquay, Bells Beach, Fairhaven, Thirteenth Beach, Portsea, Gunnamatta, Smiths Beach, Cape Woolamai and Kilcunda. However, there are many more surfing locations along the coast, all dependent on having the right tide, swell and wind combination.

Surfing Victoria estimates that there are more than 500,000 recreational and professional surfers in Victoria, and that surfing makes a significant contribution to Victoria's economic, social and environmental wellbeing. Surfing Victoria is the organising body for surfing in Victoria and is committed to the provision of competitive and recreational surfing opportunities in a safe, healthy and clean environment. The World Championship Tour event held at Bells Beach in April attracts more than 35,000 spectators.

Economic analysis undertaken for the Surf Coast Shire indicated that the surf industry is a key contributor to the local economy, supporting around one quarter of the shire's industry value ($217 million) and local jobs (2034 fulltime equivalent jobs).[37] To maintain this economic value, it is considered critical for the shire to maintain its surf culture, history and key surf assets such as Bells Beach to ensure the long term sustainability of the local surf industry.

In 2013, Phillip Island was recognised as Australia's eighteenth national surfing reserve, the first in Victoria. The reserve includes surf breaks at Cape Woolamai, Smiths Beach Summerland and Cat Bay. The island has a long and rich surf culture and history that dates to the late 1950s and early 1960s. National surfing reserves recognise iconic sites of cultural and historical significance in Australian surfing. They acknowledge the surfing way of life and link past, present and future generations with our oceans, waves and coastline.[38] Having reserve status does not provide legislative protection for a site, but it does provide broader community recognition that would be considered in planning decisions.

Scuba diving and snorkelling

The Victorian coastline (including bays and inlets) has many dive sites and opportunities for snorkelling. In the Melbourne area, popular dive sites are at the southern end of Port Phillip Bay or just outside the heads and near the entrance to Western Port. Dive sites include Popes Eye (a ring of rocks that was originally built on the seabed as a fort at Port Phillip Heads) and Seal Rocks (off the western tip of Phillip Island). Port Phillip Heads is home to some of the most spectacular wall dives in Australia starting at a depth of about 12 metres and extending beyond 90 metres.

There are many shore dives or snorkelling opportunities on nearshore rocky reefs and beneath the many piers and jetties, such as those at St Leonards, Mornington, Rosebud, Rye, Blairgowrie and Flinders. Several of the 24 marine national parks and sanctuaries along Victoria's coastline provide excellent diving and snorkelling opportunities for all skill levels. There are nearly 80 sites close to Melbourne for snorkelling.

One dive site recommended for novice snorkelers is the Octopuses' Garden at Rye Pier. This 200-metre long trail follows the pier, with underwater signs pointing out some of the more unusual inhabitants, such as a large variety of sponges, fishes including pipefish and seahorses, seastars, stingrays and octopuses.

Melbourne is also an excellent area for shipwreck diving, with more than 60 shipwrecks providing opportunities for divers. Many of these wrecks were scuttled in shallow water making them relatively easy to access.

Outside Melbourne, the Shipwreck Coast between Cape Otway and Port Fairy, and further west towards Portland, provides many shipwreck dive sites. However, many of the shipwrecks on the open coast are in deep waters and only suitable for experienced divers.

The ex-HMAS Canberra, a former warship which served the Australian Navy between 1981 and 2005, is the first artificial reef in Victoria created specifically for diving. The vessel was scuttled 1.4 kilometres off Barwon Heads in October 2009 and now lies in approximately 28 metres of water. The top of the mast is about 5 metres below the surface at low tide. The site, which is managed by Parks Victoria, provides opportunities for divers with varying levels of experience and certification, from open water level certificates to advanced wreck divers, to enjoy this site. The dive site is clearly marked by two special mark buoys and two mooring buoys. A diver shot line has also been installed to assist with location of the vessel and to improve safety.

Across Australia the recreational dive industry, which includes retail dive shops, charter vessels, equipment manufacturers and suppliers, training agencies and diving instructors, employs more than 10,000 people with an estimated total economic contribution of $4.2 billion.[39]

Bird watching

Bird watching has grown in importance in recent decades and is an important component of the broader category of nature-based tourism and recreation. Internationally, growth is reflected in the increase in specialist tourism companies, websites and guidebooks, mostly in Western nations.[40]

Data are available on bird watchers in the United States where, in 2011, surveys indicated that 20 per cent of the population were bird watchers with 38 per cent of this group taking trips away from home for the primary purpose of observing birds. The greatest number of bird watchers were 55 years or older; participation rates were particularly low for people aged 16-24. The higher the income and

Responsible dog ownership is regulated by local government. Photo: Amber Perry

education level the more likely a person was to be a bird watcher. Bird watchers were not a racially or ethnically diverse group, with 93 per cent identifying themselves as white.[41]

In Australia, data are not readily available, but there is indirect and anecdotal evidence of considerable growth in bird watching reflecting trends evident throughout the Western world. Many studies indicate that bird watchers are an affluent and well-educated group, compared to the general population.[42]

Bird watchers spend money on a variety of goods and services for trip-related (accommodation, transport, food, guide fees) and equipment-related (binoculars, cameras, camping equipment) purchases.

Bird watchers come from across the world to explore bird habitats in some of Victoria's coastal wetlands and marine environments. Bird watchers can explore mangroves and mudflats, such as those at Rhyll Inlet, to witness wading birds, spoonbills, oyster catchers and cormorants (Visit Melbourne website).

The Western Treatment Plant at Werribee is one of the most popular sites for bird watching in Victoria, with 284 species of birds recorded there from southeastern Australia and east Asia. The lagoons, grasslands and coastline of the area provide varied habitats for birds with a permanent water supply, plenty of food and little interference from humans.

Organised tours for bird watching are available, but bird watchers are mostly self guided.

Dog walking

Victoria has a significant dog population, with an estimated 40 per cent of households owning a dog.[43] A visit to most beaches will find people walking and exercising dogs.

The 'dogs on holidays' website (https://www.dogsonholidays.com.au/beaches/) provides a list of beaches along the Victorian coast where dogs are permitted on and off leash. Many of these have time restrictions and other conditions that owners must follow. Local councils are usually responsible for creating and enforcing laws governing dogs on beaches. For those beaches within national, state and coastal parks or marine protected areas, Parks Victoria is responsible for rules regarding dogs, within the framework of the National Parks Act and associated regulations. Dogs are generally not allowed in national parks other than in specified areas.

Hunting game ducks

Estuaries and coastal lakes along the Victorian coast provide suitable habitat for a range of species targeted by duck hunters. In State game reserves and some areas in coastal parks duck hunting is allowed during the duck hunting season (mid March to mid May in 2019) subject to regulatory conditions. For example, hunting for game duck is allowed on Sydenham Inlet in the Cape Conran Coastal Park and in sections of the Nooramunga Marine and Coastal Park. It is also allowed in some of the coastal state game reserves including Lake Connewarre on the Surf Coast, Jack Smith Lake and Lake Denison on the Ninety Mile Beach and Jones Bay in the Gippsland Lakes.

Citizen science and conservation activities

Many people are participating in citizen science projects, conservation activities and other voluntary activities that contribute to improving the health of the marine environment. Citizen science involves public participation and collaboration in scientific research with the aim of increasing scientific knowledge.[44]

Participating in these programs has secondary benefits associated with health and wellbeing, which are increasingly recognised in natural resource management programs. Melbourne Water's Healthy Waterways Strategy, which encompasses estuaries includes participation rates in citizen science programs and conservation activities as a performance indicator for progress towards social value targets.

The Victorian Biodiversity Atlas, managed by DELWP, allows volunteer naturalists to record their observations of marine plants and animals. DELWP manages the data in conjunction with key partners, including reviewing and verifying new records and error checking.

Parks Victoria runs several marine citizen science projects. These include Sea Search and Reef Life surveys. Marine citizen science projects have been implemented for intertidal reefs, seagrass and subtidal reefs in five marine sanctuaries and two marine national parks. In 2018, the Minister for Energy, Environment and Climate Change launched the new app for the Sea Search program developed in partnership with CSIRO.[45]

As part of the Reef Watch program run by the Victorian National Parks Association, underwater photographers are being asked to upload their photographs of common (or weedy) seadragons. The sighting information is being used to get a better understanding of the abundance and distribution of this important species in Port Phillip Bay and Western Port.

There are many more examples of citizen science projects and conservation activities that are providing opportunities for people to contribute to marine science and to raise awareness of marine values.

10.2.2 Future marine recreation

Nature-based outdoor activities

Employment in the outdoor adventure sector has shown very strong growth in the last ten years from 900 jobs in 2005 to 2600 jobs in 2015. Employment opportunities in the sector are predicted to continue growing to 2900 jobs in 2020.[46]

Within Victoria's parks, visitor numbers increased in 2017/18. Wilsons Promontory National Park received record numbers of visitors over summer and the Twelve Apostles showed an 8.5 per cent increase in visitation.[45] Visitor numbers increased from 98.5 million visits in 2014/15 to 106 million visits in 2016/17.[47,48] Visitor numbers are recorded biannually, so will be repeated in 2018/19. Based on past growth, visitor numbers are likely to continue increasing.

Recreational boating

In research undertaken for Transport Safety Victoria, the main area for improvement nominated by those who said they would be willing to pay more for their boat registration was 'improved boat launch facilities' (68 per cent), followed by 'better navigation aids and signage' (41 per cent) and a similar proportion for 'better boating safety education programs' (37 per cent).[34]

Sailing

Australian Sailing expect yacht club membership across Victoria's 87 sailing clubs to increase at an annual growth rate of more than five per cent. Clubs are also being encouraged to increase their involvement and role in supporting community activities and marine safety.

Swimming

The role of Life Saving Victoria in supporting safe swimming is likely to increase as Victoria's population and use of beaches continues to grow. There is likely to be greater uptake of technology in promoting safety and raising awareness of risks associated with water conditions.

Surfing

Surfing is expected to remain a popular activity and grow in line with population growth. Recognition of the need to protect both surf breaks and surf culture is likely to increase in prominence in both tourism and coastal development strategies.

At Bells Beach there is pressure from local groups to create a 'surf sanctuary' to protect the area from the demands of increased visitation rates, tourism, commercial development and housing; and to respect, protect and cultivate the environmental values, Indigenous heritage and recreational surfing experience of Bells Beach now and for future generations.

Striking a balance between commercial activities, conservation and cultural values will be important for maintaining the economic value of the surfing sector.[37]

Scuba diving and snorkelling

It is expected that interest in diving will continue to grow at the current rate. There is likely to be increased interest in the creation of artificial reefs for diving following the success of the sinking of the ex-HMAS Canberra. Artificial reefs can also promote and build recreational fish stocks.[49]

Bells Beach has been proposed as a 'surf sanctuary'. Photo: R Molloy

Volunteers are assisting researchers with dolphin identification projects. Photo: Marine Mammal Foundation

Bird watching

Bird watching is a growing pastime in line with population growth. The rise of citizen science has also seen more people involved in monitoring and collecting data on Australia's birds.[50]

Dog walking

In 2016, 38 per cent of Australian households owned at least one dog with an estimated total of 4.8 million dogs. This represented a 3 per cent increase in the number of dogs from 2013. With the number of dogs on the rise, and the increasing consideration of dogs as members of the family rather than companions, it is likely that dog walking will continue to grow as a popular activity.[43]

Given the increased popularity of dog ownership, there is likely to be more requests to local councils for access to beaches for exercising dogs. Bass Coast Shire is currently considering extending times and opening up more beaches for off-lead exercise. Councils are also likely to increase enforcement of dog ownership by-laws to offset the negative impacts of the increased use of beaches.

Citizen science and conservation activities

Since 2000, when multiple scientific publications using citizen science data were published, the number of publications using citizen science has increased. Between 2010 and 2015 there was a 224 per cent increase in publications from 124 to 402.[51] This indicates strong growth in participation in citizen science, facilitated by access to digital platforms for accessing and sharing data.

It is important for citizen-science projects to minimise the barriers to first-time participants and to design projects to meet the needs and interests of the audience. Opportunities for data collection are a promising way to bring newcomers to citizen science in the marine environment as research has shown that this is where the greatest interest lies. Allowing opportunities for co-design of projects, rather than recruiting volunteers after a project has been developed, is also more likely to engage potential volunteers.[52]

10.2.3 Threats to marine recreation

Nature-based outdoor activities

Nature-based outdoor recreation relies on healthy and functioning ecosystems. Threats to ecosystem function are therefore threats to nature-based outdoor recreation. Key threats to marine ecosystems include climate change (e.g. ocean acidification and sea level rise), physical processes (e.g. habitat loss and erosion), biological processes (e.g. pests and diseases), catchment processes (e.g. sediments and nutrients), pollutants (e.g. marine debris and microplastics) and community or industry demand (e.g. demand for recreational access). For more detail on these threats, see chapter 6.

Recreational boating

Many of the recreational boating facilities provide adequate capacity for average demand; however, during periods of high boating activity (i.e. over summer), facilities are put under strain and demand can exceed capacity. Capacity pressures can lead to 'unmet' demand or a reduced number of boaters using desired areas during peak periods as they may seek alternative options with fewer infrastructure/ facility capacity constraints. Overstretched facilities can lead to congestion or conflict, which can cause safety concerns for boaters. Carpark congestion can further exacerbate this frustration and reduce the number of boaters able to access popular areas.

Research undertaken for Transport Safety Victoria indicated that almost one-quarter (23 per cent) of respondents said they were not able to launch from their preferred location in the past 12 months on at least one occasion.[34] Of those who could not launch, almost half (46 per cent) said that they ended up giving up on boating that day, while around one-third (36 per cent) said they ended up launching from another location. The qualitative research highlighted that it is likely that the proportion of boaters having difficulty accessing launching may be even higher due to an unknown number who elect not to go boating on peak use days.

Discharge of water and sewage from boats is a concern, especially where boats are used as full or part-time residences. Boats without onboard storage and pumpout facilities for sewage, and those that choose not to use them, contribute to water pollution of enclosed waters through illegal discharges. There was some concern expressed during consultation for the new Marine and Coastal Act in 2016 that agencies are not enforcing discharge regulations. There is also a need to invest in more pumpout facilities to service the increased number of boats with onboard facilities. This includes areas in the southern part of Port Phillip Bay and in Western Port.

Sailing

Key threats to sailing include climate change impacts to land-based infrastructure that is at risk from coastal erosion and storm surge. Conflicts with other vessels and restrictions imposed by shipping can reduce the area available for sailing.

Swimming

As with other shore-based water activities, threats to swimming include water pollution, overcrowding and conflict with other water users, such as jet skis and speed boats. Water quality can be degraded by pathogens and litter that enters the sea from local drains. It can also be degraded by excess phytoplankton growth (algal blooms) and sediment that reduces water clarity. Conversely, popular swimming beaches can result in higher levels of disturbance to wildlife through noise and littering and trampling on intertidal reefs.

Surfing

The Surfrider Foundation Australia, founded in 1991, advocates for local surfers to highlight threats to surfing and the marine environment more broadly. Their 'endangered waves' program highlights key issues that impact on the surfing experience including:

- coastal structures and works such as breakwaters, seawalls, ports and dredging that cause changes to reefs, sand flows, beach shape, currents or swell
- accessibility or overcrowding, caused by too much or too little public access to the beach. This can result from private or public developments that might close waves to the public or make 'wilderness breaks' too accessible, in both cases damaging the surf experience
- polluted water quality from sewage or stormwater outfalls, poor development, industrial and agricultural runoff, or badly managed rivers and catchments
- visual amenity as seen from the shore and from the surf is undervalued in most planning decisions and is spoiled by ridgeline developments and beachfront invasions. Surfers equally value what they see from the sea as well as from the shore
- ecosystem threats, where the environmental integrity of the surfbreak is threatened, or areas adjacent to it, causing risk to aquatic or terrestrial life. For example, overuse by fisherman, surfers, divers, recreational vehicles or tourists may necessitate legal protection and safeguards
- climate change impacting surfbreaks and the shape of the coast itself, tempting governments to propose physical barriers and limit access. Rising sea levels and water temperatures will also change tides, currents, swells, banks and the weather that defines the ideal window for each surfbreak.[53]

Scuba diving and snorkelling

As with other in-water activities, threats to diving include water pollution, overcrowding and conflict with other water users. Diving requires clear water, which can be degraded by excess phytoplankton growth (algal blooms) and sediment that reduces water clarity.

Bird watching

Bird watching opportunities rely on healthy and functioning ecosystems to support bird populations. Threats to ecosystem function are therefore threats to bird watching. Key threats to marine ecosystems that support birds include climate change (e.g. sea level rise impacting beach nesting birds), physical processes (e.g.

weed encroachment impacting habitat quality), biological processes (e.g. overharvesting leading to food web collapse), catchment processes (e.g. nutrients impacting recruitment of favoured fish species), pollutants (e.g. light pollution impacting fledging of nocturnal species) and community or industry demand (e.g. dog walking impacting nesting hooded plovers). For more detail on these threats, see chapter 6.

Dog walking

Dog walking on public land is frequently a source of conflict, especially in urban areas where public open space is highly contested and the available land is used for multiple activities.[54,55] In some areas, dogs pose a conservation threat to Victoria's native fauna. For example, hooded plovers are particularly vulnerable to disturbance by dogs and will abandon their eggs or chicks if they are persistently disturbed. As a precaution, dogs have been excluded from the Mornington Peninsula National Park since November 2016. This action has resulted in an increased survival rate for hooded plover chicks, but reduced the opportunity for exercising dogs on Mornington Peninsula beaches.

Citizen science and conservation activities

Negative perceptions about the accuracy of citizen science data can hinder its wider acceptance and use. One of the negative assumptions includes the belief that citizen scientists will bring an agenda and bias to their observations.[56] However, a study using citizen scientists in the United States to monitor water quality during unconventional gas extraction found that citizen scientists were more cautious in reporting impacts than professional scientists.[57] With appropriate training and experience, volunteer-collected data can equal that of professional scientists in accuracy and precision.[58,59]

Another negative assumption about citizen science is that the data collected lack verification.[56] This is readily remedied by including data metrics into the analysis to identify outliers and to incorporate cross-comparisons of data collected by citizen and professional scientists.[58] Applying citizen science data sets in management processes such as adaption mitigation strategies has proven to bolster the credibility of citizen science.[58] For example, the US Environment Protection Agency relies on citizen scientists to conduct monitoring. Citizen science data are used to identify potential areas of concern that are then followed up on by agency staff.[60,61] Similar concepts are being used for the Drain Detectives Program, which is using the public to help monitor water quality at beaches in Port Phillip Bay.

A general threat to citizen science and conservation activities is the need to maintain interest in long-term data collection programs or conservation programs. Volunteers can lose interest unless steps are taken to reinforce the positive contributions they are making towards the overall goals of the project.

Nipper program, Inverloch. Photo: Y McMahon

10.3 References

1. Victorian Competition and Efficiency Commission (2011) *Unlocking Victorian tourism: an inquiry into Victoria's tourism industry, summary report*. https://www.dtf.vic.gov.au/sites/default/files/2018-02/unlocking-victorian-tourism-summary-report-pdf.pdf
2. Papageorgiou, M. (2016) Coastal and marine tourism: a challenge factor in marine spatial planning. *Ocean and Coastal Management* 129: 44–48.
3. Tourism Research Australia (2017) *Victorian regional tourism satellite accounts summary 2016-17*. https://www.business.vic.gov.au/__data/assets/pdf_file/0007/1679551/Victorian-regional-tourism-satellite-accounts-summary-2016-17.pdf
4. Tourism, Events and Visitor Economy Research Unit (TEVE) (2019) *Regional Victoria's top attractions: results for the year ending September 2018*. Factsheet. http://www.business.vic.gov.au/__data/assets/pdf_file/0004/1758793/Visitors-to-Regional-Victorias-Top-Attractions_year-ending-September-2018.pdf
5. Ecotourism Australia (2019) *What is eco certification?* https://www.ecotourism.org.au/our-certification-programs/eco-certification/
6. Environment and Natural Resources Committee (2014) *Inquiry into heritage tourism and ecotourism in Victoria. Report.* Parliament of Victoria, Environment and Natural Resources Committee. https://www.parliament.vic.gov.au/images/stories/Ecotourism/ENRC_-_Inquiry_into_Heritage_Tourism_and_Ecotourism_-_Final_Report.pdf
7. Jamrozy, U. and Lawonk, K. (2017) The multiple dimensions of consumption values in ecotourism. *International Journal of Culture, Tourism and Hospitality Research* 11(1): 18-34. https://doi.org/10.1108/IJCTHR-09-2015-0114
8. Moore, S.A., Rodger, K. and Taplin, R.H. (2013) Moving beyond visitor satisfaction to loyalty in nature-based tourism: a review and research agenda. *Current Issues in Tourism*, DOI: 10.1080/13683500.2013.790346.
9. Curtis, A. and Davidson, P. (2013) *A review of the concepts of enjoyment, appreciation and understanding as applied to Victoria's marine protected areas (MPA)*. Report to Victorian Environmental Assessment Council to inform the VEAC Marine Investigation. (Report ILWS, No. 71.) Institute for Land, Water and Society, Charles Sturt University, Albury.
10. Department of Sustainability and Environment (2009) *Wildlife (Marine Mammals) Regulations 2009 Regulatory Impact Statement.* Prepared for the Department of Sustainability and Environment by Tim Harding & Associates in association with Rivers Economic Consulting.
11. Woodley, A.E. (1973) *Western Port ferries past and present and Captain Clarke, their most notable skipper*. Hill of Content Publishing Company Pty Ltd, Melbourne.
12. Byrnes, T., Buckley, R., Howes, M. and Arthur, J.M. (2016) Environmental management of boating related impacts by commercial fishing, sailing and diving tour boat operators in Australia. *Journal of Cleaner Production* 111: 383–398.
13. Environment and Natural Resources Committee (2002) *Inquiry into the management of the fishing charter industry in Victoria. Report.* Parliament of Victoria, Environment and Natural Resources Committee. https://www.parliament.vic.gov.au/images/stories/Compiled_report.pdf
14. Cruise Lines International Association (CLIA) (2017) *Cruise tourism's contribution to the Australian economy 2016-17*. Prepared by Business Research & Economic Advisors for Cruise Lines International Association Australasia, with support of Australian Cruise Association. http://www.cruising.org.au
15. Short, A. (1996) *Beaches of the Victorian coast and Port Phillip Bay – a guide to their nature, characteristics, surf and safety.* Australian Beach Safety and Management Program, University of Sydney.
16. Department of Economic Development, Jobs, Transport and Resources (DEDJTR) (2016) *Victorian Visitor Economy Strategy.* https://economicdevelopment.vic.gov.au/__data/assets/pdf_file/0006/1340979/Visitor_Economy_Strategy.pdf
17. AECOM Australia Pty Ltd (2018) *Cowes to Stony Point car ferry – full business case.* Prepared for Bass Coast Shire Council and Mornington Peninsula Shire Council.
18. McGregor Coxall (2016) *Shipwreck coast master plan – master plan report.* Prepared for Parks Victoria. https://www.shipwreckcoast.vic.gov.au/__data/assets/pdf_file/0016/327013/Shipwreck-Coast-Master-Plan-Part-1.pdf
19. IBISWorld (2018). *Marine sightseeing tours - Australia market research report.* https://www.ibisworld.com.au/industry-trends/specialised-market-research-reports/consumer-goods-services/marine-sightseeing-tours.html
20. Victorian Ports Melbourne (2019) *Cruise shipping statistics.* Accessed 18/2/2019 http://www.vicports.vic.gov.au/cruise-shipping/Pages/cruise-shipping-statistics.aspx
21. AECOM Australia Pty Ltd (2015) *Mornington Peninsula marine precincts strategy.* Prepared for Mornington Peninsula Shire Council. https://www.mornpen.vic.gov.au/files/assets/public/new-website-documents/about-us/strategies-amp-plans/docs/marine_precinct_strategy_-_final_-_adopted_by_council_23_march_2015.pdf
22. Dwyer, L. and Kim, C. (2003) Destination competitiveness: determinants and indicators. *Current Issues in Tourism*, 6(5): 369–414.
23. Wilde, S.J. and Cox, C. (2008) Linking destination competitiveness and destination development: findings from a mature Australian tourism destination. *Proceedings of the Travel and Tourism Research Association* (TTRA): 467-478. European Chapter Conference - Competition in tourism: business and destination perspectives, Helsinki. TTRA.

24. Preece, N., van Oosterzee, P. and James, D. (1995) *Biodiversity conservation and ecotourism: an investigation of linkages, mutual benefits and future opportunities.* Biodiversity Series, Paper No. 5 prepared by Ecoz-Ecology Australia and Ecoservices Pty Ltd for Department of the Environment, Sport and Territories. http://www.environment.gov.au/archive/biodiversity/publications/series/paper5/twoexe.html
25. Newgate Engage (2018) Station Pier redevelopment engagement report. Prepared for Victorian Ports Corporation (Melbourne). http://www.vicports.vic.gov.au/cruise-shipping/Documents/community-consult-report-%20181030.pdf
26. Leggett, C.G., Scherer, N., Haab, T.C., Bailey, R., Landrum, J.P. and Domanski, A. (2018) Assessing the economic benefits of reductions in marine debris at Southern California beaches: a random utility travel cost model. *Marine Resource Economics* 33 (2): 133–153.
27. Frankston City Council (2016) *Frankston City Council Coastal Management.*
28. City of Port Phillip (2019) Community satisfaction survey. http://www.portphillip.vic.gov.au/community-satisfaction.htm
29. Chen, C.L. and Teng, N. (2016) Management priorities and carrying capacity at a high-use beach from tourists' perspectives: a way towards sustainable beach tourism. *Marine Policy* 74: 213–219.
30. Marine Estate Management Authority New South Wales (MEMA) (2014) *Marine estate community survey final report,* July 2014. Sweeney Research.
31. Ipsos (2019) *Wave 5 – Marine and coastal community attitudes and behaviours research 2018, draft report.* Prepared for the Department of Environment, Land, Water and Planning by Ipsos-Eureka Social Research Institute, Melbourne.
32. Marsden Jacob Associates (2016) *Victoria's nature-based outdoor economy - key estimates and recommendations.* Prepared for Outdoors Victoria & Sport and Recreation Victoria https://outdoorsvictoria.org.au/wp-content/uploads/2016/03/Outdoor-Economics.pdf
33. Marine Safety Victoria (2017) *Marine safety incident statistics,* Maritime Safety Victoria 2016-17 Annual Report. https://transportsafety.vic.gov.au/maritime-safety/regulation-and-investigation/maritime-incident-statistics
34. Transport Safety Victoria (2015) *Boating behaviour 2014.* Prepared by Ipsos for Transport Safety Victoria https://transportsafety.vic.gov.au/__data/assets/pdf_file/0016/33820/Victorian-Boating-Behaviour-Report-2015.pdf
35. Australian Sailing (2017) *National sailing participation census 2017.* Prepared by Street Ryan and Associates Pty Ltd for Australian Sailing.
36. Life Saving Victoria (2018) *Life Saving Victoria annual report 2017/2018*. https://lsv.com.au/about/publications/
37. AEC Group (2014) *Economic value of the surf industry to Surf Coast Shire. Final Report.* Prepared for Surf Coast Shire Council.
38. National Surfing Reserves (2019) *National surfing reserves – about us.* https://www.surfingreserves.org/what-is-nsr.php
39. Dive Industry Association of Australia (2017) *Dive Industry Association of Australia submission on marine parks,* November 2017. Accessed February 2019 http://www.diveindustry.com.au/marine-parks/
40. Connell, J. (2009) Birdwatching, twitching and tourism: towards an Australian perspective. *Australian Geographer* 40: 203-217.
41. Carver, E. (2011). *Birding in the United States: a demographic and economic analysis. Addendum to the 2011 National survey of fishing, hunting, and wildlife-associated recreation.* Report 2011-1. U.S. Fish & Wildlife Service, Arlington. https://digitalmedia.fws.gov/digital/collection/document/id/1874
42. Jones, D.N. and Buckley, R. (2001) *Birdwatching tourism in Australia*. Wildlife Tourism Research Report Series: No. 10. CRC for Sustainable Tourism.
43. Animal Medicines Australia (2016) *Pet ownership in Australia 2016*. Report by Newgate Research for Animal Medicines Australia.
44. Australian Citizen Science Association (ACSA) (2018) *Ten principles of citizen science.* Australian Citizen Association, Sydney. https://citizenscience.org.au/
45. Parks Victoria (2018) *Annual report 2017-18*. Parks Victoria, Melbourne. https://parkweb.vic.gov.au/about-us/publications-list/annual-reports
46. SkillsIQ (2017) *Sports and recreation IRC industry skills forecast April 2017.* Report prepared for Sport and Recreation Industry Reference Committee. https://www.skillsiq.com.au/site/DefaultSite/filesystem/documents/Industry-Skills-Forecasts-June2017/Sport%20and%20Recreation%20IRC%20Industry%20Skills%20Forecast_April2017%20Refresh.pdf
47. Parks Victoria (2015) *Annual report 2014-15.* Parks Victoria, Melbourne. https://parkweb.vic.gov.au/about-us/publications-list/annual-reports
48. Parks Victoria (2017) *Annual report 2016-17.* Parks Victoria, Melbourne. https://parkweb.vic.gov.au/about-us/publications-list/annual-reports
49. Brickhill, M.J., Lee, S.Y. and Connolly, R.M. (2005) Fishes associated with artificial reefs: attributing changes to attraction or production using novel approaches. *Journal of Fish Biology* 67: 53-71.
50. Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P. and Franklin, K. (2017) *The Australian Bird Guide.* CSIRO Publishing, Melbourne.

51. Kullenberg, C. and Kasperowski, D. (2016) What is citizen science? A scientometric meta-analysis. *PLOS One* 11, e0147152.

52. Martin, V.Y., Christidis, L. and Pecl, G.T. (2016) Public interest in marine citizen science: Is there potential for growth? *BioScience* 66: 683-692.

53. Surfrider Foundation Australia (undated). Endangered waves criteria. http://www.surfrider.org.au/endangeredwaves

54. Weston, M.A., Fitzsimons, J.A., Wescott, G., Miller, K.K., Ekanayake, K.B. and Schneider, T. (2014) Bark in the park: a review of domestic dogs in parks. *Environmental Management* 54: 373–382.

55. Victorian Environmental Assessment Council (VEAC) (2016) *Statewide assessment of public land discussion paper*. East Melbourne. http://www.veac.vic.gov.au/documents/SAPL%20Discussion%20Paper_online_o.pdf

56. Norman, L.C. (2018) No butterfly catchers here! Citizen science involvement in environmental impact assessment compliance monitoring. *Environmental and Planning Law Journal* 35: 571-587.

57. Wilderman, C. and Monismith, J. (2016) Monitoring Marcellus: A case study of a collaborative volunteer monitoring project to document the impact of unconventional shale gas extraction on small streams. *Citizen Science: Theory and Practice* 1: 1-17.

58. Freitag, A., Meyer, R. and Whitman, L. (2016) Strategies employed by citizen science programs to increase the credibility of their data. *Citizen Science: Theory and Practice* 2: 1-11.

59. Cabuang, Y. and Gooderham, J. (2018) *The waterbug bug: how to attract and retain citizen scientists.* Presentation at Australian Citizen Science Conference, Adelaide.

60. Markell, D. and Glicksman, R. (2016) Dynamic governance in theory and application, Part 1. *Arizona Law Review* 58: 563-631.

61. Brett, A.E. (2017) Putting the public on trial: can citizen science data be used in litigation and regulation? *Villanova Environmental Law Journal* 28: 163-206.

11 Fisheries

This chapter provides an outline of the four marine fisheries sectors in Victoria: commercial wild catch, aquaculture, recreational and Aboriginal (the latter overlapping with the other three sectors). The available information on the specific values, threats and emerging uses varies substantially across these sectors. While there is perceived competition between sectors, there can also be substantial interconnected and mutually beneficial relationships. For example, commercial fishers catch bait used by recreational fishers.

KEY POINTS AT A GLANCE

- The commercial wild catch sector targets a diversity of species (finfish, molluscs, echinoderms, crustaceans and sharks) across various environments (bays, inlets and open ocean).
- Almost 5000 live weight tonnes of seafood were commercially harvested in Victorian waters in 2016-17; this represents approximately half of the commercial wild catch in 1986-87.
- Domestic seafood production (both wild caught and aquaculture) accounted for 27 per cent of ready-to-eat seafood consumed in Australia in 2016-17.
- Assessing fish stocks and the impacts of harvesting is difficult and more data are needed for some target species and most non-target species.
- Aquaculture is currently limited to a few mollusc species (abalone and mussels) but is growing in value. Aquaculture production is well-documented through returns by licensees. In 2016-17, almost 1600 tonnes of marine organisms were cultured.
- Recreational fishing is a large and dispersed sector. Around 10 per cent of Victorians fish recreationally in marine and estuarine waters, particularly Port Philip Bay, Western Port, Corner Inlet and the Gippsland Lakes.
- Current government policy aims to increase recreational fishing participation. Monitoring of recreational fishers (e.g. number of fishers, total catch) is logistically challenging and expensive, so there are large knowledge gaps for this sector.
- The Victorian Aboriginal Fishing Strategy aims to incorporate the rights, interests, aspirations and culture of Aboriginal people into fisheries management. Customary use and access rights are available to only some Traditional Owners under native title or settlement agreements. Harvests of pipis and short-finned eels have received most attention, but there is little information about most aspects of this sector.
- For a species or population to support fishing, it needs to be part of a healthy and functioning ecosystem. Habitat loss affects key life stages, such as larval recruitment, especially for species dependent on limited habitats such as seagrass beds. Other threats to fisheries include poor water quality, invasive species and diseases.
- Certain traits render species more vulnerable to overexploitation: these include being long-lived, slow to mature, producing few young and having narrow habitat requirements. Several species have been overexploited in Victoria, most recently scallops in the 2000s.
- South-eastern Australia is a climate change hotspot with well-documented recent changes in the marine environment, including warming waters, changes in the continental currents and reduced freshwater flows into bays and estuaries. The potential impacts to fish stocks from these changes needs further investigation.
- Commonwealth and state fisheries legislation adopts a sustainable use approach. Fishing is prohibited or restricted in certain places across the Victorian coast, such as in marine national parks and sanctuaries.
- Competition between the commercial and recreational fishing sectors for limited resources has led to the exclusion of commercial fishing activities from many bays and inlets since the 2000s.

The broad categories of threats to fisheries are summarised and examples are provided for each threat in table 11.1; for more detail see the relevant section of this chapter. Discussion of threats in this chapter are threats to fisheries. The threats that fishing might pose to other values are discussed in other chapters.

Table 11.1 Summary of threats to fisheries in Victoria

Threat class	Pathway/outcome	Example (with section reference)
Climate change	Altered oceanography	The eastward-flowing Leeuwin Current has weakened. This impacts on species that rely on pelagic transport of larvae and adults (e.g. short-finned eel, western blue groper, King George whiting) (6.4.7, 11.2.3)
	Sea level rise	Mangroves provide nursery habitats for juvenile fish (e.g. yellow-eye mullet). Mangroves are at risk of inundation by rising sea levels in areas where they cannot retreat landward (6.4.4)
	Ocean warming	Warming oceans have led to the southward expansion of several species (e.g. black sea urchin), likely to have been aided by the extension of the East Australian Current (6.5.1)
	Ocean acidification	In more acidic oceans, molluscs (e.g. abalone, scallops) will experience reduced reproduction, immune response and survival and may struggle to grow shells (6.4.6)
	Increased storm frequency	In combination with sea level rise and wave and wind changes, aquaculture infrastructure in the ocean and on low-lying coastal land will be at greater risk of damage or destruction (11.3.2)
Physical	Damage to infrastructure	Ports, boat launching facilities and navigational aids may be damaged by extreme sea storm events (12.3.1)
Biological	Bycatch	School shark is classified as overfished but is still taken as bycatch in the commercial fishery for gummy shark (6.4.7)
	Overharvesting/stock collapse	Species which have previously been subject to overexploitation in Victoria include beds of native flat oyster and blue mussel, school shark, barracouta and scallops (11.1.1)
	Recruitment failure	Reduced freshwater flows into bays and estuaries, associated with reduced rainfall, have impacted negatively on recruitment in Australian bass and sand flathead (6.4.7)
	Food web disruption	Ocean acidification will impair species at the bottom of food webs (e.g. calcifying plankton) with impacts on all the species that feed on them (6.4.6)
	Altered species abundance/distribution	The weight of commercial wild catch has declined by almost 50 per cent since 1986 (11.2)
	Disease	Abalone viral ganglioneuritis caused mass mortalities in abalone aquaculture farms and the wild populations in Victoria (11.3.2)
	Marine pests	Northern Pacific sea star, which is a listed marine pest, led to population declines of globefish and eastern shovelnose stingaree in Port Phillip Bay after the millennium drought due to competition for limited food[1] (11.2.3)
	Range expanding species	Black sea urchins, which have expanded their range from New South Wales, create barrens that no longer support abalone (6.5.1)
	Habitat loss/ degradation	Habitat loss affects key life stages such as larval recruitment. Many species associate with seagrass beds for at least part of their lifecycle including King George whiting and flatheads (6.4.3)

Threat class	Pathway/outcome	Example
Catchment processes	Water quality	Water quality impacts most strongly on bay and estuarine species, as flushing times are slower than for open water species. Photosynthetic organisms (e.g. seagrass) and filter feeders (e.g. mussels) are particularly sensitive (11.3.2)
	Sedimentation/nutrients	Extreme rainfall events increase sedimentation and nutrient levels in bays and estuaries. High levels of suspended sediments can smother important habitats such as seagrass beds (6.4.3)
Pollution	Contamination	While no recent studies have shown elevated mercury levels in black bream, work in the 1990s showed that mercury levels in Gippsland Lakes black bream had increased since the 1970s[2]
Community/ industry demand	Expansion of industry	To increase opportunities for recreational fishers, commercial netting has been phased out of Western Port and Corio Bay and will be excluded from all of Port Phillip Bay by 2022 (11.2.3)
	Access to coastal land	Coastal land will increasingly come under pressure from rising sea levels and population growth. Competing land use priorities may prevent expansion of onshore marine aquaculture (11.3.2)
	Sector competition over resources	Some recreational fishers perceive commercial fishing as a threat to recreational fishing. In response, the state government implemented several commercial exclusion zones and bans (11.4.3)
	Illegal fishing	Illegal, unreported and unregulated fishing threatens stock sustainability, affects the market price of fish and threatens the social acceptability of fishers who are complying with regulations (11.2.3)
	Demand for ecotourism	Increasing ecotourism may compete with fishers for access to infrastructure (e.g. boat launching) and fish resources (10.1.2)
	Complex regulatory environment	Bag limits may not accommodate small groups of regular fishers providing food for extended networks of people who cannot fish themselves (11.5.3)
	Altered input and output controls	Numbers of commercial fishing licences available are subject to environmental and policy pressures. Total allowable catch limits vary annually (11.2.3)

11.1 Introduction

The benefits of the fishing industry have traditionally been quantified in monetary and employment terms. The gross value of Victorian wild catch fishery and aquaculture (including freshwater) production increased by 10 per cent in 2016-17 to $94 million. The increase was due to a rise in the value of aquaculture, which increased by 43 per cent in 2016-17 to $39 million. However, wild catch fishery production value fell by 6 per cent in 2016-17 to $54 million. This was driven by a fall in production value for some finfish, particularly King George whiting and snapper, and lower production value of rock lobster, prawns and squid. Since 2008–09 the gross value of aquaculture has generally increased due to growth in the value of salmonid and abalone production. In 2016-17 the value of Victorian aquaculture abalone was $18 million.[3]

There is increasing recognition of the non-monetary benefits of recreational and customary fishing, including mental health and wellbeing, environmental stewardship, maintenance of cultural practices, and the intergenerational transfer of skills and knowledge.[4,5,6] The fishing industry also generates flow-on benefits to other industries and sectors such as bait and tackle retailers, seafood processing and wholesaling, boat building and repair, transport and accommodation.[6,7] In 2017-18, PrimeSafe (the regulatory authority for meat, poultry and seafood safety) issued licences to 188 wild catch businesses, 19 aquaculture businesses, and 350 seafood processing or retailing businesses.[8]

A range of teleost fish (bony fishes), chondrichthyans (sharks and rays), molluscs (e.g. abalone, mussels, scallops, squid), crustaceans (e.g. rock lobster, prawns, crabs) and echinoderms (e.g. sea urchins, sea cucumbers) are targeted by fishers. Key commercial species in Victoria, as assessed by the tonnes captured, include Australian sardine (*Sardinops sagax*), abalone (*Haliotis* spp.), Australian salmon (*Salmo salar*), southern rock lobster (*Jasus edwardsii*) and King George whiting (*Sillaginodes punctata*).[9] Marine aquaculture focuses predominantly on bivalve molluscs (i.e. blue mussels *Mytilus galloprovincialis*), while land based aquaculture of marine organisms focuses on abalone.[10] Important recreational species, as assessed by self-reports from licensed recreational fishers, include snapper (*Pagrus auratus*), King George whiting, flathead species (*Platycephalus* spp.), squid (*Nototodarus gouldi*) and gummy shark (*Mustelus antarcticus*).[11] Recognition of the Aboriginal fishing sector is growing. Initial attention has focused on short-finned eel (*Anguilla australis*) and pipis (*Donax deltoides*).[12,13]

In the 2016-17 financial year, Australians consumed more than 357,000 tonnes of commercially produced, ready-to-eat seafood. This equates to an average of 14.5 kilograms per person. As domestic seafood production (both wild caught and aquaculture) accounts for only 27 per cent of ready-to-eat seafood, approximately two thirds (63 per cent) is imported, primarily in the form of canned tuna, frozen fish and frozen prawns.[3] On average, Australians eat roughly three meals a week containing seafood products. Some of the reasons people like seafood include its health benefits, ease of preparation, reasonable prices, and for a change from meat consumption.[14]

11.1.1 Threats

Fishing off Lorne Pier

For a species or population (stock) of a species to support fishing, it needs to be part of a healthy and functioning ecosystem. Protection of key life stages, such as spawning and larval recruitment sites, as well as foraging and sheltering sites are essential. Species which have previously been subject to overexploitation in Victoria include beds of native flat oyster (*Ostrea angasi*) and, blue mussel,[15] school shark (*Galeorhinus galeus*),[16] barracouta (*Thyrsites atun*)[17] and scallops (*Pecten fumatus*).[18]

Certain traits render species more vulnerable to overexploitation. In fish, these traits include living longer than 25 years, reaching reproductive maturity after 15 years, producing fewer than 100 eggs annually, reaching a large size at maturity (more than 200 centimetres), bearing live young

Scallop in Posidonia seagrass meadow in Corner Inlet, Victoria. Photo: P Carnell

and occurring at a high trophic level (e.g. a carnivore in the food web).[19] Similar constraints operate on invertebrates: longevity, low reproductive output, poor dispersal capacity (e.g. short-lived planktonic larval stage, brooding, asexual reproduction by fission or budding), low mobility, and narrow habitat requirements (e.g. seagrass specialists, embayments).[20,21] Irrespective of traits that make species vulnerable to overexploitation, some consistent threats apply. Southeastern Australia is a climate change hotspot with well-documented recent changes in the marine environment.

11.1.2 Fisheries management

The Victorian Fisheries Authority (VFA) administers the *Fisheries Act 1995*, the Fisheries Regulations 2009, and the Fisheries (Fees, Royalties and Levies) Regulations 2017. The Fisheries Act provides the legislative framework for the facilitation, promotion, management and regulation of Victoria's fisheries resources and sets out the general provisions applicable to all recreational fishing activities and commercial access licences.

The Fisheries Regulations outline the measures and regulations in place to manage fisheries sustainably. They contain details of the recreational and commercial regulations in specific fisheries and areas of Victoria, including gear types, catch limits, size limits, area or temporal closures, and specific licence conditions such as daily catch and effort records and boat restrictions. The Fisheries (Fees, Royalties and Levies) Regulations prescribe the fees, royalties and levies payable for commercial fishery licences, individual quota units, recreational fishery licences, permits to take protected aquatic biota and boat registrations.

All Australian governments, including Victoria, have made a commitment to manage fisheries according to the principles of ecologically sustainable development. These principles are enshrined in the Commonwealth *Fisheries Administration Act 1991* and include:

- ensuring that fishing is carried out in a biologically and ecologically sustainable manner
- ensuring that there is equity within and between generations regarding the use of fish resources
- maximising economic and social benefits to the community from fisheries within the constraints of sustainable utilisation
- adopting a precautionary approach to management, particularly for fisheries with limited data
- ensuring that the processes and procedures involved in management of a fishery are appropriate, transparent and inclusive.

Fishing is prohibited or restricted in some places across the Victorian coast. All fishing is prohibited in marine national parks, marine sanctuaries and the nine shipwreck protected zones. Collection of invertebrates in the intertidal zone is prohibited in Port Phillip Bay other than worms, bass yabbies, squid, octopus, cuttlefish and dead shells. Invertebrate collection is restricted along the rest of the Victorian coast where all molluscs are protected other than pipis, mussels, oysters, squirters, squid, octopus and cuttlefish.

VFA's annual report is available at https://vfa.vic.gov.au/about/annual-report

11.2 Commercial fishing

Nearly 5000 live weight tonnes of seafood were harvested in Victorian waters in the 2016-17 year (table 11.2).[9] In 2016, the Victorian commercial fishing industry generated approximately 580 jobs. A further 800 people were employed in fish and seafood processing and wholesaling.[3]

Commercial fishing occurs in Victorian coastal waters and the larger bays and inlets (Port Phillip Bay, Western Port, Corner Inlet, Nooramunga, and the Gippsland Lakes). The bay and inlet fisheries are multi-species, multi-method fisheries. In Lake Tyers, Mallacoota Inlet and Anderson Inlet, commercial fishing is restricted to bait and eels. Commercial netting was phased out in Western Port in 2009 and by 2022 there will be no commercial netting in Port Phillip Bay. The state government recently committed to phasing out commercial fishing in the Gippsland Lakes through a compulsory licence buy-back scheme.

Many fish stocks are present across the three nautical mile limit of state coastal waters into Commonwealth waters (to 200 nautical miles). In 1979 the states and the Commonwealth completed an agreement for the settlement of offshore constitutional issues, including jurisdictional arrangements for fisheries. The Offshore Constitutional Settlement (OCS)[22] allows management responsibility for fisheries to be passed exclusively to the Commonwealth or to the adjacent states/Northern Territory.[23] Victoria currently has ten OCS fisheries agreements in place. Eight were signed in 1997 and related to trawl fisheries, finfish and invertebrates. A further two were signed in 2001 relating to gummy shark and school shark (see appendix 6). For details of species covered by these agreements see appendix 7.

Australia is a party to a range of international instruments concerning fisheries, most of which stem from the United Nations Convention on the Law of the Sea (1982). Australia is also part of several Regional Fisheries Management Organisations (FMOs) established under the United Nations *Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* (1995). FMOs that are relevant to or abut Victorian coastal waters include the Commission for the Conservation of Southern Bluefin Tuna, the Indian Ocean Tuna Commission, and the South Pacific Regional Fisheries Management Organisation.

11.2.1 State waters

The key commercial fisheries managed by the Victorian government are:

- abalone (*Haliotis rubra rubra, H. laevigata*) fishery
- bait fisheries
- bays and inlets fisheries
- eel (*Anguilla australis, A. reinhardtii*) fishery
- giant crab (*Pseudocarcinus gigas*) fishery
- multi-species ocean fisheries
- pipi (*Donax deltoides*) fishery
- rock lobster (*Jasus edwardsii*) fishery
- scallop (*Pecten fumatus*) fishery
- wrasse (*Notolabrus tetricus, N. fucicola*) fishery.

Many of these fisheries are multi-species and multi-method fisheries. Table 11.2 provides details of the main types of species targeted and the live weight tonnes harvested. In 2016-17, nearly 5000 tonnes were harvested.

Over the past thirty years, the commercial wild catch has almost halved, although this is not even across groups or species. The catch of chondrichthyans has dropped dramatically, by more than 98 per cent. The catch of molluscs and echinoderms has dropped by more than 60 per cent, much of which was driven by a 52 per cent reduction in the harvest of blacklip abalone. During the same period, the catch of black sea urchins and octopus increased. Teleost fish experienced a moderate decline in production. A near doubling of the harvest of sardines offset reductions in Australian salmon and King George whiting. While the catch of crustaceans has remained relatively stable, in 2016-17 southern rock lobsters made up 60 per cent of the production for this group, compared with 86 per cent in 1986-87. Increases in the production of sand crab and eastern school prawn offset the reduction in rock lobster.

Southern rock lobster Photo: Parks Victoria

Table 11.2 Statewide commercial catch for all species including dominant three species (by weight) for each group, 1986-87 to 2016-17[9]

Species	Production (live weight tonnes)				Percentage change 1986-87 to 2016-17
	1986-87	1996-97	2006-07	2016-17	
Teleost fish	4817	4556	2970	3516	-27
Australian sardine *Sardinops sagax*	1184	773	724	2344	+98
Australian salmon *Salmo salar*	362	310	907	265	-27
King George whiting *Sillaginodes punctata*	189	229	166	115	-39
Molluscs and echinoderms	2599	1651	2642	967	-63
Blacklip abalone *Haliotis rubra rubra*	1499	1453	1216	716	-52
Octopuses *Octopus* spp.	16	43	22	45	+188
Black sea urchin *Centrostephanus rodgersii*	9	6	19	45	+408
Crustaceans	500	583	484	442	-11
Southern rock lobster *Jasus edwardsii*	428	455	395	262	-39
Sand crab[1] *Ovalipes australiensis*	id	16	1	67	+347
Eastern school prawn *Metapenaeus macleayi*	6	1	10	40	+622
Chondrichthyans[2]	1713	1142	63	30	-98
Gummy shark *Mustelus antarcticus*	732	682	33	15	-98
Elephantfish *Callorhinchus milii*	40	53	4	1	-98
School shark *Galeorhinus galeus*	527	137	0	1	-99.9
Total	9628	7932	6160	4955	-49

id= insufficient data to report, as fewer than five licence holders contributed data. Data are included in the group total
[1] Per cent change for sand crab calculated between 1996-97 to 2016-17 instead of 1986-87
[2] Shark carcass weight (beheaded and gutted with fins attached) for Victorian proclaimed waters only

All Victorian fisheries are managed by a range of input controls (e.g. limited entry (maximum number of licences issued), gear restrictions, seasonal and area closures, size limits) and output controls (e.g. total allowable commercial catch (limits). Some 22 different types of fisheries access licences are issued to commercial fishers under the Fisheries Act. Data for 2016-17 on numbers of licences, total catch in tonnes and total allowable commercial catch (where relevant) are provided in table 11.3. Levies payable for access to Victorian fisheries are detailed in the Fisheries (Fees, Royalties and Levies) Regulations 2017.

A condition of commercial access licences is that licence holders must keep daily catch and effort records and submit these monthly. This allows the VFA to track the trajectory of fish stocks. The VFA prioritises the allocation of resources for the monitoring and assessment activities required to inform management of stocks based on importance to the community and risk to the resource.

Abalone, rock lobster, Port Phillip Bay and Western Port snapper and King George whiting, and Gippsland Lakes black bream (*Acanthopagrus butcheri*) fisheries are subject to complex monitoring and assessment. Smaller, lower value and lower risk fisheries are assessed using simpler and less resource-intensive approaches and may also include angler diary program data. Fisheries Victoria, the predecessor to the VFA, reviewed the stock status of commercial species every three to five years during the last decade.

National Status of Australian Fish Stocks (SAFS) reports[24] are prepared every two years as a partnership between the Fisheries Research and Development Corporation (FRDC) and all jurisdictional fisheries agencies including the VFA using a nationally agreed, consistent approach and criteria. The Victorian components of these assessments are conducted by VFA scientists in collaboration with fisheries scientists from other relevant jurisdictions (assessments are conducted at a biological stock scale where possible) with an independent peer review process managed by FRDC. It is important to note that the definition of sustainability these assessments use refers to the ability of the fish stock to sustain current levels of fishing pressure and does not include broader ecological or economic considerations.

The VFA also conducts a review for key Victorian fishery species or stocks between SAFS years, using the SAFS classification framework, and including additional species of interest to Victoria.[25] All these assessments use a weight of evidence approach and draw on the detailed stock assessments conducted by VFA for key quota managed species such as abalone and rock lobster. Status of stock assessments for Victorian fish species can be found in appendix 8 and are summarised in figure 11.1. Descriptions of stock assessment status categories are provided in table 11.4.

Several Victorian fisheries are accredited under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. These assessments are designed to ensure that all export fisheries are managed in an ecologically sustainable way. Current EPBC Act-accredited fisheries in Victorian include the abalone fishery, Corner Inlet fishery, eel fishery, giant crab fishery, rock lobster fishery, scallop fishery (both Port Phillip Bay dive and ocean fisheries) and the sea urchin fishery.

Table 11.3 Fisheries Access Licences and catch data for Victorian fisheries in 2016-17[9]

Fisheries Access Licence type	Number of licences	2016-17 catch (tonnes)	Total allowable commercial catch[1] (tonnes)
Abalone[2]	71	709	695
Bait (general)	12	nd	na
Giant crab[3]	14	9	10.5
Eel (Fishery A, transferable)[4]	18	approx. 65	na
Ocean (general)	171	2756	na
Purse seine (ocean)	1		

Wrasse (ocean)	22	24`	na
Southern rock lobster	107 (97,235 licensed pots)	262	289
Scallop (ocean)	90	nd	135
Scallop dive (Port Phillip Bay)	1	nd	60
Sea urchin	10	45 black urchin 24 white urchin	114 black urchin 117 white urchin
Trawl (inshore)	54	nd	na
Corner Inlet	18	346	na
Gippsland Lakes	10	232	na
Gippsland Lakes (bait)	9		
Gippsland Lakes (mussel dive)	2		
Lake Tyers (bait)	1		
Mallacoota lower lake (bait)	1	id	na
Port Phillip Bay-Western Port[5]	10	268	na
Port Phillip Bay (mussel bait)	1	id	na
Snowy River fishery (bait)	2	id	na
Sydenham Inlet fishery (bait)	2	id	na
Permits[6]	15	nd	na

id= insufficient data as fewer than five licence holders contributed data, so data are aggregated and in the 'other' category, na= not applicable, nd= no data obtained[10]
[1] Some fisheries do not have total allowable commercial catch limits. They are managed instead through input control measures including limited entry (maximum number of licences), size restrictions, gear restrictions and area closures
[2] Abalone tonnes may exceed total allowable commercial catch under licences as it also includes allowable catch under other permits
[3] 2015-16 catch data reported for giant crab, as no data was reported in 2015-16 due to there being fewer than five licence holders contributing the data
[4] Eel catch data estimated from Victorian Eel Fishery Management Plan[25]
[5] Catch for Port Phillip Bay-Western Port excludes data for abalone, blue mussel, southern rock lobster and commercial scallop
[6] Permits allow non-typical activities to occur, including taking fish for education, research or fisheries development, or possessing equipment related to fisheries development

Figure 11.1 Stock status for 130 commercially harvested fish species and stocks in Victoria, assessed between 2016 and 2018.[24,25,26,27]

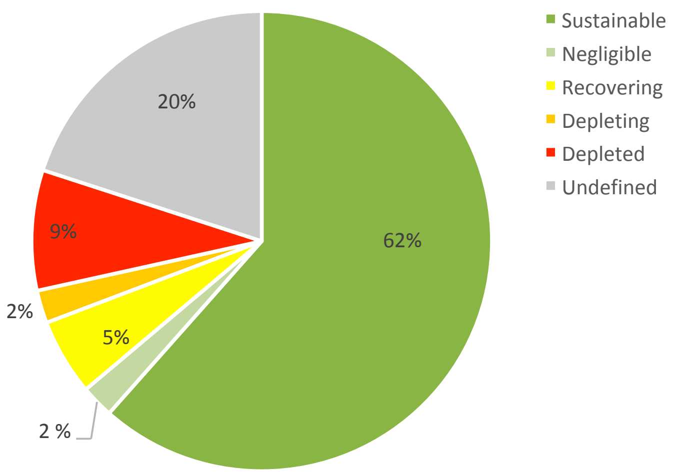


Table 11.4 Stock assessment categories for commercial fish species in Victorian waters[24]

Stock status	Description
Sustainable	Biomass (or proxy) is at a level sufficient to ensure future levels of recruitment are adequate (recruitment is not impaired) and for which fishing mortality is adequately controlled to avoid the stock becoming recruitment impaired (overfishing is not occurring).
Negligible	Catches are so low as to be considered negligible and inadequate information exists to determine stock status.
Recovering	Biomass (or proxy) is depleted and recruitment is impaired, but management measures are in place to promote stock recovery, and recovery is occurring.
Depleting	Biomass (or proxy) is not yet depleted and recruitment is not yet impaired, but fishing mortality (or proxy) is too high (overfishing is occurring) and moving the stock in the direction of becoming recruitment impaired.
Depleted	Biomass (or proxy) has been reduced through catch and/or non-fishing effects, such that recruitment is impaired. Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements.
Undefined	Not enough information exists to determine stock status.

11.2.2 Commonwealth waters

Two Commonwealth-managed fisheries operate in Victorian waters: the Southern and Eastern Scalefish and Shark Fishery and the Southern Bluefin Tuna Fishery. A further five Commonwealth-managed fisheries abut Victorian coastal waters. These fisheries are managed by the Australian Fisheries Management Authority (AFMA). For details of these fisheries, see appendix 9.

Access for commercial fishers to Commonwealth-managed fisheries occurs through fishing concessions, which can be statutory fishing rights, fishing permits or foreign fishing licences. Fishing concessions allocate 'shares' to fisheries resources, access to which is controlled by 'input' and/or 'output' controls. Input controls include limiting the number or type of fishing vessels, the amount or type of fishing gear, or the areas and times when fishing can occur. Output controls include the amount of fish that can be caught. Most Commonwealth fisheries are managed through limiting the number of statutory fishing rights and output controls. Details on numbers of statutory fishing rights, active vessels and fishing effort for 2016-17 and 2017-18 can be found in appendix 9.

Urchin barren near Mornington. Photo: P Carnell

The sustainability of 57 species and stocks that occur in Commonwealth-managed fisheries that encompass or abut Victorian coastal waters was assessed by AFMA and FRDC.[24,27] Due to the large areas over which these fisheries operate, not all the fish species necessarily occur within Victorian waters. Full details of species covered can be found in appendix 8.

11.2.3 Threats to commercial fisheries

Stock collapse

Overexploitation of stocks, such as native flat oyster[15] in the mid-1800s, school shark[16] in the 1940s, barracouta[17] in the 1970s and scallops[18] in the 2000s can lead to the collapse of commercial fisheries. Stock assessments by the VFA and AFMA are intended to inform quota allocations and other output controls to avoid overfishing.[17]

Reductions in spawning and recruitment of commercial species can threaten the viability of fisheries. For example, the recruitment of King George whiting to Port Phillip Bay depends on successful spawning in South Australian waters, survival of the larvae while they drift eastward through Bass Strait for several months, and abundant seagrass beds in which to settle. Changes in winds and a weakening of the prevailing Leeuwin Current associated with climate change could reduce stock of King George whiting.[28]

Loss of key habitat can also lead to stock collapse. The black sea urchin (*Centrostephanus rodgersii*) has expanded its range from central and southern New South Wales to eastern Victoria and Tasmania in response to warming of sea surface temperatures and strengthening of the East Australian Current. This species forms barrens that are devoid of habitat-forming macroalgae such as kelp, which is the preferred food of commercially important blacklip abalone (*Haliotis rubra*).[29]

Water quality

Oceans are predicted to become increasingly acidic under climate change.[30] This will impact negatively on invertebrates (e.g. scallops and abalone) through depressed shell calcification, growth and immune function. Species that feed on zooplankton (e.g. pilchards *Sardinops sagax*) and the species that feed on them (e.g. southern bluefin tuna *Thunnus maccoyii*) will also be negatively impacted.[31]

Elevated levels of catchment-derived nutrients can encourage the growth of toxic algal blooms.[32] Since 1986, recurring blooms of *Nodularia spumigena* have led to the periodic closure of recreational and commercial fisheries in the Gippsland Lakes.[33] Species of particular concern include mussels and prawns, with finfish accumulating lower levels of toxins.[32]

Insecure tenure

The nature of commercial fishing property rights (licences) generates challenges for commercial fishers. Unlike a property which can be mortgaged for business investment, commercial fishing licences, while costly to purchase, are often not acceptable collateral.[23,34] The types and numbers of commercial fishing licences available are subject to environmental and policy pressures.[34,35] Even when fishers can secure licences, total allowable catch limits are subject to annual variation. These uncertainties contribute to poor mental health among some fishers.[34,36]

Competition with recreational fishers

A relatively recent contribution to tenure insecurity among commercial fishers is driven from the recreational fishing sector. During the mid-2000s, political support for recreational fishers grew at the expense of commercial fishers, particularly in the bay and inlet fisheries.[35] In 2006 and 2007 recreational fisheries reserves were created in Lake Tyers, Mallacoota and Anderson Inlet. Commercial netting was phased out in Western Port in 2009 and Corio Bay in 2018. Commercial netting will be excluded from all of Port Phillip Bay by 2022. Increased netting exclusion zones were regulated for the Gippsland Lakes in 2017 [37]and, in the lead up to the 2018 state election, the peak body for recreational fishers (VRFish) called for a compulsory buy-back of all Gippsland Lakes fishery access licences. This was subsequently announced as a policy by the returned Labor government. These closures threaten the viability of commercial fishers operating in these environments.

Illegal, unregulated and unreported fishing

Illegal fishing activities take a variety of forms and include not reporting or under-reporting catches, mixing legal and illegal catches to avoid detection, selling commercial catch to restaurants or private individuals on a cash or barter basis, exceeding the allowable catch, or swapping catch between commercial and recreational allowances.[38] There is a small but significant group of habitual or repeat offenders who can be characterised as criminals who systematically flout fisheries regulations to profit from the illegal sale of high-value species, fish thieves who regularly flout the regulations for personal benefit (including illegal sale, bartering and personal use), and fishers who regularly flout the regulations to provide themselves and their families with seafood items not readily obtainable through normal retail outlets.[39]

High-value, low-volume species are the focus of most illegal fishing activities.[40] Species harvested from Victoria for illegal sale into international markets include abalone, sharks (for fins) and seahorses. For domestic sale, targeted species include abalone, rock lobster, King George whiting and snapper.[41] Most research on illegal fishing activities historically has focused on abalone. Although illegal, unregulated, and unreported abalone harvests occur in all states and their magnitude is difficult to estimate,[42] the highest levels of illegal fishing activities for abalone occur closer to urban areas in New South Wales and Victoria.[43]

Such illegal fishing activities pose a threat to commercial fishers as they impact on stock sustainability and affect the market price of catches.[44]

11.2.4 Emerging uses

Recreational fishing

The reallocation of bay and inlet fish resources from the commercial to the recreational sector is continuing in Victoria.[35]

Macroalgae

A small-scale experimental harvest of wakame (*Undaria* sp.) has occurred in Victoria but has not developed further as it is a low-value product.

11.2.5 Knowledge gaps

Stock assessment

Stock assessment involves synthesising data on life history, fishery monitoring, and resource surveys to estimate stock size and harvest rate relative to predetermined reference points. It can also involve predicting the response of the stock to alternative management scenarios.[45] Because of the amount of data that goes into stock assessment, fish stocks are challenging to establish accurately, even for commercially-targeted species in developed countries.[46] For example, in Victorian waters further information is required on the stock structure of gummy shark and silver trevally, and the stock composition of southern calamari, rock flathead, flounder species, southern garfish and King George whiting.[47] For some additional species assessed using the national SAFS classification framework there were insufficient data to assess the stock sustainability.[24] In some instances, this may be due to the commercial catch being too low for the species to be a priority for the collection of detailed data.

The stock composition, distribution and spatial structure of non-target species are even more poorly understood. Non-target catch is comprised of byproduct (non-target species that are retained for sale) and bycatch (species that are not retained). In Victoria, several fisheries are multi-gear, multi-method fisheries (i.e. they do not target a single species). While there is some information on non-target species for individual fisheries (e.g. chondrichthyans in the Commonwealth southern and eastern scalefish and shark fishery),[48] generally non-target captures are unknown. In Victoria, byproduct catches are reported but reporting of the amount and type of bycatch is not mandatory. The VFA provides commercial operators with logbooks to record all species landed, but the VFA does not collect information on the type or amount of bycatch species unless it involves protected species interactions.[47]

There is no sound estimate of recreational catches (see section 10.4), but some estimates have put recreational catches for key species above commercial catches both in Victoria[49] and overseas[50]. As stock assessments rely on data including total catches, underestimating the total catch by excluding recreational catch could underestimate the actual biomass of the species,[51] with flow-on impacts on stock assessment results and management advice.[46]

Illegal, unregulated and unreported fishing

By of its very nature, illegal fishing is challenging to quantify. The VFA is responsible for fisheries compliance in Victoria. In 2017-18, 5052 offenders were detected, 2394 verbal warnings given, 1699 official warnings issued, 1721 infringement notices issued and 44 prosecution files submitted. Some 1777 calls were also placed by members of the public to 13FISH, the offence reporting line.[52] Details on the severity of offences are not provided.

Fisheries stock assessments are based on catch and effort data. However, illegal catches result in the absence of a potentially significant part of the annual catch that is not included in the assessment resulting in possibly distorted estimates of sustainable catches.[53]

11.3 Aquaculture

11.3.1 Victorian industry

Aquaculture can complement the supply of seafood from wild catch fisheries as consumer demand rises and can supply niche products such as tiger abalone (*Haliotis rubra* x *H. levigata*) that are not available as wild harvest. Aquaculture in Victoria experienced growth of 18 per cent in 2016-17, up from 14 per cent growth the previous year. In 2016-17, aquaculture generated almost 300 jobs.[3] Aquaculture products tend to command higher prices than wild catch equivalents, largely due to on-site processing at many farms and well-developed branding and marketing. In 2016-17, almost 1600 tonnes of marine organisms were cultured (table 11.5).[10]

Table 11.5 Aquaculture industry sectors, licences types, licence numbers and production for 2016-17[10]

Industry sector	Types of licences (issued under the Fisheries Act)	Number of licences[1]	Production (tonnes)
Abalone	Crown land[2] abalone Onshore abalone	10	462
Blue mussel and other molluscs (bivalves)	Crown land bivalve	16	1136
Ornamental fish	Private land ornamentals	9	na
Other (some freshwater)	Crown land offshore Crown land other Private land indoor intensive Private land marine Private land other Private land tourism	21	2
Eels (freshwater)	Crown land eels Private land eels	13	6
Salmonids (freshwater)	Private land salmonids	18	1282
Warm water finfish (freshwater)	Private land warm water finfish	18	256
Yabby (freshwater)	Private land yabbies Private land yabbies multi-waters	17	3

n/a= not applicable
[1] Some licensees hold multiple licences.
[2] Crown land is public land and includes the seabed within Victoria's coastal waters and bays.

Aquaculture is conducted by 109 licence holders across public (Crown) land and private land under 16 different licence types (table 11.5). All marine aquaculture licensees require local Council planning permission, Marine and Coastal Act consent for seawater supply, pipeline licences for pipelines to cross coastal Crown land and an EPA discharge licence to regulate the discharge water quality. Aquaculture licensees operating on Crown land also require a Crown land lease to operate.

Crown land has been set aside for aquaculture within twelve designated aquaculture fisheries reserves, of which ten are offshore and two are onshore (figure 11.2). Because high-energy waves can damage aquaculture infrastructure, much offshore aquaculture occurs in sheltered bays. Eight offshore aquaculture fisheries reserves occur in Port Phillip Bay, one in Western Port near Flinders, and a tenth is located 2.6 kilometres offshore in Portland Bay.[54] The two onshore aquaculture fisheries reserves are in Point Lillias (40 hectares) and Avalon (17 hectares).[55] Currently, the Portland, Beaumaris and Point Lillias fisheries aquaculture reserves are unoccupied, and there is opportunity for additional licensees to operate within the other existing reserves.

The dominant marine aquaculture species in Victoria are abalone and blue mussels (*Mytilus galloprovincialis*). Most abalone is produced in four onshore farms in the Avalon fisheries aquaculture reserve (Jade Tiger Abalone), Port Fairy (Southern Ocean Mariculture), Narrawong (Yumbah Narrawong) and Indented Head (Jade Tiger Abalone). A fifth farm has been proposed for Portland. Three species are grown: blacklip (*Haliotis rubra rubra*), greenlip (*H. laevigata*) and the hybrid known as tiger abalone. These farms have licensed pipeline access for both intake and discharge of sea water. Offshore cages have been experimentally trialled but are not in commercial use due to logistical difficulties in accessing cages for daily inspection and removal of unused food.[56] Abalone sold on the domestic market end up in the restaurant trade. Asia is the biggest export market. The production value of aquaculture abalone has increased more than 70-fold from $0.23 million in 2002 to $17.7 million in 2016.[10,11] This represents two thirds the current tonnage of wild catch abalone although it is growing.

Figure 11.2 Aquaculture fisheries reserves in Port Phillip Bay

Blue mussels are grown on ropes suspended in the water column in aquaculture fisheries reserves within Port Phillip Bay and Western Port. In the early 2000s, a decline in the availability of juvenile mussels ('spat') to colonise mussel ropes led to a decline in the industry.[15,57] Possible causes of the decline included climate change, reduced nutrients, increased salinity and smothering of spat by other marine species. In response, the Queenscliff Shellfish Hatchery was established to provide a commercial source of spat. The industry is now recovering and, in 2016, aquaculture production of mussels was worth $4.3 million, more than twice the value of $1.6 million when data were first recorded in 1989.[10,11]

11.3.2 Threats to aquaculture

Disease

In 2006, a herpes-like virus caused mass mortalities in several abalone aquaculture farms in south-west and central Victoria. Abalone viral ganglioneuritis was also found in wild populations and spread more than 200 kilometres along the Victorian coast. The impacts of this disease, which caused up to 90 per cent mortality in affected populations, included significant financial losses to aquaculture facilities as well as commercial and recreational fishers.[58]

While the culturing of marine finfish is currently not permitted in Victoria outside land-based inland recirculating farms, the use of imported wild caught fish to feed cultured species, such as occurs in South Australian tuna ranching, carries potential disease risks.[56]

Water quality

Bivalves (e.g. mussels) require water with relatively high nutrient levels to sustain healthy phytoplankton populations, high dissolved oxygen, and low sediment loads. Bivalves grown in contaminated areas can accumulate pollutants,

Mussels and flat oysters. Photo: Bay Sea Farms

Abalone farm, Indented Head. Photo: VFA

particularly bacteria, heavy metals and algal-borne biotoxins. Poor water quality resulting from waste sources such as sewage, industrial waste outfalls or spills can make bivalves unsuitable for human consumption. The concentration of bacteria, virus particles and biotoxins due to algal blooms (e.g. *Dinophysis* spp.) in bivalves has particularly adverse implications for commercial bivalve culture.[56] Extensive ongoing monitoring of shellfish and the growing waters under the Victorian Shellfish Quality Assurance Program assures bivalves are safe for human consumption and comply with the Food Standards Code. This monitoring by shellfish farmers provides an early warning of toxic algal blooms.

Oceans are predicted to become increasingly acidic under climate change. This will impact negatively on molluscs (e.g. blue mussels and abalone), through depressed shell calcification, growth and immune function.[30]

Extreme weather events

More frequent and extreme storms are predicted under climate change. In combination with sea level rise and wave and wind changes, aquaculture infrastructure in the ocean and on low-lying coastal land will be at greater risk of damage or destruction.[11,30]

Increasing competition for coastal land

Onshore marine aquaculture requires large areas of land close to clean seawater inputs; however, there are only four farms currently on the coastline. Coastal land will increasingly come under pressure from rising sea levels on the ocean side[30] and population growth on the landward side.[59] Competing land use priorities may squeeze opportunities for the expansion of onshore marine aquaculture in the future.[11]

11.3.3 Emerging uses

Aquaculture is a relatively new industry worldwide, and suitable species and culture technologies are continually being developed and refined to ensure its environmental and economic sustainability.[56] Several species (e.g. flat oysters, sea urchins) and techniques are currently under experimental development or proposed for development in Victoria.

The experimental grow out culture (where juveniles are cultured onshore then placed offshore to mature) of shellfish including commercial scallops (*Pecten fumatus*) and akoya pearl oysters (*Pinctada fucata*) has been trialled in the Pinnace Channel fisheries aquaculture reserve.[60] The trial of akoya pearl oysters was unsuccessful and there is no future interest in the species. Experimental grow out of scallops and flat oysters has occurred at Clifton Springs and Grassy Point aquaculture fisheries reserves.[61] Other shellfish species that have been identified as having potential for aquaculture in Victoria include queen (*Equichlamys bifrons*) and doughboy scallops (*Chlamys asperrimus*).[56]

Cage culture of abalone is permitted in all aquaculture fisheries reserves but does not currently occur. One impediment is that the existing artificial diets are not well suited to offshore cage grow out systems where regular feeding is more difficult to deliver effectively, wastes are cumbersome to clear out regularly enough and feed is leached and lost quickly to the environment. Research is underway into local native macroalgae that could be cultured as food alongside abalone in sea-cages.[62]

Abalone ranching (the non-contained culture of abalone) is not permitted in the aquaculture fisheries reserves. Abalone ranching involves releasing hatchery-reared juvenile (seed) abalone onto natural or artificial reefs. This practice has the potential to increase commercial wild catch production and restore depleted reefs. However, concerns about

Tuna farm off the coast of Port Lincoln in Spencer Gulf, South Australia. Photo: Clean Seas (www.cleanseas.com.au)

juvenile survival, disease risk and the genetic diversity of hatchery-reared individuals need to be adequately addressed. An experiment conducted in Port Phillip Bay determined that abalone ranching was currently only marginally commercially viable.[63]

Cage culture is widely used both interstate and overseas as a cost-efficient method for marine finfish production. In South Australia, schools of small wild tuna are caught using nets and transferred to floating pontoons that are towed back to shore. The fish are then transferred to floating cages where they are held for 3-6 months until they reach market size (30-40 kilograms). The doubling of body weight over the culture cycle allows extra tonnage of tuna to be produced over the catch quota. Farmed tuna is fed with pilchards, of which half are imported from northern California and half are caught locally.[56] Currently, offshore finfish culture is not permitted in Victoria unless research demonstrates that there are no adverse environmental impacts. Species identified for further research into finfish culture include southern bluefin tuna, yellowtail kingfish (*Seriola lalandi*) and snapper (*Pagrus auratus*).[56] However, cage culture of finfish is highly unlikely to occur in Victoria, as there are no suitable locations with calm protected waters with a depth of at least 30 metres.

Sea urchins (*Centrostephanus rodgersii* and *Heliocidaris erythrogramma*) are part of a wild catch fishery which harvests roe (eggs).[64] Proposals have been put forward to collect live animals and then subsequently culture them to harvest higher-quality roe, but this has not yet eventuated.

Penaeid prawns (black tiger *Penaeus monodon*, Kuruma prawn *Penaeus japonicus* and school prawn *Metapenaeus macleayiare*) are cultured in northern New South Wales and Queensland. The expansion of this industry into Victoria is unlikely because of the requirement for substantially warmer waters (21-35°C) to allow adequate growth rates.[65]

The Victorian Shellfish Hatchery was established as a joint project between Fisheries Victoria and a consortium of Victorian mussel growers. Very specific local conditions are needed for the hatchery, as it requires very clean oceanic water that can be filtered finely. The hatchery currently operates as a commercial tenant in VFA buildings at Queenscliff. It has a small footprint and is near full capacity. If mussel spat or flat oyster spat production were to increase in the future, the hatchery would require more space.[66]

11.3.4 Knowledge gaps

Because aquaculture is a relatively new and growing industry, several important knowledge gaps exist.[11] While some gaps are being addressed through experimental work, existing gaps include:

- improving survivorship of seed abalone through predator control and better artificial reef design[63]
- better understanding the risks of finfish culture, particularly the impacts of accumulation of wastes below cages[56]
- developing commercial pelleted diets for species that require feeding (e.g. finfish, caged abalone) to reduce reliance on wild caught stocks. This will reduce risks associated both with supply and disease transfer, as well as reducing pressure on sources of wild stock.[56,62]

11.4 Recreational fishing

11.4.1 Recreational fishers

It has been estimated that between 10 and 18 per cent of Victorians fish recreationally.[49,67,68,69] Of these, 60 per cent fish in marine waters, 39 per cent in estuarine waters, and 56 per cent in inland waters.[69] Most recreational fishers are aged between 35 and 55 and male.[7,67,69] While some form of recreational fishing occurs in most places with adequate access to shoreline, piers or boat ramps, the key locations for marine and estuarine recreational fishing are Port Phillip Bay, Western Port, Corner Inlet and the Gippsland Lakes, (i.e. not very far offshore).[7,67,69]

Most recreational fishers go fishing between six and ten times a year. Favoured recreational species include flathead, King George whiting, Australian salmon, black bream, snapper and calamari.[7,67,68,69] As with commercial fishers, recreational fishers are subject to gear restrictions, as well as size and catch limits and seasonal closures. These are all detailed in the Victorian recreational fishing guide.[70]

While separate figures are not available for game fishing, the Game Fishing Association of Victoria has 16 affiliated clubs representing approximately 700 game fishers. Offshore waters are home to yellowtail kingfish, southern bluefin tuna, albacore, dolphin fish (mahi mahi), thresher and mako sharks, and striped and blue marlin. In 2016, broadbill swordfish was caught by anglers for the first time off the East Gippsland coast. Popular locations include Mallacoota, Portland or off the entrance to Port Phillip Bay. Anecdotally, the popularity of the southern bluefin tuna has as many as 150 boats lined up at Portland's two boat ramps on some weekends. Game fishers support fish tagging programs and other data collection programs to support the sustainable management of fisheries (e.g. current research being conducted by VFA to improve understanding of yellowtail kingfish stock structure). Some anglers choose to release catch such as mako sharks and threshers to help sustain wild populations.

While spear fishing is a tiny proportion of total recreational fishing effort,[67] it is a popular activity with organised events. For example, the National Spearfishing Championships were held in Port Fairy in February and March 2019, attracting about 50 competitors. Spear fishing as a form of fishing is considered by participants to be ecologically sustainable as it is targeted and does not produce bycatch. Spear fishers are limited in where and when they can hunt, with factors like visibility, depth of water and strong currents combining to limit the impact of the sport on fish resources. However, there is anecdotal evidence that shallow reefs in popular coastal areas have seen significant declines in species that are commonly targeted by spear fishers. These localised impacts have led to spear fishing competitions being prohibited in the multiple-use Wilsons Promontory Marine Park.

Recreational fishing brings substantial economic benefits to fishers themselves, who are estimated to receive on average $1.22 value for every $1 spent, primarily through the market value of captured fish. In 2014, it was estimated that recreational fishing generated 16,257 direct, and a further 17,710 indirect fulltime equivalent jobs. Just under half of

Recreational fishers on Rye Pier. Photo: Amber Perry

these jobs were in regional Victoria. While many people fish from both shorelines and boats, expenditure on boats accounts for much of the cost associated with recreational fishing. In 2000-01, it was estimated that the value of recreational fishing boats in Victoria was $620 million. Including boat-related costs, Victorians spent on average $721 per fishing trip in 2000-01, or $326 per trip in 2013-14 excluding boat-related costs. Other common expenses associated with fishing trips include travel, accommodation, fishing gear and camping gear. Most funds spent on recreational fishing in Victoria remain within Victoria, as fishers favour retail shops over online spending[7,67].

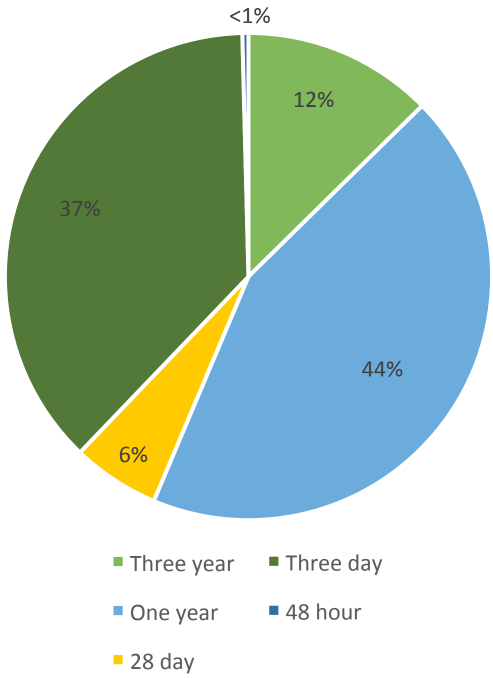
The social benefits associated with recreational fishing are receiving increasing attention. A review in 2011 identified many benefits associated with fishing, including physical fitness, mental health, rehabilitation after surgery, and intergenerational transfer of skills and knowledge. Many of these social, physiological and psychological benefits apply to fishing because it can be a low-cost outdoor pursuit accessible to any age and level of mobility. Several surveys showed that non-catch related motives (e.g. being outdoors, being with family and friends, and relaxation) ranked more highly than catch-related ones (e.g. sport and food).[5,67,69]

11.4.2 Management of recreational fishing

Recreational fishing is managed through a range of input controls (gear restrictions, seasonal and area closures, size limits), output controls (bag limits), stock enhancement (habitat protection and rehabilitation, stocking, fish aggregating devices, artificial reefs), communication (education, engagement) and enforcement.

Recreational fishers are required to hold a recreational fishing licence, unless they are

Figure 11.3 Recreational fishing licence types in 2016-17



exempt from licensing requirements. People under the age of 18 are exempt from holding a fishing licence under the Fisheries Act. Under the Fisheries Regulations several other exemptions exist, including being more than 70 years old, holding a Seniors card or receiving certain Commonwealth pensions. It has been estimated that the proportion of exempt fishers could be anywhere from 30 per cent[68] up to between 50 and 60 per cent.[67,71]

In 2016-17, a total of 271,395 licences were sold, generating $8.56 million in revenue. Five different licence types are available to recreational fishers, each operating for a different period between three years and 48 hours (figure 11.3). In 2018, a three-year licence was $98.20 (or $93.00 if bought online) and a three day licence was $10. Revenue from recreational fishing licences is managed in the Recreational Fishing Licence Trust Account, and funds are spent to improve recreational fishing opportunities through fisheries-related research, habitat improvement, education and training, access and facilities, and communication and compliance products (e.g. fish length rulers).[72]

Target One Million is the state government's plan for recreational fishing, which aims to increase participation in Victoria to one million anglers by 2020 and to get more people fishing, more often. Recreational fishing licence fees contribute to this program. Some of the key initiatives of this program that are relevant to marine and estuarine waters include:

- halt commercial netting in Port Phillip Bay and Corio Bay
- ban netting at the mouths of rivers in Gippsland Lakes
- implement a marine species stocking program
- undertake a statewide recreational catch survey.

After the Andrews Labor Government government was returned at the 2018 election, a second phase of Target One Million was announced. New marine and estuarine initiatives include:

- phase out commercial fishing in the Gippsland Lakes
- stock eastern king prawns into Lake Tyers
- habitat restoration projects in the Gippsland Lakes and Port Phillip Bay
- develop a recreational fishing tourism plan
- numerous boating commitments.

Fish stocking (the release of hatchery-reared juveniles into natural environments) is a common practice to improve recreational fishing opportunities across freshwater, estuarine and, less frequently, marine environments. In Victoria, more than six million fish are stocked annually across 12 species including both native threatened fish such as Murray cod, golden perch, trout cod, Macquarie perch, silver perch, catfish, Australian bass, and estuary perch, and popular introduced recreational fish species such as brown trout, rainbow trout, chinook salmon and brook trout). Native estuarine species stocking began with Australian bass[73] in 1996 and then estuary perch[74] in 1999. In 2018, 311,000 Australian bass and 230,500 estuary perch were stocked.

Marine fish stocking has been undertaken in New South Wales since the mid-2000s.[75] Trial marine fish stocking began in Victoria with the release in 2013 of eastern king prawn (*Melicertus plebejus*) larvae into Lake Tyers. This was followed up with the stocking of estuary perch (2015-2018) and mulloway (*Argyrosomus japonicus*) in 2015 and 2016 across Lake Tyers, Tamboon Inlet and the Bemm River. The efficacy and impacts of these introductions are currently being monitored and assessed.

Fish aggregation devices (FADs: moored or free-floating structures placed in the open ocean) are used to promote recreational fishing by providing new target fishing locations. FADs attract pelagic game fish such as yellowtail kingfish (*Seriola lalandi*), southern bluefin tuna (*Thunnus maccoyii*), dolphinfish (*Coryphaena hippurus*), striped tuna (*Katsuwonus pelamis*), and albacore tuna (*Thunnus alalunga*) to locations that are easy for recreational fishers to access. FADs are used in New South Wales, Queensland and Western Australia[76] and were first trialled in Victoria in 2007.[77] Based on their success, five devices are currently deployed between October and March off Torquay. They are removed prior to winter to avoid damage or loss from the stronger winter swells and to avoid entangling migrating whales.

There are two key reasons why large game species associate with FADs. The first is that natural aggregations of floating objects occur in areas caused by oceanic convergences, so indicate productive areas. The second is that fish make use of geographic reference points (such as FADs) to assist with school recomposition. Smaller species may use FADs for protection from predation, enhanced feeding opportunities and onshore transport to suitable settlement habitats. While useful for recreational fishers, there is some concern that FADs have the potential to modify residence times in an area, feeding ecology, migratory pathways of pelagic fish and susceptibility to fishing.[78]

The government has installed 15 artificial reefs in Victorian waters: one in Torquay, six in Port Phillip Bay and eight in East Gippsland. These reefs are constructed out of purpose-built concrete modules arranged in clusters and are designed to provide fish habitat for species (such as snapper) targeted by recreational fishers.

There are two theories for how artificial reefs attract fish. The first suggests that artificial reefs act like FADs and simply aggregate fish that are already in the environment. According to this theory, artificial reefs concentrate existing individuals into a smaller area of habitat, making segments of fish stocks that may have been previously unavailable or cost-ineffective to exploit, more vulnerable by increasing the efficiency of fishing activity. An opposing theory suggests that artificial reefs provide additional habitat and increase an area's carrying capacity. Increased feeding and shelter opportunities encourage fish to settle at reefs, and as a greater number of juveniles survive, the reef promotes an increase in local abundance of fish because new individuals can be accommodated by the new habitat formed by the artificial reef. Ultimately both attraction and production processes operate at artificial reefs, and the outcomes depend on species-specific biological life cycles, fish adaptation to the reef environment and fishing management strategies.[79]

The Seal the Loop program is raising awareness of risks to wildlife from discarded fishing line. Photo: R Molloy

11.4.3 Threats to recreational fishing

Commercial fishing

Some recreational fishers perceive commercial fishing to be a threat to recreational fishing opportunities.[35] In response, the state government implemented several commercial exclusion zones and bans (e.g. recreational fisheries reserves and commercial netting bans). In the lead up to the 2018 state election, the peak body for recreational fishers (VRFish) called for further commercial closures in the Gippsland Lakes which subsequently became government policy.

Illegal fishing practices

While most recreational fishers obey regulations, a small number fish illegally. This typically involves catching more than the allowed limits and selling this catch to domestic businesses for cash or bartering for services. Targeted species include whiting, snapper, abalone and rock lobster.[39,41] There is also concern about pseudo-recreational fishing that uses commercial equipment or harvests commercial quantities without a commercial licence.[41] For example, in 2018 the VFA prosecuted a man who was catching fish without a commercial licence and then selling them in his fish and chip shop.[52] In addition to threatening stock sustainability and the business model of commercial fishers, illegal fishing by recreational fishers damages their social licence to operate (i.e. community acceptance of recreational fishing as a legitimate pastime).[80]

11.4.4 Emerging uses

Trial marine fish stocking of eastern king prawns, estuary perch and mulloway began in Gippsland in 2013. Based on the outcomes (currently being monitored), additional species identified for stocking include sand flathead (*Platycephalus bassiensis*), dusky flathead (*P. fuscus*), black bream (*Acanthopagrus butcheri*) and yellowtail kingfish (*Seriola lalandi*).[81]

Increased access for recreational fishers, through the exclusion of commercial fishing (e.g. netting bans in Port Phillip Bay, mandatory buy back of Gippsland Lakes Fishery access licences) is current government policy as part of Target One Million.

11.4.5 Knowledge gaps

Numbers of recreational fishers

Getting an accurate estimate of the number of recreational fishers active in Victoria in any year is difficult. The last comprehensive survey – the National Recreational and Indigenous Fishing Survey – was conducted almost 20 years ago. This survey used a random sample of nearly 30,000 households with landlines to determine, amongst other things, the number of recreational fishers in each state. In 2000-01, an estimated 12.7 per cent of Victorians (approximately 550,000 people) were recreational fishers.[67] A more recent survey used a much smaller sample of 599 people to determine that 18 per cent of Victorians were recreational fishers in 2013-14. This figure was then multiplied by the estimated resident population of Victoria to generate a figure of 838,119 adult recreational fishers.[8]

Sales of recreational fishing licences can give some indication of the number of recreational fishers. However, people who purchase three-year licences are not captured in the second and third years of their licence, and people may purchase more than one short-term licence in a year. Many recreational fishers are exempt from licensing requirements, but the absolute number of exempt fishers is also unknown. Estimates of the proportion of exempt fishers vary from 30 per cent[68] to between 50 per cent and 60 per cent.[67,71] To address the unknown magnitude of this group, it has been suggested that compulsory free licences be issued to all exempt fishers.[49] This would make contact details for these

Flathead in kelp forest near Mornington.
Photo: P Carnell

fishers part of the recreational fishing database, which is used for various purposes including the recent VRFish survey of 1856 recreational fishers.[69] Other suggestions are for the collection of key profiling data (such as estimates of how often people fish) with recreational fishing licence applications as these data provide efficiency in stratification of screening surveys and reduce future survey costs.[68]

Recreational harvest

Methods to provide reliable estimates of recreational catches are challenging for all Australian jurisdictions. Some data are routinely collected in Victoria through a voluntary angler diary program, but this is limited in extent. To improve information on the numbers of rock lobster taken by the recreational sector, since mid-2017 all recreational fishers are required to tag the rock lobster they catch and keep as part of a three-year trial program. Estimates of the total recreational catch of important fish stocks are required for:

- assessment of fisheries where the recreational component is significant
- fisheries that require decisions concerning resource allocation between commercial and recreational sectors
- development, implementation and review of fishery management plans.[68]

The National Recreational and Indigenous Fishing Survey estimated (based on self-reports of numbers of species caught) in 2000-01 the statewide total recreational catch of snapper (332 tonnes), King George whiting (215 tonnes), and flathead (597 tonnes).[67] While these were only estimates, they were all greater than the annual commercial catches for these species of 84 tonnes, 137 tonnes and 110 tonnes respectively.[49] Such comparisons are important when determining the sustainability of the stocks and the allocation of fishing effort and can only be made from monitoring the recreational fishery.

Catch and release fishing

At a national level, it was estimated in 2000-01 that almost half (44 per cent) of all fish caught in Australia by recreational anglers are returned to the water.[67] While this practice may minimise the impacts of fishing on target species, the survival of released fish appears to be highly dependent on a complex interplay between fisher behaviour (gear selection, bait type, handling time), environmental features (capture depth, water temperature) and biological features (hook location, fish size, species).[82] For example, experiments in Port Phillip Bay show the survival of snapper ranged from as high as 97 per cent for fish hooked in the mouth to just 42 per cent in 'deep hooked' fish.[49]

Further research is needed to better understand the impacts of catch and release fishing.[82]

Marine stocking

The potential genetic and ecological consequences of marine stocking are largely unknown. In planning marine stocking in New South Wales estuaries, potential hybridisation effects are considered prior to releasing finfish (e.g. to prevent hybridisation between yellowfin bream *Acanthopagrus australis* and black bream *A. butcheri)*. Other ecological impacts to consider prior to stocking include the genetic diversity of broodstock, potential interactions with threatened species and biosecurity risks.[75]

11.5 Aboriginal fishing

11.5.1 Pre-contact resource use

Aboriginal Victorians have long fished the rivers, beaches and estuaries along Australia's southeast coastline. Much early evidence of human interactions with the marine environment was submerged by sea level rise by the end of the last Ice Age.[83] However, archaeological sites dating back as far as 12,000 years demonstrate the importance of marine and estuarine species including finfish (flounder, mullet, snapper *Pagrus auratus*, garfish, perch, bream, flathead, short-finned eel *Anguilla australis*), shellfish (mussels, abalone, pipis *Donax deltoides*), crustaceans (rock lobster), whales and seals to traditional diets (see also chapter 7 on

Remains of eel farming systems in the Budj Bim Landscape. Short-finned eels migrate from freshwater systems to the ocean to spawn. Photo: denisbin via on Flickr

Traditional Owner interests and values).[4,84,85]

One of the best-preserved archaeological sites is the short-finned eel farming systems in the National Heritage-listed Budj Bim Landscape which extends from Budj Bim National Park along the associated lava flows to the coast. Short-finned eels were actively farmed through a network of traps, channels and holding areas. Eels were smoked and likely traded across the region. The people of the region lived in permanent villages around this important cultural and economic resource.[4,86,87]

11.5.2 Current resource use and access rights

For many Aboriginal peoples, customary fishing practices are of immense value and multi-faceted importance; being able or unable to access customary fisheries can have profound repercussions for the cultural, social, economic, physical and mental health of individuals, families and communities. Recognising and facilitating the values and aspirations of Aboriginal peoples in the management and use of their sea countries has the potential to generate substantial positive flow-on effects for overall health, wealth and wellbeing.[88]

The Victorian Aboriginal Fishing Strategy aims to incorporate the rights, interests, aspirations and culture of Aboriginal people into fisheries management. The strategy focuses on achieving three key outcomes:

- recognition of customary fishing rights for recognised Traditional Owner groups
- better economic opportunities for all Aboriginal people in fishing and related industries
- sustainable fisheries management in collaboration with Traditional Owner groups.[89]

Aboriginal Victorians currently have several existing rights to access natural resources recognised under law. Members of Traditional Owner groups with a native title determination under the Commonwealth's *Native Title Act 1993* have non-exclusive rights to hunt, fish and gather natural resources for personal, communal and cultural purposes, without the need to obtain a licence. In addition to rights recognised in a native title determination, section 211 of the Native Title Act also applies to preserve native title rights and interests in natural resources by removing legal restrictions on activities such as fishing. This provision essentially allows native title claimants and holders to access resources (including in some cases for commercial use) without a licence, in accordance with their traditional laws and customs. Aboriginal rights are also recognised under Victoria's *Traditional Owner Settlement Act 2010*. A settlement may include access to certain species for traditional and specified commercial purposes.[12] For details of native title determinations and settlements see chapter 7.2.

Outside of these arrangements, Aboriginal Victorians can apply for permits under the *Fisheries Act 1995* (Vic) that authorise fishing for specific cultural ceremonies or events (for example, different catch and size limits or equipment). These arrangements as applied to Aboriginal access to and involvement in the short-finned eel and pipi fisheries are detailed in current management plans.[12,13]

11.5.3 Threats to Aboriginal fishing

Complex fisheries regulations

In some cases, existing regulations aimed at recreational fishers do not adequately allow for Aboriginal fishing practices. For example, bag limits may not consider the common practice of a small group of regular fishers providing food for extended networks of people who for various reasons could not fish themselves. In other examples from New South Wales and South Australia, both fisheries enforcement officers and Aboriginal fishers had incomplete understanding of their rights. A legal right for Aboriginal people to fish does not necessarily translate into full enjoyment of that right.[88]

Climate change impacts to culture

In addition to climate change impacts on species targeted by fishers (see section 10.1.1), sea level rise and more intense storms threaten cultural heritage associated with fishing, such as shell middens. Less well acknowledged are climate change impacts on cultural practices, such as fishing. For example, the loss of access to important fishing sites through sea level rise or erosion affects not only the opportunity to fish, but also to pass on cultural knowledge and stories about fishing to future generations.[88,90]

Conflict over access

Perceived or actual conflict between recreational, commercial and Aboriginal fishers for access to restricted resources, such as abalone, can hinder Aboriginal fishers from practising cultural fishing.[88]

11.5.4 Emerging uses

Cultural tourism is an emerging business area for Aboriginal Victorians. Budj Bim National Park is Victoria's first national park managed through a partnership with Traditional Owners. The Gunditjmara are developing sustainable tourism businesses including tours, bush tucker and eel aquaculture.[91]

11.5.5 Knowledge gaps

The extent of Aboriginal fishing is currently unknown. No separate data are available on Indigenous catches except where they form part of a customary fishing agreement.

Fishing for flathead, Corner Inlet. Photo: A Kilborn

11.6 References

1. Parry, G.D. and Hirst, A.J. (2016) Decadal decline in demersal fish biomass coincident with a prolonged drought and the introduction of an exotic starfish. *Marine Ecology Progress Series* 544: 37-52.
2. Fabris, G., Theodoropoulos, T., Sheehan, A. and Abbott, B, (1999) Mercury and organochlorines in black bream, *Acanthopagrus butcheri*, from the Gippsland Lakes, Victoria, Australia: evidence for temporal increases in mercury levels. *Marine Pollution Bulletin* 38: 970-976.
3. Mobsby, D. (2018) *Australian fisheries and aquaculture statistics 2017*. Fisheries Research and Development Corporation project 2018-134, ABARES, Canberra. http://www.agriculture.gov.au/SiteCollectionDocuments/abares/publications/AustFishAquacStats_2017_v1.0.0.pdf
4. Framlingham Aboriginal Trust and the Winda Mara Aboriginal Corporation (2004) *Kooyang Sea Country Plan*. Report prepared by Smyth and Bahrdt Consultants on behalf of the Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation https://parksaustralia.gov.au/marine/management/resources/scientific-publications/kooyang-sea-country-plan/
5. McManus, A., Hunt, W., Storey, J. and White, J. (2011) *Identifying the health and well-being benefits of recreational fishing*. FRDC Project Number 2011/217. Centre of Excellence for Science, Seafood and Health, Curtin Health Innovation Research Institute, Curtin University. http://www.frdc.com.au/project/2011-217
6. Voyer, M., Barclay, K., McIlgorm, A. and Mazur N (2016) *Social and economic evaluation of NSW coastal professional wild-catch fisheries: valuing coastal fisheries* (FRDC 2014-301). Canberra, Australia, Fisheries Research and Development Corporation. https://www.uts.edu.au/sites/default/files/fass-vcf-social-economic-evaluation-fisheries-report.pdf
7. Ernst and Young (2015) *Economic study of recreational fishing in Victoria*. Report to Victorian Recreational Fishing peak body (VRFish). Melbourne, Victoria. https://www.vrfish.com.au/wp-content/uploads/2017/06/Economic-Study-of-Recreational-Fishing-in-Victoria_Final_06112015.pdf
8. PrimeSafe (2018) *PrimeSafe annual report 2017/18*. PrimeSafe, South Melbourne. https:// www.primesafe.vic.gov.au/4.
9. Victorian Fisheries Authority (2017a) *Commercial fish production information bulletin 2017*. Victorian Fisheries Authority, Queenscliff, Victoria. https://vfa.vic.gov.au/commercial-fishing/commercial-fish-production
10. Department of Economic Development, Jobs, Transport and Resources (2017) *Victorian aquaculture strategy 2017-2022*. Department of Economic Development, Jobs, Transport and Resources, Melbourne. https://vfa.vic.gov.au/operational-policy/strategy-and-policy/aquaculture-strategy#
11. Australian Survey Research (2018) *Recreational fishing in Victoria: report of survey findings*. Report for Victorian Fisheries Authority. https://vfa.vic.gov.au/about/publications-and-resources
12. Victorian Fisheries Authority (2017d). *Victorian eel fishery management plan 2017*. Fisheries Victoria, Melbourne. https://vfa.vic.gov.au/commercial-fishing/eels/victorian-eel-fishery-management-plan
13. Victorian Fisheries Authority (2018b) *Victorian pipi fishery management plan*. Victorian Fisheries Authority, Melbourne. https://vfa.vic.gov.au/commercial-fishing/pipi-fishery
14. Danenberg, N. and Mueller, S. (2011*) Omnibus consumer research findings wave 2*. Project no. 2008/779, Australian Seafood Cooperative Research Centre and the University of South Australia Ehrenberg-Bass Institute for Marketing Science, Canberra. http://www.seafoodcrc.com/southern-bluefin-tuna/consumer-research/2008-779-omnibus-consumer-research-findings-wave-2.html
15. Ford, J.R. and Hamer, P. (2016) The forgotten shellfish reefs of coastal Victoria: Documenting the loss of a marine ecosystem over 200 years since European settlement. *The Royal Society of Victoria,* 128, 87-105.
16. Walker, T.I. (1998) Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries. *Marine and Freshwater Research* 49: 553-72.
17. Tilzey, R.D.J. and Rowling, K.R. (2001) History of Australia's south east fishery: A scientist's perspective. *Marine and Freshwater Research* 52: 361-375.
18. Koopman, M., Knuckey, I., Harris, M. and Hudson, R. (2018) *Eastern Victorian ocean scallop fishery – 2017-18 abundance survey*. Report to the Victorian Fisheries Authority. Fishwell Consulting, Queenscliff. https://vfa.vic.gov.au/__data/assets/pdf_file/0007/423736/Copy-of-DOC-18-385073-FINAL_Vic-Ocean-Scallop-2017-18-Survey-Final-Report-1.PDF
19. Hobday, A.J., Smith, A.D.M., Stobutzki, I.C., Bulman, C., Daley, R., Dambacher, J.M., Deng, R.A., Dowdney, J., Fuller, M., Furlani, D., Griffiths, S.P., Johnson, D., Kenyon, R., Knuckey I.A., Ling, S.D., Pitcher, R., Sainsbury, K.J., Sporcic, M., Smith, T., Turnbull, C., Walker, T.I., Wayte, S.E., Webb, H., Williams, A., Wise, B.S. and Zhou, S. (2011) Ecological risk assessment for the effects of fishing. *Fisheries Research* 108: 372-384.
20. O'Hara, T.D. (2002) Endemism, rarity and vulnerability of marine species along a temperate coastline. *Invertebrate Systematics* 16: 671-684.
21. Ponder, W., Hutchings, P. and Chapman, R. (2002) *Overview of the conservation of Australian marine invertebrates*. Report for Environment Australia by the Australian Museum, Sydney. https://australianmuseum.net.au/uploads/documents/10418/marine%20invert%20conservation%20overview.pdf
22. Attorney-General's Department (1980) *Off shore constitutional settlement – a milestone in co-operative federalism*. Australian Government Publishing Service, Canberra. https://www.ag.gov.au/Internationalrelations/InternationalLaw/Documents/offshore-constitutional-settlement-a-milestone-in-cooperative-federalism-pages-1-10%20ocr.pdf

23. Borthwick, B. (2012) *Review of Commonwealth fisheries: legislation, policy and management*. Report for the Department of Agriculture, Fisheries, and Forestry, Canberra. http://www.agriculture.gov.au/SiteCollectionDocuments/fisheries/fisheries-review/commonwealth-fisheries-management-review-report.pdf
24. Stewardson, C., Andrews, J., Ashby,C., Haddon, M., Hartmann, K., Hone, P., Horvat, P., Klemke, J., Mayfield, S., Roelofs, A., Sainsbury, K., Saunders, T., Stewart, J., Nicol, S. and Wise, B. (2018) *Status of Australian fish stocks reports 2018*. Fisheries Research and Development Corporation, Canberra. http://fish.gov.au/
25. Victorian Fisheries Authority (2017c) *Review of key Victorian fish stocks – 2017*. Victorian Fisheries Authority Science Report Series No. 1., Melbourne. https://vfa.vic.gov.au/about/publications-and-resources/status-of-victorian-fisheries
26. Stewardson, C., Andrews, J., Ashby, C., Haddon, M., Hartmann, K., Hone, P., Horvat, P., Mayfield, S., Roelofs, A., Sainsbury, K., Saunders, T., Stewart, J., Stobutzki, I. and Wise, B. (2016) *Status of Australian fish stocks reports 2016*. Fisheries Research and Development Corporation, Canberra. http://www.fish.gov.au/
27. Patterson, H., Larcombe, J., Nicol, S. and Curtotti, R. (2018) *Fishery status reports 2018*. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. http://www.agriculture.gov.au/abares/research-topics/fisheries/fishery-status
28. Longmore, A. (2014) *Spatial and temporal scales of key ecological processes in marine protected areas*. Fisheries Victoria Science report series # 4. http://www.veac.vic.gov.au/documents/Longmore%202014%20Spatial%20and%20temporal%20scales%20of%20key%20ecological%20processes.pdf
29. Carnell, P.E. and Longmore, A.R. (2014) *Resilience of Victorian reefs to climate change: an investigation utilising the sub-tidal reef monitoring program.* Report prepared for Victorian Environmental Assessment Council. Marine Investigation. Centre for Aquatic Pollution Identification and Management Technical report 42. University of Melbourne, Melbourne. http://www.veac.vic.gov.au/documents/Carnell%20&%20Longmore%202014%20Resilience%20of%20Victorian%20reefs%20to%20climate%20change.pdf
30. Holper, P., Torok, S. and Pearce, K. (2018) *Victoria's coast and marine environments under projected climate change: impacts, research gaps and priorities*. Victorian Coastal Council, Melbourne. http://www.vcc.vic.gov.au/assets/media/files/Victorian_Coastal_Council_Science_panel_report_WEB.pdf
31. Parker, L.M., Ross, P.M., O'Connor, W.A., Portner, H.O., Scanes, E. and Wright, J.M. (2013) Predicting the response of molluscs to the impact of ocean acidification. *Biology* 2: 651-692.
32. Van Buynder, P.G., Oughtred, T., Kirkby, B., Phillips, S., Eaglesham, G., Thomas, K. and Burch, M. (2001) Nodularin uptake by seafood during a cyanobacterial bloom. *Environmental Toxicology* 16(6): 468-471.
33. Boon, P.I., Cook, P. and Woodland, R. (2016) The Gippsland Lakes: management challenges posed by long-term environmental change. *Marine and Freshwater Research* 67(6): 721-737.
34. King, T., Kilpatrick, S., Willis, K. and Speldewinde, C. (2015) A different kettle of fish: mental health strategies for Australian fishers and farmers. *Marine Policy* 60: 134-140.
35. King, T.J. and O'Meara, D. (2018) The people have spoken: how cultural narratives politically trumped the best available science (BAS) in managing the Port Phillip Bay fishery in Australia. *Maritime Studies* DOI: doi.org/10.1007/s40152-018-0097-S
36. King, T.J., Kilpatrick, S. and Willis, K. (2014) *Staying healthy: industry organisations' influence on behaviours and services used by fishers*. Fisheries Research and Development Corporation, Canberra. http://www.frdc.com.au/project/2012-402
37. Ingram, C. (2016) *Delivering on the election commitment on banning netting at the Gippsland lakes river mouths.* Victorian Fisheries Authority, Melbourne. https://vfa.vic.gov.au/featured/current-consultation/netting-of-gippslands-river-mouths
38. Anderson, K.M. and McCusker, R. (2005) Crime in the Australian fishing industry: key issues. *Trends and issues in crime and criminal justice*. #297 https://aic.gov.au/publications/tandi/tandi297
39. Environment and Natural Resources Committee (ENRC) (2002) *Inquiry into fisheries management*. *Second Report*. Parliament of Victoria, Melbourne. https://www.parliament.vic.gov.au/images/stories/Reports/VPARL1999-2002No166.pdf
40. Sumaila, U.R., Alder, J. and Keith, H. (2005) Global scope and economics of illegal fishing. *Marine Policy* 30: 696-703.
41. Putt, J. and Nelson, D. (2008) Crime in the Australian fishing industry. *Trends and issues in crime and criminal justice* #366. https://aic.gov.au/publications/tandi/tandi366
42. Gorfine, H.K., Tailby, R., Gant, F., Donaldson, M. and Bruce, I. (2002*) Estimation of illegal catches of Australian abalone: development of desk-based methods*. Final report to the Fisheries Research and Development Corporation, Project No. 2000/112. Marine and Freshwater Resources Institute, Queenscliff.
43. Mayfield, S., Mundy, C., Gorfine, H., Hart, A.M. and Worthington, D. (2012) Fifty years of sustained production from the Australian abalone fisheries. *Reviews in Fisheries Science* 20: 220-250.
44. Food and Agriculture Organisation (2001) *International plan of action to prevent, deter and eliminate IUU fishing.* Food and Agriculture Organisation, Rome. http://www.fao.org/fishery/ipoa-iuu/en
45. Cadrin, S.X. and Dickey-Collas, M. (2015) Stock assessment methods for sustainable fisheries. *ICES Journal of Marine Science* 72: 1–6.
46. Maunder, M.N. and Piner, K.R. (2015) Contemporary fisheries stock assessment: many issues still remain. *ICES Journal of Marine Science* 72: 7–18.

47. Department of the Environment and Energy (DEE) (2017) *Assessment of the Victorian Corner Inlet fishery.* Commonwealth of Australia, Canberra. http://www.environment.gov.au/system/files/pages/e74d6451-56a5-4857-a67e-89f4e2f825a3/files/assessment-report-2017.pdf

48. Walker, T.I. and Gason, A.S. (2007) *Shark and other chondrichthyan byproduct and bycatch estimation in the Southern and Eastern Scalefish and Shark Fishery.* Final report to Fisheries Research and Development Corporation Project No. 2001/007. July 2007. 182 + vi pp. (Primary Industries Research Victoria: Queenscliff, Victoria, Australia).

49. Ford, J. and Gilmour, P. (2013) *The state of recreational fishing in Victoria: a review of ecological sustainability and management options*. Report to the Victorian National Parks Association, Melbourne. https://vnpa.org.au/wp-content/uploads/2017/02/The-State-of-Recreational-Fishing-in-Victoria.pdf

50. Coleman, F., Figueira, W., Ueland, J. and Crowder, L. (2004) The impact of United States recreational fisheries on marine fish populations. *Science* 305: 1958-1960.

51. Van Beveren, E., Duplisea, D., Castonguay, M., Doniol-Valcroze, T., Plourde, S. and Cadigan, N. (2017) How catch underreporting can bias stock assessment of and advice for northwest Atlantic mackerel and a possible resolution using censored catch. *Fisheries Research* 194: 146-154.

52. Victorian Fisheries Authority (2018a) *Victorian Fisheries Authority Annual Report 2017-18.* Victorian Fisheries Authority, Melbourne. https://vfa.vic.gov.au/__data/assets/pdf_file/0005/443138/Victorian-Fisheries-Authority-Annual-Report-2017-18.pdf

53. Pauly, D., Christensen, V., Guenette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R. and Zeller, D. (2002) Towards sustainability in world fisheries. *Nature* 418: 689-95.

54. Department of Primary Industries (2006) *Portland aquaculture fisheries reserve management plan*. Fisheries Victoria management report #39. Department of Primary Industries, Melbourne. https://vfa.vic.gov.au/operational-policy/fisheries-management-plans

55. Environment Conservation Council (2000) *Marine, coastal and estuarine investigation*. *Final Report.* Environment Conservation Council, Melbourne.

56. Gavine, F.M. and McKinnon, L.J. (2002) *Environmental monitoring of marine aquaculture in Victorian coastal waters: a review of appropriate methods.* Technical Report No. 46. Marine and Freshwater Resources Institute, Queenscliff. https://vfa.vic.gov.au/operational-policy/fisheries-management-plans/portland-aquaculture-fisheries-reserve-management-plan/environmental-monitoring-of-marine-aquaculture

57. Hickman, N. and Mercer, J. (2006) *Protocol for the translocation of mussels*. Fisheries Victoria Management Report Series No. 26. https://vfa.vic.gov.au/operational-policy/moving-and-stocking-live-aquatic-organisms/protocol-for-the-translocation-of-blue-mussels

58. Gavine, F., Ingram, B. and Doroudi, M. (2009) *Development of management strategies for herpes-like virus infection in abalone.* Fisheries Research and Development Corporation Project No. 2006/243. https://vfa.vic.gov.au/operational-policy/pests-and-diseases/abalone-disease/research-and-surveillance/development-of-management-strategies-for-herpes-like-virus-infection-in-abalone#

59. McKenzie, F. (2018) *Coastal demographics in Victoria*. Background research paper prepared by Land Use and Population Research Branch, Department of Environment, Land, Water and Planning. Melbourne.

60. Department of Primary Industries (2005) *Pinnace channel fisheries aquaculture reserve management plan*. Fisheries Victoria management report #31. Department of Primary Industries, Melbourne. https://vfa.vic.gov.au/operational-policy/fisheries-management-plans

61. Department of Primary Industries (2005) *Geelong arm aquaculture fisheries reserve management plan.* Fisheries Victoria management report #34. Department of Primary Industries, Melbourne. https://vfa.vic.gov.au/operational-policy/fisheries-management-plans

62. Kirkendale, L., Robertson-Andersson, D.V. and Winberg, P.C. (2010) *Review on the use and production of algae and manufactured diets as feed for sea-based abalone aquaculture in Victoria*. Report by the University of Wollongong, Shoalhaven Marine and Freshwater Centre for the Department of Primary Industries, Fisheries Victoria. https://ro.uow.edu.au/smfc/

63. James, D.S., Day, R.W. and Shepherd, S.A. (2007) Experimental abalone ranching on artificial reef in Port Phillip Bay, Victoria. *Journal of Shellfish Research* 26: 687-695.

64. Department of Environment and Primary Industries (2014) *Sea urchin fishery baseline management arrangements*. Department of Environment and Primary Industries, Melbourne. https://vfa.vic.gov.au/__data/assets/pdf_file/0020/340661/Sea-Urchin-Fishery-Baseline-Management-Arrangements_FINAL_03072014.pdf

65. Department of Primary Industries New South Wales (2018) *Prawns- aquaculture prospects*. https://www.dpi.nsw.gov.au/fishing/aquaculture/publications/species-saltwater/prawns

66. Jahangard, S., Williams, M., Mercer, J.A., Ab Rahim, E. and Ingram, B.A. (2010) *A technical report on hatchery production of blue musse*l Mytilus galloprovincialis *at the Victoria Shellfish Hatchery (VSH), Queenscliff – 2008*. Fisheries Victoria Technical Report No. 112. Department of Primary Industries, Queenscliff.

67. Henry, G.W. and Lyle, J.M. (2003) *The national recreational and indigenous fishing survey*. FRDC Project No. 99/158. NSW Fisheries Final Report Series No. 48. http://www.frdc.com.au/project/1999-158

68. Ryan, K.L., Morison, A.K. and Conron, S. (2009) *Evaluating methods of obtaining total catch estimates for individual Victorian bay and inlet recreational fisheries*. Final report to Fisheries Research and Development Corporation Project No. 2003/047. Department of Primary Industries, Queenscliff. http://www.frdc.com.au/project/2003-047

69. VRFish (2017) *Survey of fisher priorities 2017*. VRFish. https://www.vrfish.com.au/wp-content/uploads/2018/03/Survey-summary.pdf

70. Victorian Fisheries Authority (2018c) *Victorian recreational fishing guide 2018*. Victorian Fisheries Authority, Melbourne. https://vfa.vic.gov.au/recreational-fishing/recreational-fishing-guide

71. Victorian Environmental Assessment Council (VEAC) (2016) *Statewide assessment of public land*. *Discussion paper*. Victorian Environmental Assessment Council, Melbourne. http://www.veac.vic.gov.au/investigation/statewide-assessment-of-public-land/reports

72. Victorian Fisheries Authority (2017b) *Recreational fishing licence trust account 2016-17. Report to each House of Parliament on the disbursement of Recreational Fishing Licence revenue*. https://www.parliament.vic.gov.au/file_uploads/Recreational_Fishing_Licence_Trust_Account_Report_2016-17_CxhgzgHB.pdf

73. Fisheries Victoria (1998) *Native fish releases 1993-94 to 1997-98*. Fisheries Note FN 0144. https://vfa.vic.gov.au/recreational-fishing/fish-stocking/fish-stocking-reporting

74. Fisheries Victoria (2000) *Native fish releases 1999-2000*. Fisheries Note FN 0152. https://vfa.vic.gov.au/recreational-fishing/fish-stocking/fish-stocking-reporting

75. Department of Primary Industries New South Wales (2014) *Marine fish stocking fishery management strategy*. Department of Primary Industries, Sydney. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/630683/marine-fish-stocking-fishery-management-strategy.pdf

76. Green, C.P. (2013) *Victorian fish aggregation devices – feasibility assessment and concept design*. Recreational Fishing Grant Program research report. Department of Primary Industries, Melbourne. https://www.vrfish.com.au/wp-content/uploads/2018/11/RFL_VIC-FADs-Report_FINAL_20130326.pdf

77. Koopman, M. and Hotchin, J. (2008) *Trial of fish aggregation devices in Victorian waters. Final report.* Fishy Business Consulting, Geelong. https://vfa.vic.gov.au/about/publications-and-resources/fisheries-reports/your-licence-fees-at-work-reports/2003-2008/trial-of-fish-aggregation-devices

78. Dempster, T. and Taquet, M. (2004) Fish aggregation device (FAD) research: Gaps in current knowledge and future directions for ecological study. *Reviews in Fish Biology and Fisheries* 14: 21-42.

79 Brickhill, M.J., Lee, S.Y. and Connolly, R.M. (2005) Fishes associated with artificial reefs: attributing changes to attraction or production using novel approaches. *Journal of Fish Biology* 67: 53-71.

80. Cullen-Knox, C., Eccleston, R., Haward, M., Lester, E. and Vince, J. (2017) Contemporary challenges in environmental governance: technology, governance and the social licence. *Environmental Policy and Governance* 27: 3-13.

81. Taylor, M. (2010) *Marine stocking in Victoria: a preliminary assessment of the potential suitability of Victorian waters selected for fish releases*. University of New South Wales, School of Biological Earth and Environmental Sciences. https://vfa.vic.gov.au/recreational-fishing/fish-stocking/marine-stocking-in-victoria

82. Bartholomew, A. and Bohnsack, J.A. (2005) A review of catch-and-release angling mortality with implications for no-take reserves. *Review in Fish Biology and Fisheries* 15: 129-154.

83. Nunn, P.D. and Reid, N.J. (2016) Aboriginal memories of inundation of the Australian coast dating from more than 7000 years ago. *Australian Geographer* 47: 11-47.

84. Eastern Maar Aboriginal Corporation (2015) *Eastern Maar meerreengeeye ngakeepoorryeeyt country plan.* Prepared by Eastern Maar Aboriginal Corporation with assistance from Native Title Services Victoria. http://easternmaar.com.au/wp-content/uploads/2012/10/EM_CountryPlan_FINAL.pdf

85. Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) (2015) *Gunaikurnai Whole-of-Country Plan*. Plan developed by Gunaikurnai Land and Waters Aboriginal Corporation with assistance from Native Title Services Victoria. https://www.gunaikurnai.org/wp-content/uploads/gk_whole-of-country%20plan%20LR%20FINAL%20270815.pdf

86. Drew, M.M., Koehn, J., Clunie, P. and McCristal, N. (2008) *A guide to the management of native fish: Victorian coastal rivers, estuaries and wetlands.* Arthur Rylah Institute for Environmental Research and Corangamite Catchment Management Authority, Victoria. http://www.ccmaknowledgebase.vic.gov.au/resources/NativeFishGuide.pdf

87. Gunditj Mirring Traditional Owners Aboriginal Corporation (2013) *Cultural features of the Budj Bim Landscape: short-finned eel (Kooyang)*. Gunditj Mirring Partnership Project Fact Sheet. https://www.gunditjmirring.com/gunditj-mirring-fact-sheets?lightbox=i172ly

88. Smyth, L., Egan, H. and Kennett, R. (2018) *Livelihood values of indigenous customary fishing. Final report to the Fisheries Research and Development Corporation, Canberra.* Australian Institute of Aboriginal and Torres Strait Islander Studies. FRDC project number 2015/205. http://www.frdc.com.au/Archived-Reports/FRDC%20Projects/2015-205-DLD.pdf

89. Fisheries Victoria (2012) *Victorian Aboriginal fishing strategy*. Fisheries Victoria. https://vfa.vic.gov.au/aboriginal-fishing

90. Christoff, P. (2008) Places worth keeping?: global warming, heritage and the challenges to governance. *Historic Environment* 21: 41-44.

91. Parks Victoria (2015) *Ngootyoong Gunditj Ngootyoong Mara South West Management Plan*. Parks Victoria, Melbourne. https://parkweb.vic.gov.au/explore/parks/mount-eccles-national-park

12 Ports and Shipping

This chapter provides a discussion of the location and types of ports along the Victorian coast and their current and future role in supporting trade to and from Victoria. The discussion covers shipping routes, navigation, anchorages, maintenance of channels and operational constraints associated with the marine environment, impacts of climate change and increased demand. Other issues and threats that may impact ports and shipping that are discussed include marine pests, ballast water, hull fouling, oil and chemical spills and land constraints for port expansion.

KEY POINTS AT A GLANCE

- Ports are now part of complex supply chains that link road, rail and sea transport.
- Victoria has four commercial ports: Port of Melbourne, Port of Hastings, Port of Geelong and Port of Portland. There are also fourteen local ports managed by eight local port managers including Parks Victoria, Gippsland Ports and local councils.
- The initial construction of port facilities often involved substantial impacts on sensitive environments through dredging and land reclamation. Present day maintenance (such as dredging) and upgrading of port facilities is conducted with much more attention on understanding and mitigating these environmental impacts.
- The Port of Melbourne is Victoria's only container port. Over the past ten years, the volume of all trade through the port has grown by 3.2 per cent annually. This growth is projected to continue, with strongest growth predicted in container trade. While the Port of Melbourne has capacity to more than double the volume of container trade, long-term plans have been developed for a second container port, Bay West, near Werribee.
- More than 4000 ships visit Victorian ports annually, with about 3200 visiting the Port of Melbourne.
- Locations at highest risk of shipping accidents and spillages are the ports of Melbourne, Geelong and Hastings as well as Port Phillip Heads. These areas are associated with the greatest levels of nearshore shipping activity and, in the case of the ports, an additional threat posed by oil transfer activities.
- Once outside port waters, ships take the shortest route to the next port of call, with these routes mostly outside of Victoria's coastal waters. Exceptions are for routes around Cape Nelson for ships visiting Portland, and Cape Otway and Wilsons Promontory for ships visiting Port Phillip Bay and Western Port.
- To reduce the risk of ship collisions in Bass Strait, there are two traffic separation schemes. Eastbound and westbound shipping lanes have been established for ships to pass the islands south of Wilsons Promontory and also for ships to pass between the oil rigs in Bass Strait.
- To accommodate increasing volumes of trade, ships are becoming longer and wider but not deeper. Increasing draught would impact on the ability of ships to use existing port infrastructure, including channels and berths.
- Climate change impacts on port infrastructure in Victoria are predicted to be low, as many engineering solutions are already in place to accommodate rising sea levels and changing ocean chemistry. Port authorities could be faced with substantial costs to upgrade or retrofit infrastructure if design standards are upgraded.
- Concerns exist about the impact of ship anchors on sensitive benthic environments, particularly within marine protected areas.
- There is substantial latent capacity in Victoria's commercial ports. If capacity is reached, the ability to expand existing ports depends on surrounding land uses, environmental sensitivities and connectivity to road and rail networks.
- While port authorities may collect extensive monitoring data around specific impacts or activities, often this information is either unavailable to the public because it is commercial in confidence or is not broadly informative because it was collected for a very targeted purpose.

The broad categories of threats to ports and shipping are summarised and examples are provided for each threat in table 12.1; for more detail see the relevant section of this chapter. Discussion of threats in this chapter are threats to ports and shipping. The threats that ports and shipping might pose to other values are discussed in the relevant chapter.

Table 12.1 Summary of threats to values associated with ports and shipping in Victoria

Threat class	Pathway/outcome	Example (with section reference)
Climate change	Altered oceanography – change to prevailing currents, waves and wind	Larger berth infrastructure (e.g. quay cranes) become more expensive to build and replace to allow for increased design standards, particularly around wind loading (12.3.1)
	Sea level rise	Areas for layout and storage and access roads to the port may be at lower elevation so are at greater risk of inundation and erosion (12.3.1)
	Increased storm frequency and storm surge	Navigation aids may be damaged in storms. Increased design standards could impose additional construction and/or replacement costs (12.3.1)
	Ocean acidification	Ocean acidification could lead to requirement for additional cathodic protection with increased installation, replacement and power supply costs (12.3.1)
Physical	Degradation of coastal infrastructure	Between 20 and 30 per cent of coastal protection assets are in poor condition and 30 to 50 per cent have less than 10 years of useful life remaining (9.7.3)
Biological	Marine pests	Increased obligations on high-risk vessels operating within Australian waters to assist in reducing the introduction and spread of invasive marine pests via ballast water (12.3.3)
	Biofouling	Failure to manage biofouling marine pests can result in ships being refused entry to some ports or being required to undertake works to remove the risk of transfer (12.3.3)
Catchment processes	Sedimentation	Maintenance dredging is required to remove build-up of sediment and ensure minimum depths are maintained in entrance channels and areas adjacent to berths (12.1.3)
Pollution	Oil and chemical spills	Oil and chemical spills lead to costly emergency clean-up costs, damage infrastructure and limit access (12.3.2)
	Litter	Catchment-sourced litter collects in sheltered areas where ports are typically located, creating nuisance impacts and costs to clean up (9.7.6)
	Toxic sediments	Disposal of dredge spoil containing contaminated sediments is more complicated and costlier (12.1.3)
Community/industry demand	Expansion of tourism and recreation activities	There is increasing expectation that ports will become more integrated with local communities. This will require substantial redesign and planning (12.4)
	Competing land use demands	Coastal land will increasingly come under pressure from rising sea levels and urban growth, which may limit opportunities for port expansion (9.8.5)
	Global economy	Ports are impacted by economic downturns both locally and internationally that lead to slowdowns in both imports and exports (12.2.4)
	Requirements for safety and sustainability	If design standards are increased to withstand climate change there could be additional construction or replacement costs (12.3.1)

12.1 Ports and harbours

Safe harbours were critical to the development of trade and defence of Victoria's economy in the 1800s (see chapter 8 for discussion of early maritime history). The development of ports and shipping allowed the transport of goods and communication with the rest of world. As Victoria's dependence on road, rail and air transport increased, our needs for ports and shipping also changed.

Ports are now part of an integrated transport system with connections to road and rail as important as the seafaring side of trade. Complex supply chains exist, moving product from regional communities, transporting cars from ports to dealerships and servicing cities with building materials, groceries and consumer products.

Over time the size of ships – length, width and depth – has changed, as has the way cargo is transported. Since the 1950s there has been a steady increase in the containerisation of freight, which has required significant changes to the landward side of ports with more storage area and reliance on road and rail for transfer to distribution centres and industrial areas away from ports.[1]

12.1.1 Commercial ports

Victoria currently has four major ports at Melbourne, Hastings, Geelong and Portland. The Port of Melbourne is Victoria's only container port; the other ports handle a mix of dry bulk, break bulk and liquid bulk. Table 12.2 describes the characteristics and current trades of each port.

Table 12.2 Victoria's major ports – characteristics and current trades[1]

Port	Melbourne	Geelong	Hastings	Portland
Owner	Leased by State	Private	State	Private
Berths	34	16	3	6
Land (hectares)	510	226	Long Island Point: 6.2 Crib Point: 4.8 Stony Point: 1.9	65
Channel depth (metres)	15.5 to Williamstown 14.6 in Yarra Channel	12.3	14.2	12.1
Maximum vessel draught with tidal assist (metres)	14.7 tankers 14 container ships	12	15	12.9
Trades	Containers, dry bulk, break bulk, liquid bulk	Liquid bulk, break bulk, dry bulk	Liquid bulk, break bulk	Dry bulk, break bulk

Commercial shipping in Port Phillip Bay is managed by the Victorian Ports Corporation (Melbourne) for Port Phillip Bay and Melbourne, and the Victorian Regional Channels Authority for the approaches to the Port of Geelong. Responsibilities for the commercial operations within the port lie with Port of Melbourne Operations Pty Ltd and Geelong Port respectively. Victorian Ports Corporation and Victorian Regional Channels Authority both provide the harbour master function, which includes shipping control, oversight of channel management and the provision of navigation aids.

The Victorian Regional Channels Authority also manages the commercial navigation of the channels for the Port of Hastings (includes access to jetties at Long Island and Crib Point) and oversees the channel management for the Port of Portland.

Container ship being unloaded, Port of Melbourne. Photo: A Kilborn

Container ship being assisted by two tugs, Port of Melbourne. Photo: A Kilborn

Port of Melbourne

The Port of Melbourne is located at the northern end of Port Phillip Bay within the Yarra River estuary and Hobsons Bay. The port covers around 500 hectares of land and has more than 30 commercial berths for shipping a diverse range of containerised, general and bulk cargo.

Much of the area, which extends west from the Bolte Bridge to the west bank of the Maribyrnong River and south from the West Gate Freeway to the bay, has required significant engineering works to reshape the rivers and original wetlands to improve access and navigation for ships and their cargos.

A system of channels within Port Phillip Bay allows large ships to enter the bay and navigate to the ports of Melbourne or Geelong. These channels are shown in figure 12.1.[1]

The difficulty of navigating these channels, particularly the entrance to Port Phillip, has prompted the Melbourne Harbour Master to require all ships to engage a pilot. The Harbour Master also restricts the size of vessels that can enter the bay and under what conditions.

Ships approaching from Bass Strait must first pick up a pilot at the boarding ground outside the heads, then navigate through the heads using one of several channels. Nearly all container ships use the Great Ship Channel, the deepest through the heads.

Once inside the entrance, ships must turn east and follow the South Channel to cross the Great Sands, a large shallow area in the southern part of the bay. At the end of the South Channel, close to Rosebud, ships turn around the Hovell Pile and head north to the Port Melbourne Channel, north-west to the start of the Geelong channel near Portarlington, or to the anchorage on the western side of the bay.

The Port Melbourne Channel starts at Fawkner Beacon and runs north to Station Pier. Cargo ships heading for the Port of Melbourne turn into the Williamstown Channel which leads to the mouth of the Yarra and Webb Dock. Around Williamstown the ship is joined by one or more tug boats which will assist it manoeuvring to its berth.

The Port of Melbourne includes Australia's largest container terminal at Swanson Dock and an automotive trade terminal at Webb Dock that can handle up to 1000 motor vehicles per day. The port has multipurpose terminals for handling a variety of non-containerised pack types including farm equipment and machinery and breakbulk commodities such as timber, paper, iron and steel. There are also specialised berths that handle dry cargo including cement, sugar, grain and gypsum, and bulk liquids from petrochemicals to crude oil and molasses.

Of the 3200 ships that visited the port in 2017-18, about a third were container ships. The port can handle approximately 8000 containers movements in and out and around the port each day. Full export containers arrive at the port to be loaded onto visiting ships, and full import containers are collected from the port to begin the land leg of their journey to storage or their end user. The movement of empty containers constitutes around 21 per cent of all shipments through the port.

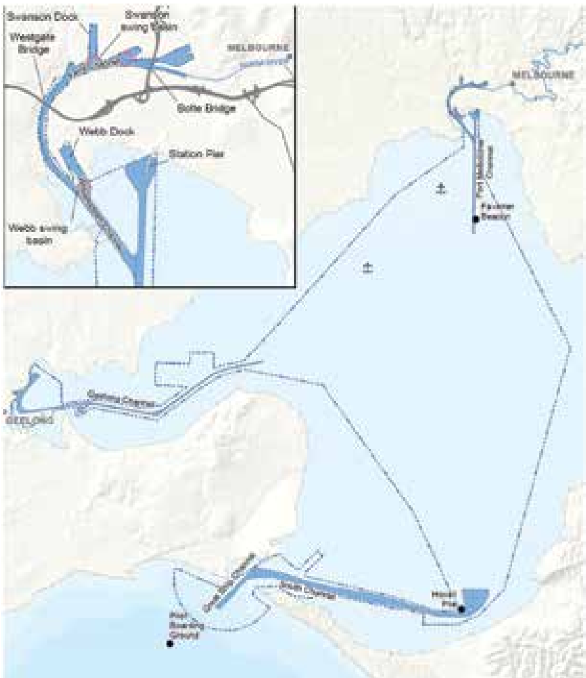
Following the granting of a 50-year lease of the port in 2016, the roles and responsibilities of port-related operators and the government changed. Port of Melbourne Operations Pty Ltd is the private operator of the port and is responsible for planning, operating and maintaining port land and shipping channels. This means ensuring the port has the capacity and capability needed to handle cargo and that facilities and infrastructure are developed and maintained.[2]

Victorian Ports Corporation (Melbourne) (VPCM) is the government-owned entity responsible for the management of commercial shipping navigation in Port Phillip Bay, waterside emergency and marine pollution response, and the planning, management and operation of Station Pier (cruise and passenger shipping terminal). The Harbour Master also sits within VPCM and is responsible for safe navigation in the port's waters, as well as emergency management, health and safety.

Marine pilots are employed by shipmasters to guide commercial vessels through dangerous and often congested waters. Private operators provide tugs for manoeuvring large vessels within the port.

Stevedoring companies are responsible for servicing visiting vessels, unloading and storing cargo until it is collected and loaded onto trucks and trains for onward transport. A range of private companies transport cargo to and from the port by rail and road. These companies use specialist transport equipment, such as container trucks, car carriers, road tankers and grain trains to connect the port to importers and exporters.

Figure 12.1 Port Phillip Bay channels and waters under the control of port authorities (within dashed line)[1]



Port of Geelong

Geelong is the largest regional port in Victoria and an important hub for the movement of cargo into and out of the state. It is a major driver of Victoria's economy, managing more than $7 billion of trade and generating more than 1800 jobs across the state. The port handles over 12 million tonnes of cargo annually, with more than 600 vessel visits per year.

Waters within the Port of Geelong are managed by the Victorian Regional Channels Authority (VRCA). The commercial wharves and piers are owned by the port operator, Geelong Port (except for Point Wilson Explosives Pier, which is owned by the Commonwealth Government, and Bulk Grain Pier Number 3 Berth which is owned by Graincorp).

The port handles a wide variety of cargoes including bulk liquid (crude oil, petroleum, and chemicals), unitised aluminium, break bulk (steel, timber) and dry bulk (including alumina, calcite, fertilisers, grain, and woodchips). In addition, Point Wilson handles dangerous and explosive cargoes exclusively and Cunningham Pier provides berthing for cruise ships.

Dredging is a routine part of maintaining and improving Geelong's shipping channels. It has occurred periodically during the past 150 years and is an important activity in ensuring the port and its channel network can operate at capacity. The last major capital dredging works were in 1997, when the entrance channel was deepened by one metre. Monitoring after the channel deepening project revealed no long-term health effect on the bay's marine environment. In 2014, the VRCA commenced another round of maintenance dredging and minor deepening works at Corio Quay North No 4, taking the channel depth to 12.3 metres.[3]

Port of Hastings

The Port of Hastings includes Stony Point wharf and harbour tug services, Crib Point jetty and petroleum product transfer facilities, Long Island Point oil and gas plant jetty and the BlueScope Steel wharf (figure 12.2).

The port receives about 100-150 vessels each year, with a trade value of approximately $1.4 billion.[4] The port's main trade commodities include crude oil, liquified petroleum gas (LPG), unleaded petrol, diesel and steel. The port is significantly underutilised with a capacity to handle 2000 vessel movements per year. During the peak of oil exports in the 1970s and 1980s the port accepted more than 600 ship visits a year.[1]

Port of Geelong. Photo: G21 Geelong Region Alliance

Tugs tied up at Stony Point wharf. Photo: R Molloy

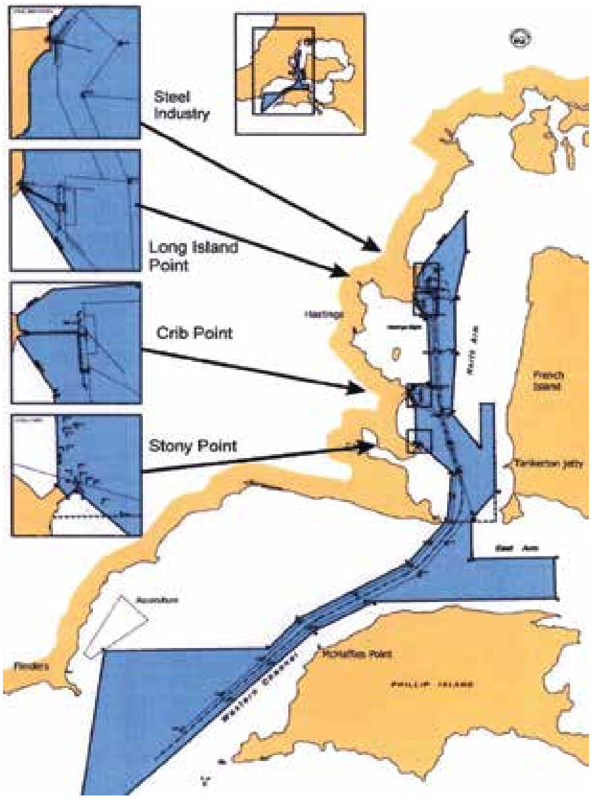
The main entrance and channel into Western Port is relatively wide and deep. Sheltered waters in the east arm between Phillip Island and French Island provide safe anchorage for ships waiting to dock. The approach channels have minimum depths of more than 14 metres, and a tidal range of more than 2 metres, which allows ships of around 15 metres draught to use the port. The channels, which are about the same depth at low tide as those in Port Phillip Bay, have the advantage of requiring less maintenance dredging because of the strong tidal currents.

The Port of Hastings Development Authority is a public entity established in January 2012 under the *Transport Integration Act 2010*. They are responsible for managing port operations, including maintaining the associated port infrastructure (except for the BlueScope-owned steel wharf). Management of the channels in Western Port is the responsibility of the Victorian Regional Channels Authority.

In July 2017, the Port of Hastings Development Authority assumed responsibility for the management of landside port operations following the expiry of the agreement under which day to day port operations were managed by Linx Cargo Care and its predecessors such as Patricks Ports (Linx). The authority's operations are currently fully funded via the revenues it receives from port operations.[4]

In addition to management of day to day operations, the port authority is planning for projected increases in bulk trades. This includes upgrading the second berth at Crib Point jetty following the announcement by AGL Limited that it was the preferred location for installation of a floating storage and regasification gas unit. If the proposal proceeds, there could be 40 additional tanker arrivals per year to supply the unit with liquified natural gas for conversion into its gaseous form for distribution into the supply network.

Figure 12.2 Port waters of the Port of Hastings



Port of Portland

The Port of Portland is an important regional port for western Victoria's rich agricultural, forest products, aluminium, mineral sands and fertiliser industries. The port, which is privately owned by Port of Portland Pty Ltd, was purchased from the state government in 1996. The port waters are managed by the Port of Portland on behalf of the Victorian Regional Channels Authority.

While the port traces its history back to the 1800s, it only became a commercial all-weather port in 1960 after extensive construction works including land reclamation, dredging and breakwater construction.[5]

Livestock carrier Anna Marra at Portland. Photo: Owen Foley, Above & Beyond Photography

The port comprises five bulk cargo berths including a dedicated smelter berth, a tug berth and bulk storage facilities. The port also owns Lee Breakwater which forms the northern boundary of the harbour. The commercial and recreational fishing precinct, known as Trawler Wharf, is located adjacent to the port, as part of the Portland local port and is managed by the Glenelg Shire Council.

The port is bordered by a mix of industrial and public park and recreation zones, with the residential community relatively buffered from operations within the port due to the local topography of the area.

The port handles export cargoes including grain, woodchips, logs, aluminium, livestock and timber products, and imports including alumina, petroleum coke, fertilisers, sulphuric acid, liquid pitch and mineral sands. The port also receives several visits from cruise ships during summer.

Figure 12.3 Port of Portland precinct plan[5]

Barry Beach Marine Terminal

The Barry Beach Marine Terminal near Port Welshpool in Corner Inlet is the main supply depot for Exxon Mobil's Bass Strait oil and gas operations. It was established in 1968 to service the Bass Strait oil and gas fields. In 2017 Esso awarded a contract to Qube Energy to operate the terminal on its behalf, as well as having the ability to offer the port facilities to third-party businesses.

The terminal provides warehousing and transport of food, supplies, fuel and equipment to the offshore platforms and installations that serve as bases for drilling, oil and gas production and processing. It is a critical service for the 300 personnel and contractors who live and work on the offshore platforms.

The 400-metre wharf with a channel depth of six metres can accommodate small to medium-sized supply vessels, such as the MV TEK-Ocean Spirit (2775 gross tonnage). Every year, around 70,000 tonnes of cargo is shipped to the Bass Strait platforms from Barry Beach.

12.1.2 Local ports

There are 14 local ports in Victoria, under the management of eight local port managers (table 12.3). Under the *Port Management Act 1995*, Parks Victoria is nominated as the manager of local ports in Port Phillip Bay and Western Port, and Gippsland Ports is the manager of local ports between Anderson Inlet and Mallacoota, which includes ports within Corner Inlet and the Gippsland Lakes. In other coastal areas, local governments have been allocated similar responsibilities.

Local ports provide safe havens and services to fishing vessels, charter boats, recreational boats and small commercial vessels. Most local ports, in addition to providing the opportunity to berth alongside a jetty, offer mooring grounds for permanent and temporary storage of boats.

Local port managers are responsible for the operation and maintenance of local ports, including:

- planning
- issuing permits and licences
- allocating moorings
- maintaining wharves, jetties and navigation aids
- dredging
- operating facilities such as slipways
- constructing new facilities.

Parks Victoria is the waterway manager for the Yarra, Maribyrnong and Patterson rivers under the *Marine Safety Act 2010*. This role includes responsibility for navigation and vessel movement, removing and marking in-water obstructions, and channel maintenance. Local governments are given similar roles under the Marine Safety Act for local waterways, including many of the estuaries and inlets along the coast.

Public jetties and piers within Port Phillip Bay and Western Port are part of the local port and are managed by Parks Victoria. These include piers and jetties at Queenscliff, Portarlington, St Kilda, Patterson River, Frankston, Mornington, Rosebud, Rye, Sorrento and Portsea in Port Phillip Bay. Flinders, Hastings, Tooradin, Corinella, San Remo, Tankerton, Rhyll and Cowes in Western Port.

Table 12.3 Local ports and port managers

Local port	Local port manager
Portland Bay	Glenelg Shire Council
Port Fairy	Moyne Shire Council
Warrnambool	Warrnambool City Council
Port Campbell	Parks Victoria
Apollo Bay	Colac Otway Shire Council
Lorne	Corangamite Shire Council
Barwon Heads	Surf Coast Shire Council
Port Phillip Bay (includes Queenscliff)	Parks Victoria
Westernport	Parks Victoria
Anderson Inlet	Gippsland Ports
Corner Inlet	Gippsland Ports
Gippsland Lakes	Gippsland Ports
Snowy River	Gippsland Ports
Mallacoota	Gippsland Ports

12.1.3 Port maintenance

Dredging is an important responsibility of port managers and is required to both maintain and improve the functionality of ports and shipping channels.

Capital dredging programs occur when a channel needs to be substantially altered by increasing the depth or making it wider. Examples of significant capital dredging projects in Victoria include the Port Phillip Bay channel deepening completed in 2009, and the Geelong Channel and Corio Bay channel deepening completed in 1997. These projects required comprehensive environment impact assessments and management plans prior to approval of the projects and to guide operations during the dredging activities.

Maintenance dredging programs are required from time to time to remove build-up of sediment and ensure minimum depths are maintained in entrance channels and areas adjacent to berths. Maintenance dredging occurs in all ports to some extent and is subject to consent under the *Marine and Coastal Act 2018*.

In most cases impacts from dredging and spoil disposal are relatively short term although any impacts can cause considerable public concern. For example, discharge of black anaerobic sand onto sandy beaches looks and smells unpleasant, but the environmental impacts are minimal and a typical sand colour returns after a few days exposure to air.[6] Where the impacts of dredging are poorly known the EPA's dredging guidelines suggest further monitoring and targeted research.

Table 12.4 provides volumes and frequency of dredging undertaken in Port Phillip Bay and Western Port for Parks Victoria. Maintenance dredging at Patterson River Entrance and Queenscliff Entrance is nearly continuous to counter the naturally high sedimentation rates. Similarly, at Lakes Entrance maintenance dredging of about 200,000 cubic metres per year is required to maintain safe use of the entrance and inner channel.

The Tommy Norton trailer suction hopper dredge is used to maintain ocean access to Bass Strait. Photo: Gippsland Ports

Table 12.4 Historical (2006-2017) and estimated (2018-2027) maintenance dredging frequency and volumes for local ports in Port Phillip Bay and Western Port[7]

Location/Asset	Dredging program 2006-2017		2018-2027 dredging program	
	Total volume (cubic metres)	Number of times dredged	Estimated total volume (cubic metres)*	Estimated frequency^
Port Phillip Bay				
Patterson River Entrance	531,847	64	585,000	6 to 10 per year
Patterson River Estuary	-	-	^	infrequent ^
Queenscliff Entrance	800,730	69	880,000	6 to 10 per year
Queenscliff Moorings	35,000	1	up to 35,000 ^	once every 10 to 15 years ^
St Kilda Harbour Inner Landing	34,018	5	37,000	once every 1 to 2 years
Portarlington Harbour	59,481	3	42,000	once every 4 to 5 years
Mordialloc Creek Entrance	74,965	25	88,000	2 to 3 per year
Werribee River Entrance	196,243	7	75,000	once every 1 to 2 years
St Leonards Harbour	16,306	1	17,000	once every 5 years
Brighton Harbour	-	-	^	infrequent ^
Hampton Pier	-	-	15,000	once in 10 years
Western Port				
Tankerton Jetty	18,771	4	20,000	once every 2 to 4 years
San Remo Jetty	9,073	3	15,000	once every 4 to 5 years
Hastings Jetty	-	-	^	infrequent ^
Total all sites	**1,776,434**		**1,951,000 ^**	

- Not dredged
^ Volume and/or frequency dependant on sediment accumulation rates and navigational requirements
* Historical volume + 5% rounded to nearest 1000

Key steps in setting up a maintenance dredging program include hydrographic surveys to establish current and desired depths, and volume of material to be dredged and relocated; and sediment sample analysis to determine sediment characteristics and level of contamination.[6] The collected data are used to design the dredging program and to inform approval processes.

Sediment quality data collected for Parks Victoria suggest that the dredged material at most sites comprises uncontaminated sand and silty sand which are considered suitable for placement on adjacent beaches. Areas closer to more urbanised rivers and creeks have elevated concentrations of heavy metals and total petroleum hydrocarbons. These include areas such as Werribee South and Williamstown.[7]

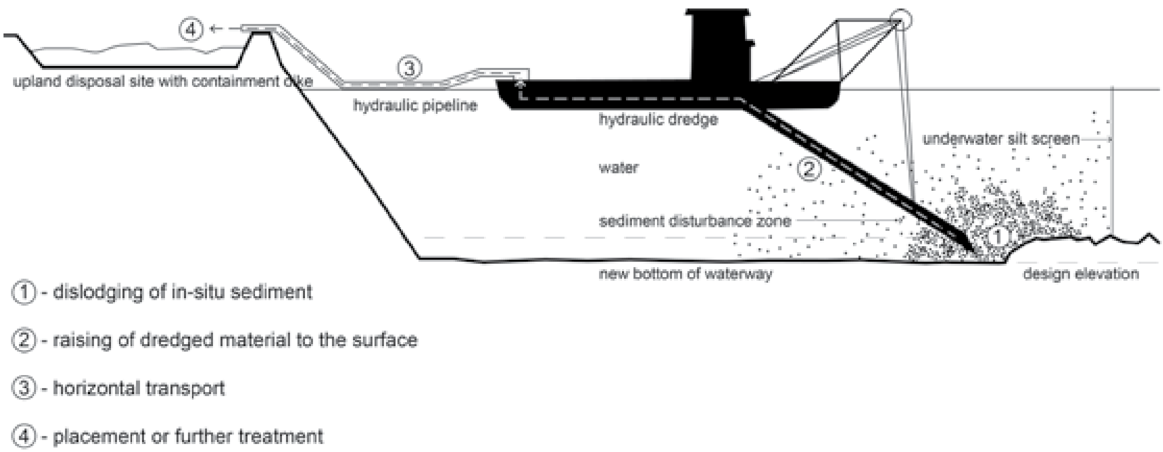
At Hampton Pier (adjacent to Sandringham Yacht Club and marina), sediment sampling indicates elevated concentrations of total petroleum hydrocarbons, cadmium, copper, lead, mercury, nickel and zinc. Given these higher levels of contaminants, the dredging plan suggests further sampling to better understand the nature of contamination and requirements for disposal.[7]

For dredging projects where disposal of dredged material to adjacent beaches is not an option, offshore dredged material grounds are used. Port Phillip Bay has three large disposal grounds, one in the north, another in the southeast and one in the Geelong Arm.

The Port of Melbourne Dredging Program 2012-22 indicates that a volume of about 3.8 million cubic metres over 10 years will need to be dredged to maintain safe navigation for vessels using the port. All sediments dredged from near the port are assumed to be contaminated unless otherwise demonstrated. Material that is contaminated is placed in the northern disposal ground and capped with a minimum 0.5 metre layer of clean sand. Spoil from the South Channel maintenance dredging program is disposed of in the southeast ground. It can also be used for capping contaminated material.[8]

DELWP is provided with a pre-dredging campaign report describing what dredging is to be undertaken, estimated volumes, bunding and capping requirements for contaminated materials, statutory approvals and environmental commitments. Following completion of the dredging campaign a close-out report is prepared within 90 business days and provided to government agencies. The report includes a summary of all dredging activities, compliance with project delivery standards, environmental performance monitoring, and post-dredging inspections and surveys to confirm outcomes.[8]

Figure 12.4 Dredging and dredged material placement using a cutter suction dredge – system typical of those used by local port managers for maintenance dredging. Dredged material can be used to renourish nearby beaches.



12.2 Shipping

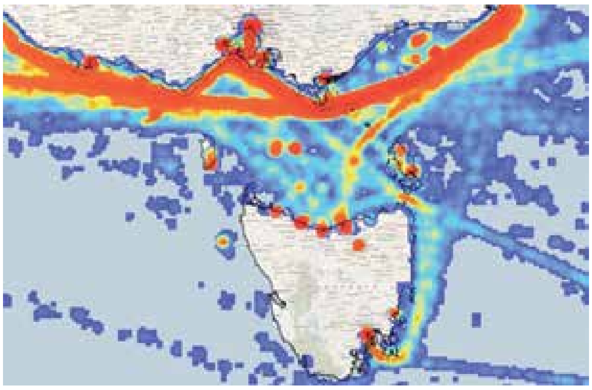
Ships travelling through Victorian waters must follow rules and regulations defined by the International Maritime Organisation, Australian Marine Safety Authority, Marine Safety Victoria and port-appointed harbour masters.

12.2.1 Navigation

Ships use designated channels within the bays and once outside and away from the coast can take the shortest route to the next port of call. The routes taken are mostly outside of Victoria's coastal waters. Exceptions to this are the passages around Cape Nelson for entrance to the Port of Portland, and around Cape Otway and Wilsons Promontory for ships visiting Port Phillip Bay or Western Port.

Analysis of ship transit data from the Australian Ship Reporting System (AUSREP) displays the common routes travelled by vessels (shown in red in figure 12.6). Some vessels are shown to pass close to prominent headlands along the Victorian coast, giving concern that should an accident occur with any of these vessels environmental impacts would be significant.[9]

Figure 12.6 Visualisation of AUSREP shipping data[9]

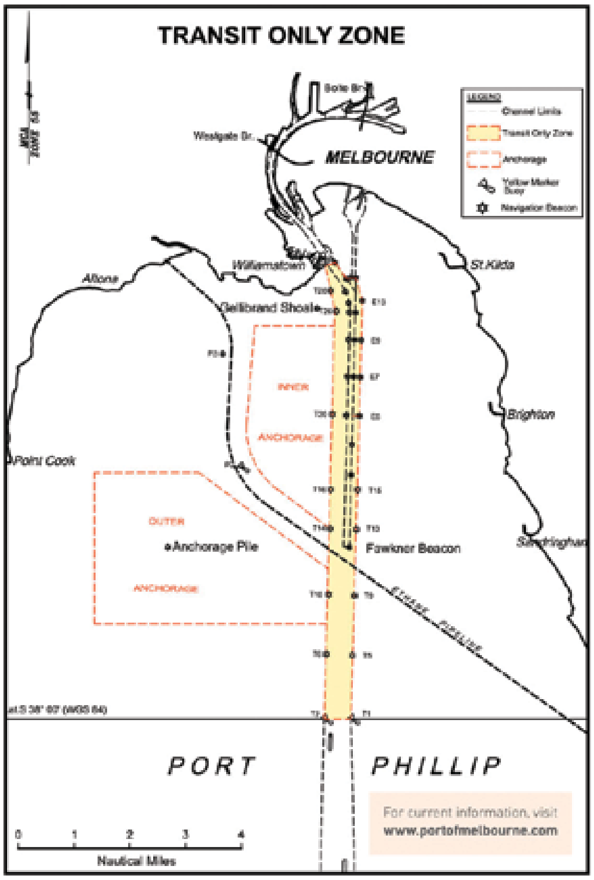


There are two traffic separation schemes operating in Bass Strait to prevent ship collisions at sea. The first is in Commonwealth waters off Gippsland and is designed to guide shipping through the offshore oil fields, as damage to a structure or pipeline could endanger lives and disrupt production. This scheme consists of a 1.5 nautical mile-wide separation zone and an eastbound and westbound shipping lane. An 'area to be avoided' is declared for large ships of more than 200 gross tonnage.

A second scheme is located south of Wilsons Promontory in Victorian waters and consists of a separation zone encompassing islands and shoals, and an eastbound and westbound shipping lane. The area between Wilsons Promontory and the northern separation line (39°12' South) is designated as an inshore traffic zone, and is not for large vessels in transit.

Within port waters, 'transit only zones' have been established. These are regulated areas of water in the vicinity of a commercial shipping channel or fairway where recreational craft must not anchor or drift. The purpose of these zones is to avoid potential collisions between small boats and large commercial ships, and to ensure the safety of small boat operators and their passengers. A transit only zone in Port Phillip Bay extends from Point Gellibrand (Williamstown) south to a line at latitude 38° South (figure 12.6). Yellow 'special mark' light buoys are used to define the zone (refer to the Vessel Operating and Zoning Rules provided by Marine Safety Victoria).

Figure 12.6 Transit only zone in Port Phillip Bay. Also shown are the two anchorages used by ships waiting for berths in the port to become available



12.2.2 Anchorages

Anchorages are designated areas within port waters where vessels can anchor or moor temporarily prior to permission to move to a berth at a wharf. In Port Phillip Bay there are two large anchorages for commercial shipping, the inner anchorage and the outer anchorage (see figure 12.7).

Ships may also choose to anchor in deeper waters outside designated port areas. However, caution needs to be exercised by the ship's captain to ensure that anchoring does not result in damage to the seabed or any infrastructure on the seabed. The following incident that occurred in Victorian waters highlights the risks associated with ships anchoring in open waters.

In September 2016 the MV Pretty Ivy, a 180 metre-long bulk carrier of 35,000 gross tonnage, was observed by Parks Victoria staff to be at anchor in the Point Addis Marine National Park. The vessel remained in the park for three days and swung around its anchor in a circle approximately 200 metres in diameter. The anchor chain was assumed to have dragged along the seafloor raising concerns that it may have caused severe and long-term damage to between 6 to 10 hectares of sensitive marine benthic habitat.[10]

A subsequent towed video survey of the seabed showed that anchor chain had narrowly missed an area of significant marine fauna. The mapping program identified extensive and diverse sessile invertebrate communities including sea squirts, soft corals, sponges and coral fans, in close proximity to the site. It was by luck that the ship had not laid anchor on this community; if it had there would have been a significant impact.

The issue highlighted the problem that vessels of any size can anchor inside a marine national park or marine sanctuary, although it is an offence if they damage flora and fauna in the park. It is difficult to undertake benthic surveys to assess damage. It is also difficult to monitor where large vessels anchor, without an active monitoring program to check vessel movements within marine protected areas. Parks Victoria have identified a number of actions that need to be implemented to avoid issues of this nature occurring in marine national parks and marine sanctuaries.[10]

12.3 Threats to ports and shipping

Climate change impacts to port infrastructure

The following discussion of threats for port operators is based on discussion with Port of Melbourne staff and is likely to be representative of most port operators.

The level of threat from rising sea levels will be dependent on the elevation of port infrastructure. For example, most wharves operated by the Port of Melbourne are at least 2.7 metres above and, in many cases, much higher than sea level and are not predicted to be materially affected over the next 30 years. However, areas for layout and storage and access roads to the port may be lower and at greater risk of inundation and erosion.

Impacts from seawater's changing chemical properties, such as increased temperature and acidity, are likely to be manageable. Marine structures such as piles have cathodic protection and antifouling to protect against corrosion and biofouling. In theory increased ocean acidification could lead to the need for additional cathodic protection that would increase installation/replacement/power supply costs; however this would be a relatively minor increase as the majority of the cost is in the works rather than the material.

With respect to extreme sea storm events, some navigation aids may be damaged. If design standards are increased, then there could be additional construction and/or replacement costs. Where stormwater drainage pipes are low lying, they are already partially submerged at high tides. For extreme rain/storm events some of the low-lying roads around the port can be affected by flooding as they cannot drain fully. When this does occur, the effect is temporary and does not last long enough to affect port activities.

The larger berth infrastructure such as the quay cranes that are owned and operated by the stevedores could become more expensive to build and/or replace to meet increased design standards, particularly around wind loading.

The Gippsland Ports safety and environmental management plan for 2016-2018 listed climate change as an emerging risk, with as yet unknown effects on maritime use and activity. Similarly, other port managers are yet to publish information on potential risks associated with climate change and prepare climate adaptation plans.[11]

Shipping accidents and incidents

Notwithstanding significant improvements in ship building standards and global shipping safety systems, there will always be potential for shipping accidents and incidents. Port authorities, shipping companies and management agencies have in place systems and processes to assess the level of risk, mitigation measures to prevent incidents and response procedures should an incident occur.

A marine pollution risk assessment using spatial analysis techniques was undertaken for the Victorian Department of Transport in 2011.[9] The relative level of risk was based on the likelihood of an incident occurring, type and volume of chemical or oil that could be spilled, oil arriving at the shore, and the potential environmental, social and economic value of the harm.

The assessment indicated that the highest-rated risk areas are the ports of Geelong, Melbourne, and Hastings as well as Port Phillip Heads and the coastline to the west of the heads. These areas are associated with the greatest levels of near-shore shipping activity and, in the case of the ports, an additional threat posed by oil transfer activities.

The areas rated at the next lower level of risk are also driven by shipping activity near to the coast compounded by high environmental sensitivity. The main coastal areas that are at this level of risk are the Cape Otway coastline, the ocean beaches of the Mornington Peninsula, most of Western Port, Wilsons Promontory, Point Hicks Marine National Park, and Cape Howe Marine National Park. Corner Inlet also rates highly because of the vessel movement associated with the offshore oil and gas support activity near marine protected areas.

Marine pollution from small to medium sized vessels

Within local ports the likelihood of individual incidents occurring is higher, but the smaller size of vessels and volumes reduces the consequence. However, the frequency of incidents in concentrated areas does result in cumulative impacts, especially where water circulation is restricted. To mitigate this, local port authorities have in place environmental management plans and procedures to reduce spillage associated with refuelling of vessels and the illegal discharge of waste (e.g. sewage pumpout facilities). They also invest in oil spill response equipment and training. Boat owners also have a responsibility to be aware of the environmental risks and safety practices needed to avoid marine pollution.

Sulfur oxide emissions

The Australian Maritime Safety Authority have announced that from 1 January 2020, all ships and vessels operating anywhere in the world will be required to use fuel which contains a maximum of 0.5 per cent mass concentration of sulfur, as agreed by the International Maritime Organization in 2016. The aim is to reduce the impacts of sulfur oxide emissions on the environment and human health. Australian ships, ports, refineries and fuel suppliers will need to be ready for the global implementation of this regulation, which is prescribed in the Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*.

There is concern that ship owners will choose to install an exhaust gas cleaning system known as a scrubber to meet the regulations on low-sulfur fuel instead of buying the more expensive clean fuel. The most commonly used scrubbers use an open loop system where the wastewater containing sulfur and other contaminants is discharged into the sea, which may result in localised environmental impacts in ports.[12]

Marine pests

Marine pests require active management by port managers and vessel owners. Processes need to be in place to prevent incursions and transfers, detect the presence and to have in place procedures to respond appropriately when marine pests are found on ships and other marine vessels within ports. Preventative measures include management of ballast water and anti-fouling protection. Failure to actively manage marine pests can result in ships and other marine vessels being refused entry to some ports or being required to undertake works to remove the risk of transfer.

A recent example of concern over marine pests on marine vessels entering ports occurred in Tasmania in November 2018. The Ocean Monarch, which had been drilling for gas in Bass Strait off the east Gippsland coast, was towed to Hobart for maintenance and minor repairs. Environmental regulators and port authorities were unsure if the drilling rig had been checked for the presence of marine pests and whether it was a biosecurity risk for Tasmania’s salmon industry.[13]

Market forces

Ports are impacted by economic downturns both locally and internationally that lead to reduced demand in both imports and exports. Increasing demand can put pressure on existing infrastructure, requiring either expansion or redirection of activities to other ports.[2]

12.4 Future uses

12.4.1 Port growth

Port of Melbourne

The Port of Melbourne development strategy discussion paper suggest that the key challenges and opportunities to consider in planning for the port over the next 30 years include:

- the port’s urban location, its land and facilities
- trade demand and the port’s role as a trade gateway for Australia’s southeast
- safe, reliable and adequate shipping channels that cater to the changing number and size of vessels
- transporting freight to and from the port – integration with connecting roads and rail and surrounding land
- surrounding land uses and environmental responsibilities.

Trade volumes have increased steadily from 71 million revenue tonnes in 2008-09 to 95 million revenue tonnes in 2017-18 (One revenue tonne equals weight in metric tonnes or volume in cubic metres, whichever is higher in terms of freight.) While the rate of change from one year to the next is influenced by international economic conditions and seasonal fluctuations, the overall 10-year trend represents an annual average growth rate of 3.2 per cent.[2] It is expected that trade volumes will continue to increase as Victoria's population grows. Forecasts for the next 15 years are presented in table 12.5.

Container trade is currently the most significant port trade (75 per cent), with 2.9 million twenty-foot-equivalent units (TEU) of containers handled during 2017-18. While container and vehicle trade has grown strongly over the past 10 years, other break bulk trade has declined. Container shipping is a more efficient method of cargo transport and companies are therefore increasing their use of containers for cargo wherever possible.

The increase in volumes of trade do not necessarily have a direct correlation with an increase in the number of ship movements, as ships continue to get bigger and carry more cargo. The increase in number of containers being transported is also one of the reasons why landside operations need to become more efficient and automated to prevent landside congestion.

Table 12.5 Current and forecast trade volumes for Port of Melbourne (data provided by Port of Melbourne Operations)

Port of Melbourne trade (in millions)	2017-18	2031-32
Container trade (TEU)	2.9	5.1
Motor vehicles	0.4	0.6
Liquid bulk demand and supply (cubic metres)	6.6	9.5
Dry bulk (mass tonnes)	3.9	4.7
Breakbulk (mass tonnes) – excludes motor vehicles	2.7	3.3

Infrastructure Victoria in its 2017 investigation of capacity at the Port of Melbourne identified an optimal capacity for container trade of approximately 8 million TEU per year (currently at 2.9 million). Achieving this capacity requires additional works to improve throughput and potential relocation of some of the existing trades to other commercial ports.

Prior to reaching capacity, consideration would be given to building a second container port to service Victoria. Two locations considered included a new port, Bay West in Port Phillip Bay near Werribee, and expansion of port facilities at Hastings in Western Port.

Infrastructure Victoria suggested that when assessed against key social, economic and environmental criteria, the Bay West location (figure 12.7) was preferred over Hastings. Bay West could initially handle overflow container capacity from the Port of Melbourne and is also well suited to becoming Melbourne's future container port in the long term.

The Port of Hastings would be an important part of Victoria's future commercial port network and is well suited to handling automotive trade. The ports of Geelong and Portland are not suitable as large container ports but could increase throughput to support growing volumes of their current trades and emerging supply chains.[1]

The government has considered Infrastructure Victoria's advice and responded as part of Delivering the Goods, Victorian Freight Plan.[14] It accepts the recommendation to plan for Bay West as Victoria's second container port. However, the Port of Hastings is retained as an option in reserve.

Over the next five years the government will further investigate the feasibility of Bay West as a container port, including:

- determining the location of the port site at Bay West
- identifying preferred land transport corridors and the required land area
- commencing a baseline environmental program for the Bay West port site
- monitoring key indicators to inform future decisions such as the size of container vessels.

Figure 12.7 Bay West concept for potential second container port for Victoria[1]

Port of Hastings

Investigations undertaken in 2013-14 for the Port of Hastings Container Expansion Project looked at expanding the port northwards from the existing BlueScope Steel wharf at Long Island Point. The two main options considered were a 'dig out' option and an 'along shore' option, both of which would have significant impact on seagrass and intertidal habitat through both direct and indirect impacts related to hydrodynamic changes and turbidity from dredging. A concept design for the 'along shore' option is shown in figure 12.8.

As stated above the government accepts Infrastructure Victoria's advice to plan for Bay West as Victoria's second container port and consider the Port of Hastings as an option in reserve.[14]

Figure 12.8 Hastings 'along shore' concept for potential second container port for Victoria [1]

Port of Geelong

The Port of Geelong is expected to maintain its current levels of service as a regional port for bulk liquid and dry bulk cargoes. The port has capacity to handle continued growth in current trade and to accept relocated trades from the Port of Melbourne should it be required.[1]

Port of Portland

Further expansion of the Port of Portland is expected to occur within the existing port precinct and not include encroachment into other marine waters.[5]

12.4.2 Trends in shipping

A trend in global shipping is for increased size of ships, with the objective to improve economies of scale by carrying greater volumes of cargo. Port managers are not expecting a material change in draught from vessels currently entering the Port of Melbourne over the next 20-30 years. However, the size of the vessels will increase. The expectation is that by 2033 the larger ships will be up to 340 metres in length, 48 metres in width (beam) but have a draught of less than 15 metres. Simplistically, the ships are getting 'fatter and longer' rather than requiring greater draught. Having bigger ships does increase their exposure to wind and push against the wharf, which may mean strengthening bollards to reduce the risk of structural damage to wharves.

12.4.3 Port redevelopment

There is an increasing expectation that ports will become more closely involved with and support local communities. While communities more broadly benefit from access to consumer goods, those local communities living close to ports may bear a disproportionate burden from the environmental impacts of their activities (for example, noise and air pollution, traffic congestion). Ports and related

Container ship leaving Port Phillip Bay. Photo: Owen Foley, Above & Beyond Photography industry operations frequently impact low-income communities, resulting in environmental justice concerns. Internationally, governments are looking to address these imbalances to ensure everyone enjoys the same degree of protection from environmental and health hazards and has equal access to the decision-making processes for the places in which they live, learn and work.[15]

Port redevelopment provides an opportunity to increase the integration between ports and local communities. Consultation for the redevelopment of Station Pier in Port Melbourne has highlighted the desire for greater access.16 However, the practicalities of increasing access within commercial ports which are traditionally restricted access areas, may mean that substantial redesign and planning is required.

With redevelopment of ports, there is also an opportunity to improve ecological outcomes through use of artificial reefs offshore to enhance habitats for marine plants and animals, and inclusion of eco-engineering features in the design and construction of infrastructure.[17]

12.5 References

1. Infrastructure Victoria (2017) *Advice on securing Victoria's ports capacity*, prepared by Infrastructure Victoria for the Victorian government. http://www.infrastructurevictoria.com.au/
2. Port of Melbourne Pty Ltd (PoM) (2018) *2050 Port development strategy discussion paper*. Port of Melbourne Pty Ltd https://www.portofmelbourne.com/community-education/port-development-strategy/
3. Victorian Regional Channels Authority (2014) *Dredging fact sheet*. Accessed January 2019 at https://www.regionalchannels.vic.gov.au/images/documents/2014_dredging/dredging_fact_sheet_3.pdf
4. Port of Hastings Development Authority (2018) *Port of Hastings Development Authority annual report 2017/18*. https://static1.squarespace.com/static/592f5720f5e2317ce97cec2c/t/5ba99d769140b71d9274c0ad/1537842566217/Annual+Report+2017-18.pdf
5. Port of Portland (2009) *Port of Portland – port land use strategy*. Published by Port of Portland Pty Limited, Portland.
6. Environment Protection Authority (EPA) (2001) *Best practice environmental management guidelines for dredging*. EPA publication 691. https://www.epa.vic.gov.au/~/media/Publications/691.pdf
7. BMT WBM Pty Ltd (2018) *Bays maintenance dredging program - long term environmental management plan 2018 – 2027*. Prepared for Parks Victoria https://parkweb.vic.gov.au/explore/bays-rivers-and-ports/port-phillip/safety-and-regulations/dredging
8. Port of Melbourne Operations Pty Ltd (2016) *Dredging program 2012-22 environmental management plan*. SEMS05 – 07Pg Rev 6 https://www.portofmelbourne.com/wp-content/uploads/DP12-22-EMP-Rev-6.pdf
9. Navigatus Consulting Limited (NCL) (2011) *Victorian marine pollution risk assessment 2011 (VMRA11).* Prepared for Victorian Department of Transport, Melbourne.
10. Parks Victoria (2017) *Investigation of possible impacts caused by anchoring of the bulk carrier MV Pretty Ivy Point Addis Marine National Park*. Parks Victoria internal report.
11. Gippsland Ports (2016) *Gippsland Ports safety and environmental management plan 2016-2018 – summary* https://www.gippslandports.vic.gov.au/wp-content/uploads/2017/03/2016-SEMP-Summary-March-2016-web.pdf
12. The Guardian (2018) Thousands of ships could dump pollutants at sea to avoid dirty fuel ban. Article by Sandra Laville, 29 October 2018. https://www.theguardian.com/environment/2018/oct/29/thousands-of-ships-could-dump-pollutants-at-sea-to-avoid-dirty-fuel-ban
13. ABC News(2019) *EPA under fire over handling of biosecurity concerns about Ocean Monarch rig*. Article by Lucy MacDonald, 4 January 2019 https://www.abc.net.au/news/2019-01-04/tasmanian-epa-and-biosecurity-laws-criticised-over-ocean-monarch/10683718
14. Department of Economic Development, Jobs, Transport and Resources (DEDJTR) (2018) *Delivering the goods, Victorian freight plan*. https://transport.vic.gov.au/ports-and-freight/freight-victoria
15. United States Environmental Protection Agency (US EPA) (2016) *Draft - A ports primer for communities – an overview of ports planning and operations to support community participation*. Office of Transportation and Air Quality. EPA-420-P-16-001. https://www.epa.gov/community-port-collaboration-and-capacity-building/draft-ports-primer-communities
16. Newgate Engage (2018) *Station Pier redevelopment engagement report*. Prepared for Victorian Ports Corporation (Melbourne). http://www.vicports.vic.gov.au/cruise-shipping/Documents/community-consult-report-%20181030.pdf
17. Bishop, M.J., Mayer-Pinto, M., Airoldi, L., Firth, L.B., Morris, R.L., Loke, L.H.L., Hawkins, S.J., Naylor, L.A., Coleman, R.A., Chee, S.Y. and Dafforn, K.A. (2017) Effects of ocean sprawl on ecological connectivity: impacts and solutions. *Experimental Marine Biology and Ecology* 492: 7–30

13 Energy and Earth Resources

Victoria's coastal waters and the adjacent Commonwealth waters provide significant resources for the energy sector. These include oil and gas production and emerging opportunities for renewable energy through offshore wind farms, wave energy converters and tidal stream turbines. Other energy-related uses include potential storage and sequestration of carbon dioxide (CO^2) in depleted offshore gas fields and use of deep-water ports for shipping and transfer of fuels.

KEY POINTS AT A GLANCE

- Three oil and gas basins straddle Victorian and Commonwealth waters: the Otway, Bass and Gippsland basins. Production in Victorian waters only occurs within the Otway Basin.
- Most of the gas Victoria consumes comes from Commonwealth waters. A shortfall in gas supply has been predicted from 2022. This may drive further exploration and development of offshore gas fields..
- Seismic surveys are an essential part of oil and gas exploration although they can have negative impacts on marine organisms. Substantial environmental controls accompany seismic survey work.
- The process of hydraulic fracturing ('fracking'), used to release unconventional gas from the sedimentary rocks in which it is found, was prohibited in Victoria in 2017.
- While substantial potential for wave and tidal energy generation has been identified in Victorian waters and pilot projects carried out, these sources seem unlikely to progress without significant government support.
- Offshore wind farms are increasingly popular in Europe. While there is a current proposal in Commonwealth waters offshore from Gippsland, the size and visual impact of offshore wind farms may limit their development in waters closer to shore.
- Other sources of renewable energy, including geothermal and biofuels, have low potential for development in Victoria.
- No mineral resources are mined in Victorian waters. Where valuable minerals occur, it is currently not economically viable to extract them in commercial quantities. In some locations offshore sand deposits are dredged for beach renourishment, although this is not considered mining.
- More research is required to assess the suitability of depleted oil and gas wells for offshore carbon dioxide sequestration. A pilot project was built onshore near Warrnambool and further investigation is occurring off the Gippsland coast.
- The potential for decommissioned oil and gas infrastructure (e.g. pipelines, platforms) to remain in the marine environment and act as artificial reefs has been considered in other jurisdictions.

The broad categories of threats to energy and earth resources are summarised and examples are provided for each threat in table 13.1; for more detail see the relevant section of this chapter. Discussion of threats in this chapter are threats to energy and earth resources. The threats that the energy and earth resources sector might pose to other values are discussed in the relevant chapter.

Table 13.1 Summary of potential threats to energy and earth resources values in Victoria

Threat class	Pathway/outcome	Example (with section reference)
Climate change	Altered oceanography – change to prevailing currents, waves and wind	The larger infrastructure may become more expensive to build and replace to allow for increased design standards, particularly around wind loading (12.3.1)
	Increased storm frequency and storm surge	Infrastructure at sea (e.g. oil platforms) may be damaged in storms. Increased design standards could impose additional construction and/or replacement costs (12.3.1)
Physical	Damage to infrastructure	Seabed infrastructure (e.g. pipelines) are at risk of damage from anchors, trawling, scallop dredging. Not protected by formal exclusion zones (13.1.3)
Biological	Biofouling	Failure to actively manage marine pests can result in ships and other marine vessels (e.g. oil rigs) being refused entry to some ports or being required to undertake works to remove the risk of transfer (12.3.5)
Community/ industry demand	Expansion of industry	The potential of wave and tidal energy has been demonstrated, but without significant investment it is unlikely to move beyond pilots (13.2.1)
	Commercial viability	Where minerals of value occur in Victorian coastal waters their extraction at a commercial scale is not currently economically viable (13.3)
	Conflict with ecotourism	Because seismic surveys impact on whales, there may be conflict between marine mammal tourism and oil and gas exploration for access to particular areas (13.1)
	Recreational access	Use of areas for recreational boating and fishing may conflict with exploration activities (13.1.3 and 13.2.6)
	Social licence	While Port Phillip Bay is theoretically appropriate for offshore wind, the community support for such a project is uncertain (13.2.3)

13.1 Oil and gas

Offshore oil and gas exploration, development and production occurs in the Gippsland Basin east of Wilsons Promontory, the Otway Basin west of Cape Otway, and in the Bass Basin between Victoria and Tasmania. Victoria's gas demand is largely met from offshore gas resources located mostly in Commonwealth waters in the Gippsland, Otway and Bass basins.

The Department of Jobs, Precincts and Regions (DJPR) has responsibility for titles administration and environmental management in offshore state waters. In 2013, Victoria conferred its functions for the regulation of health and safety and structural integrity on the National Offshore Petroleum Safety and Environment Management Authority (NOPSEMA).

The administration of petroleum titles and resource management in Commonwealth waters is the responsibility of the National Offshore Petroleum Titles Administrator (NOPTA) and the administration of the environmental, well integrity and safety regulation is the responsibility of NOPSEMA.

Exploration

Exploration is an important component in developing oil and gas resources. Geophysicists and other specialists begin by examining the geology to assess if it has the potential to form oil and gas reserves. Technologies, such as seismic surveys, are used to detect whether the underlying geology contains oil and gas deposits and how large these deposits are likely to be. If interpretation of survey results shows it is likely that oil and gas deposits exist, an exploration well may be drilled.

No oil and gas exploration activity can be undertaken in Victorian waters unless it is in accordance with an approved environment plan. All exploration proposals require relevant risk management plans (permissioning documents) to be accepted by DJPR's Earth Resources Regulation group or NOPSEMA before an activity can commence, i.e. an environment plan, a safety case and/or well operations management plan. The Victorian *Offshore Petroleum and Greenhouse Gas Storage Act 2010* and associated regulations outline the content requirements and acceptance criteria for these permissioning documents. Failure to comply with conditions of an exploration permit title may result in permit cancellation.

As part of development of an environment plan, oil and gas exploration proponents are required to consult with potentially impacted stakeholders, such as the fishing industry about the impacts of their proposal on fish stocks and fishing operations.

Seismic surveys are essential for appraising geological features beneath the sea floor. Compressed air bubbles are used to create pulses of sound waves that can penetrate the seabed. By measuring and recording the strength and time of each returning wave a picture of the underlying geology is produced. However, there is research that suggests the acoustic pulses can disturb or damage marine species that are sensitive to the frequency range of the sound. Operators are required to take a range of mitigation measures to minimise any potential impacts from the surveys.

The Victorian Fisheries Authority (VFA) has an established policy for seismic surveys that assists oil and gas explorers to ensure that the impacts on fish stocks and fishing operation are minimised. Other mitigation measures to reduce potential impacts include not allowing seismic surveys during sensitive times, such as fish spawning and whale migration, minimising the sound intensity and exposure time of surveys, and not allowing surveys in marine national parks.

Construction of wells and pipelines

The production of oil and gas requires the construction of wells, platforms and pipelines, which can have localised impacts on the seabed and associated habitats. The construction and operation of new wells and pipelines is assessed and managed on a case by case basis under a suite of state and Commonwealth legislation.

Each project requires an environmental management plan to manage potential environmental risks. For example, the Patricia-Baleen offshore pipeline, which is currently non-operational, includes routine monitoring of the structural integrity of the pipe to ensure no gas or condensate is released to the environment.[1] Where extended reach drilling is used the impact to the seabed can be avoided, as is the case for production from the Halladale and Speculant gas fields in the Otway Basin.

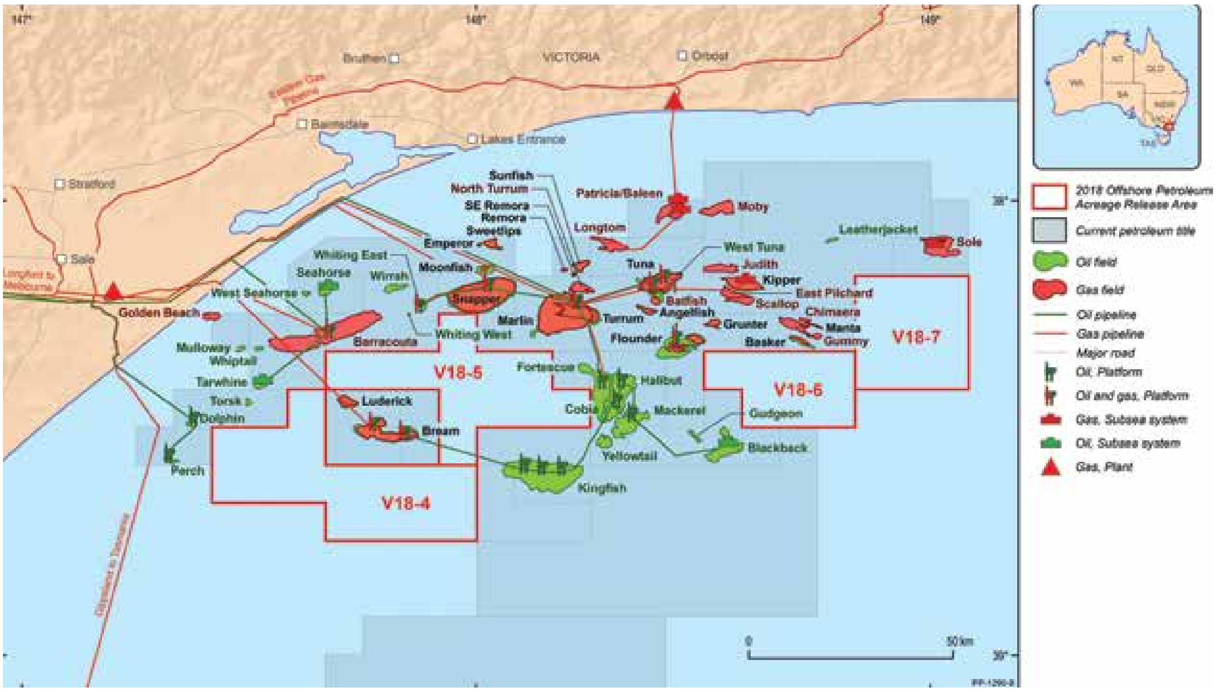
13.1.1 Current production

Gippsland Basin

The Gippsland Basin extends from the Latrobe Valley seaward to the edge of the continental shelf. Areas of the basin that are in Commonwealth waters have produced significant volumes of oil and gas since the late 1960s. The Gippsland Basin is now predominantly a supplier of gas into the Australian domestic market for consumptive use.[2]

ExxonMobil Australia has 23 offshore platforms and a 600-kilometre network of underwater oil and gas pipelines that are linked to onshore facilities at Longford.[3] Barry Beach Marine Terminal, in Corner Inlet, is the main supply depot for the oil and gas operations in the Gippsland Basin. The current configuration of operating wells and platforms are in Commonwealth waters with only pipelines crossing Victorian waters (figure 13.1).

Figure 13.1 Gippsland Basin oil and gas fields and pipelines



Otway Basin

The Otway Basin, which covers an area of 150,000 square kilometres, extends from southeast of South Australia to west of King Island, and from onshore out to the edge of the continental shelf. Gas production began onshore in the Otway Basin in the 1980s, followed by larger gas discoveries offshore in the 1990s.

The area is now an established gas-producing region, with production continuing from the offshore part of the basin in Commonwealth and Victorian waters. In the Otway Basin within Victorian waters there are two producing fields – Halladale and Speculant.[4] Some of the offshore production facilities are connected to onshore processing plants via pipelines across the seabed, whereas other production is connected via subsurface wells drilled from onshore that do not penetrate the seabed (figure 13.2).

13.1.2 Future use of oil and gas

The Australian Energy Market Operator (AEMO) in their 2018 gas planning update forecast a shortfall in gas supply from 2022 (figure 13.3). The shortfall is caused by a forecast decline in extraction of gas from current fields in the Gippsland and Otway basins over the next five years. However, the forecast shortfall could be met by development of new fields, additional pipeline imports from interstate, importation of liquified natural gas (LNG) and increased use of electricity sourced from renewable energy sources.[5]

To stimulate commercial exploration for gas resources, the Australian and Victorian governments release offshore acreage areas for tender. They also undertake airborne gravity surveys to help identify prospective areas for targeted exploration.

Figure 13.2 Otway Basin gas fields and pipelines

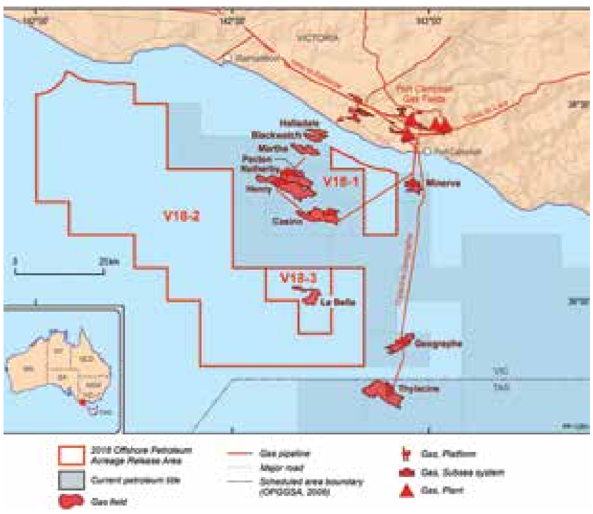
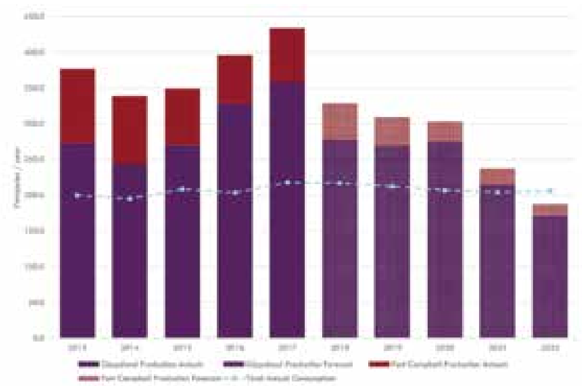


Figure 13.3 Annual gas production from Gippsland and Otway basins, highlighting potential shortfall in 2022[5]



Gippsland Basin

The eastern part of the Gippsland Basin includes the Patricia-Baleen and Longtom gas fields, which are connected via seabed pipelines to an onshore gas processing plant, located near Orbost. The wells, pipeline and plant are currently non-operational. Future use of the pipeline will be contingent on the development of adjacent gas fields.[1] To date, no oil or gas has been produced from the area within Victorian waters and there are no current plans to expand production to encompass Victorian waters.

In the western part of the Gippsland Basin, plans are progressing to develop the Golden Beach gas field.[6]

Otway Basin

Offshore of Nirranda South, plans to develop the Blackwatch field are progressing, whilst the exploration phase of the Enterprise project aims to discover new gas resources.[7] All these exploration and development activities use extended reach drilling to reach the subsurface gas reservoirs, which are located between 1.5 to 2 kilometres under the seabed.

In May 2018, the Victorian government, as part of the Victorian Gas Program, released five new offshore acreage areas for tender in the Otway Basin. Areas have also been released in adjacent Commonwealth waters.

The process from exploration to production takes time, and there is no guarantee that a discovery will result in commercial production. For example, exploration commenced in 2003 to discover the Speculant gas field in the Otway Basin, which produced first gas in 2016.[8]

Regasification unit at Crib Point

AGL Wholesale Gas Limited is investigating installation of a floating storage and regasification unit at the existing jetty at Crib Point in Western Port. The proposal is for the unit to receive shipments of liquified natural gas (LNG) for conversion into its gaseous form for distribution. Up to 40 LNG tankers per year would supply the unit, which in turn could supply 60-80 per cent of Victoria's annual gas demand. Importing LNG from interstate or overseas can contribute to diversity of gas supply, putting downward pressure on prices.

Approval of the project is subject to preparation of an environment effects statement by the project proponents, according to the *Environmental Effects Act 1978* and scoping requirement set out by DELWP. One issue of concern is the extraction and discharge of cooling waters. One option being considered is the use of up to 450 ML/day of seawater that is passed through a heat exchanger and discharged back into the water adjacent to the jetty. The water would be approximately 7°C cooler and contain low concentrations of anti-biofouling chemicals, which could impact sensitive benthic communities.

AGL is investigating a floating storage and regasification unit at the Crib Point jetty in Western Port for the importation of liquified natural gas (LNG). Photo: CEE Consulting Environmental Engineers

Unconventional gas development

Unconventional gas, which includes coal seam gas, shale gas and tight gas, is likely to be found in the Gippsland and Otway basins. These basins are located onshore but mostly occur in offshore waters. It may be that unconventional gas could be located under the seabed, but at this point in time the technology does not exist that would make it commercially viable to locate and extract unconventional gas offshore.

In 2017, the *Resources Legislation Amendment (Fracking Ban) Act 2017* was passed, banning the process of hydraulic fracturing ('fracking') used to release gas from the sedimentary rocks in which it is found.

Decommissioning

The Australian oil and gas industry is anticipating a large increase in decommissioning activity in the future as infrastructure reaches the end of its useful life. Decommissioning involves removing or otherwise satisfactorily dealing with offshore petroleum structures and wells in a safe and environmentally responsible manner. This includes plugging and abandoning wells, rehabilitating the site and carrying out any necessary monitoring.

The Commonwealth Department of Industry, Innovation and Science (DIIS) released a discussion paper in 2018 as part of its review of the government's decommissioning framework. The review aims to ensure that guidelines for decommissioning oil and gas infrastructure are fit for purpose, remain best practice, and address decommissioning challenges and opportunities now and into the future.[9]

There are three main options for decommissioning: complete removal, partial removal, and repurposing or reuse. Complete removal and the plugging and abandonment of wells is currently the default requirement, consistent with the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (also known as the London Convention). Other options can be considered if the alternative delivers equal or better environmental, safety and well integrity outcomes.

In the United States, petroleum companies can choose to donate decommissioned structures to coastal states to serve as artificial reefs. Under these arrangements, the government takes ownership of the structure and the company is no longer responsible for any adverse consequences to the marine environment. Companies are typically required to pay a fee to government (half the costs saved by 'reefing' infrastructure relative to complete removal and disposal). Any damage to the marine environment associated with well incidents (such as leakages) remains with the petroleum company.

DIIS have suggested that further research is needed on the extent to which the marine environment would benefit from using decommissioned infrastructure as artificial reefs and what risk mitigation strategies are needed.[9]

Carbon dioxide (CO_2) storage and sequestration

Carbon capture and storage (CCS) involves capturing carbon dioxide (CO_2) released by industrial processes (includes coal-fired power stations), compressing it and then transporting it to an injection site to be sequestered deep underground for long-term storage in suitable geological formations – in the way oil and gas have been stored underground for millions of years.

In 2009 the National Carbon Taskforce identified the Gippsland Basin as having the highest technical ranking of 25 major basins across Australia and the largest storage potential of any east coast basin.

The CarbonNet Project funded by the Victorian and Australian governments, is investigating the potential for establishing a commercial-scale carbon capture and storage network. The network would bring together multiple CO_2 capture projects in the Latrobe Valley, transporting CO_2 via a shared pipeline and injecting it into underground, offshore storage sites in Bass Strait.[2]

The concept has been tested at a research site near Warrnambool that is utilising an onshore depleted gas field. More than 80,000 tonnes of CO_2 have been injected and stored in a variety of geological formations, allowing the monitoring and testing of advanced technologies and techniques.[10]

The CarbonNet Project has completed feasibility studies, including detailed modelling of potential CO_2 storage sites. A marine seismic survey was undertaken in 2018 and an appraisal well is planned to be drilled in 2019 to verify conditions and accurately assess the properties of the rock that will form the 'cap rock' to hold the stored CO_2 in place.

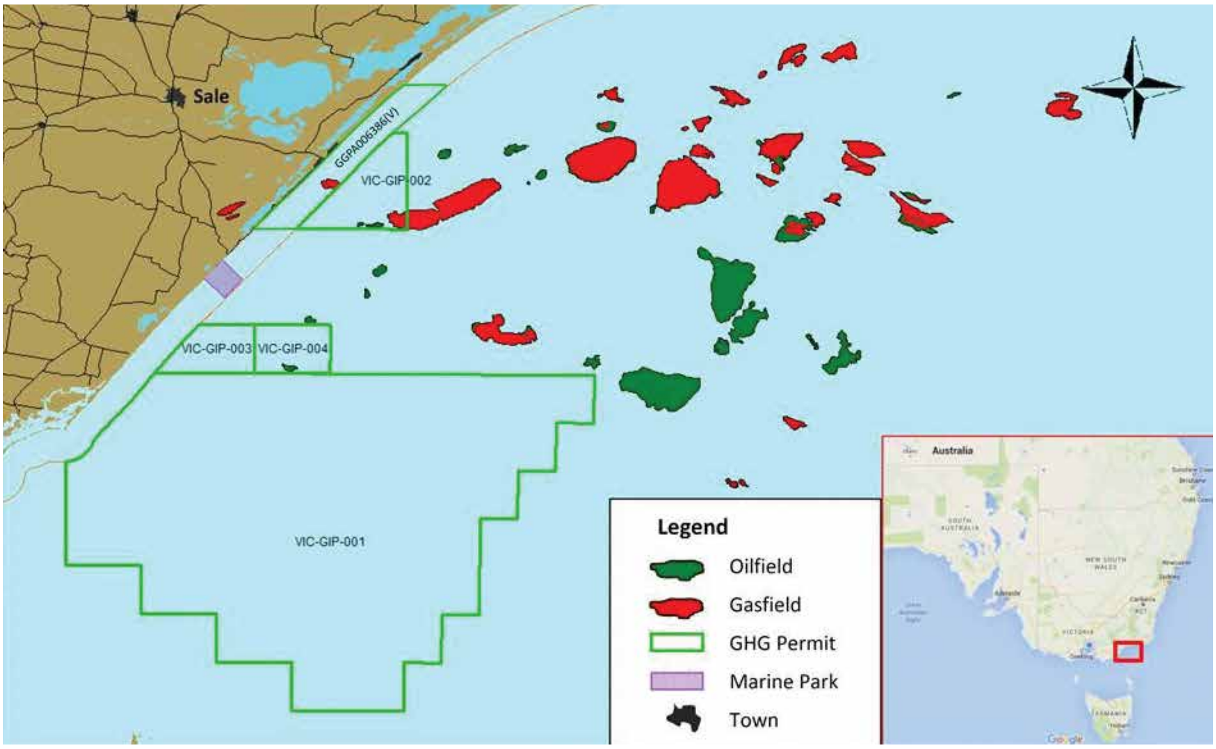
The Victorian government holds four greenhouse gas assessment permits in Commonwealth waters and one greenhouse gas assessment permit in Victorian waters (figure 13.4) which are administered by the CarbonNet Project.

13.1.3 Threats to oil and gas production

Market forces

Oil and gas production is impacted by changes in supply and demand, which influences the price of oil and gas. When prices are higher there is greater incentive for companies to invest

Figure 13.4 Greenhouse gas assessment permits held by the Victorian government



in further exploration and the viability of production is improved. With lower oil and gas prices the incentives for exploration and production are reversed.

Damage from marine vessels

The likelihood of a ship crashing into a drilling rig or production platform is extremely low; however the consequence could be significant: environmentally through oil spillage and clean up, socially through loss of life and economically through loss of production. Oil and gas platforms are designed to withstand impacts from supply vessels, but passing vessels generally travel at higher speeds, which could cause significant structural damage to both the vessel and the platform.[11] To date there have been no incidents in Bass Strait that have resulted in significant damage.

To reduce the risk of incidents occurring, owners can apply to NOPSEMA through a provision in the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cwth), for establishment of a petroleum safety zone that prohibits unauthorised vessels from entering or being present in an area surrounding their petroleum wells, structures or equipment. There are similar arrangements for establishment of greenhouse gas safety zones for the protection of structures associated with CO_2 sequestration.

These safety zones can extend up to 500 metres from the outer edge of the well, structure or equipment. There are about 40 safety zones established via notices published in the government gazette that are relevant to operations in Victoria.

There is a large area offshore from the Gippsland Lakes that has been declared as an ‘area to be avoided’ and which is defined in Schedule 2 of the Offshore Petroleum and Greenhouse Gas Storage Act. Applications are required to be made to NOPSEMA for large vessels to access this area.

A shipping traffic separation scheme has been established in Bass Strait off Gippsland to guide shipping through the offshore oil and gas fields. The scheme consists of a 1.5 nautical mile wide separation zone and an eastbound and westbound shipping lane.

Other mitigation measures for avoiding collisions include automated navigation aids and vessel tracking systems, and safety procedures on ships.

Protection of pipelines

Owners of pipelines within Victorian waters do not have formal exclusion zones. Instead they rely on mariners knowing where infrastructure is located and avoiding activities that could damage it, such as setting anchor, seabed trawling and scallop dredging. An incidental benefit of these avoidance measures is that the seabed biota and pelagic species that use these waters are provided some level of environmental protection from the avoided activities.

Several oil and gas pipelines cross parts of Port Phillip Bay. These include the 250-millimetre ethane pipeline from Mordialloc to Altona, and the 600-millimetre oil and gas pipeline from Western Port to Altona then Geelong (WAG).

The ethane pipeline, which was laid in a two-metre deep trench, is in a 'safe' zone outside Port of Melbourne anchorages, and clearly marked on navigational charts. The Harbour Master's Directions state that the master of a ship must not lay anchor within 300 metres of the pipeline or allow the ship to drag an anchor across the pipeline. Despite these precautions, in December 2008 during a storm, a container ship dragged its anchor across the pipeline, rupturing it.[12] The highly flammable gas was quickly dispersed by the winds reducing the risk of fire onboard the ship. However, the costs to business and for repair of the pipeline was reported as more than $67 million.[13]

The WAG pipeline, which takes a landward route around Port Phillip Bay, passes under the Yarra River near the West Gate Bridge. To reduce the risk of rupturing the WAG pipeline, the Port Information Guide states that vessels avoid dropping anchor in this part of the river.[14]

Marine pests

As discussed in section 12.3.5, failure to actively manage marine pests can result in ships and other marine vessels being refused entry to some ports or being required to undertake works to remove the risk of transfer. A recent example occurred in Tasmania in November 2018 when the Ocean Monarch, which had been drilling for gas off the Gippsland coast, was towed to Hobart for maintenance and minor repairs. Environmental regulators and port authorities were unsure if the oil rig had been checked for the presence of marine pests and whether it was a biosecurity risk for Tasmania's salmon industry.[15]

13.2 Renewable energy

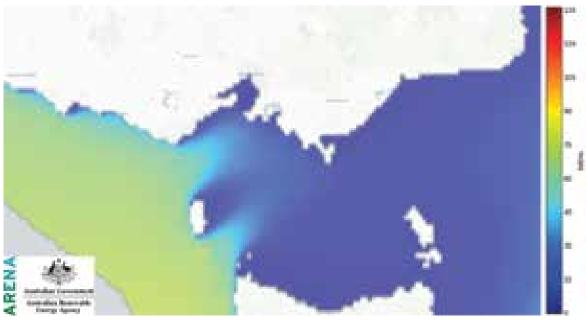
13.2.1 Wave energy

Australia has been identified as having one of the world's best wave energy resources, with the southern coast providing extensive areas of coast suitable for the extraction of wave energy for electricity production. The higher wave energy from the more exposed coastal areas in western Victoria has been identified as offering significant opportunities for installation of wave energy converters.[16]

Evaluation of wave energy project sites along the west coast of Victoria highlighted significant potential offshore from Portland and, to a lesser extent, sites adjacent to other coastal towns. This assessment considered, in addition to wave height and frequency, other factors such as distance required to connect to the electricity transfer network and proximity to sensitive marine communities.[16]

Research undertaken by Swinburne University and the Australian Maritime College shows that the consistency of waves rather than their average size is the key factor for assessing potential for wave energy conversion. By optimising a network of converters, higher amounts of electricity can be generated from smaller waves. The modelling showed that areas along the West Gippsland coast have similar or better potential than those along the more exposed west coast.[17]

Figure 13.5 Annual mean wave energy flux derived from global wave model



Port Fairy Pilot Wave Energy Project

The Australian Renewable Energy Agency (ARENA) and the Victorian government provided funding to BioPower Systems for the Port Fairy Pilot Wave Energy Project. The project involved installation of a bioWAVE unit six kilometres west of Port Fairy near Taylors Bay.[18]

The bioWAVE is a bottom-mounted wave energy system that sways back and forth with the swell to generate electricity that is delivered onshore by a subsea cable. The 26 metre-tall modular structure was designed to produce up to 250 kilowatts of steady electrical power (considered near-baseload).

Ongoing technical problems resulted in additional costs and time delays and the pilot project was put on hold in June 2017. DELWP have since requested that the site be rehabilitated and all infrastructure from the seabed be removed.

Future use

Geoscience Australia in their Australian Energy Resources Assessment suggest that despite the significant potential, wave and tidal projects in Australia to date have been small pilot projects and amount to less than 1 megawatt of installed capacity. The Port Fairy project and others have demonstrated that wave energy converters can provide a sustainable source of electricity in coastal areas. However, future development will largely depend on cost competitiveness and ability to integrate into the energy grid.

Some industry commentators have suggested that the prospects in the short to medium term for installation of wave energy converters along the Victorian coast is low, because there is limited willingness to invest in this technology on a commercial scale.

13.2.2 Tidal energy

There are a range of tidal stream turbine technologies that harness the flow of tidal currents to produce electricity.[20] Potential locations for installation of tidal turbines occur at the entrances to large tidal embayments – including the entrances to Port Phillip Bay, Western Port and Corner Inlet – where tidal currents are stronger. Smaller-scale systems could also be installed on permanently open estuaries that have significant tidal exchanges.

Tidal turbines are like underwater windmills except the rotors are driven by consistent, fast-moving currents. The submerged rotors harness the power of the marine currents to drive generators, which in turn produce electricity. Water is much denser than air and consequently tidal turbine rotors are much smaller than wind turbine rotors and therefore can be deployed much closer together and still generate equivalent amounts of electricity.[21]

Pilot projects

Three prototype tidal stream turbines (100 kW, 150 kW, and 400 kW) were installed and tested at Newhaven on Phillip Island over an eight-year period. The site was decommissioned in 2015.

Monitoring during the testing showed no apparent threat to migrating mammals from an acoustics perspective nor any of the local population of seals and penguins due to the low speed of the turbine when in operation.

Future use

As suggested for wave energy the outlook in the short to medium term for installation of tidal energy generation systems is unlikely because there is limited willingness to invest in commercial scale schemes.

13.2.3 Offshore wind

Over the past 30 years wind power has been one of the fastest growing electricity generation technologies. In Europe, where the potential for onshore wind energy is limited in populated areas, wind farms have started to be sited at sea. Advantages of offshore wind farms are that average wind speeds are higher and more consistent than on land, larger turbines can be installed, and noise and visual impacts to the community are reduced. However, offshore construction is more complicated, leading to higher investment costs than on land; accessibility to the turbines is more difficult, resulting in higher maintenance costs; and the transmission connection to the grid is more expensive.[22]

In one investigation researchers used a multi-criteria evaluation process to identify potential areas around Australia with good potential for development of offshore wind farms.[22] One of the areas identified was in Port Phillip Bay because of the strong winds, proximity to existing electricity infrastructure and high demand, and relatively shallow water for construction. However, the assessment did not take into consideration community willingness to support construction of wind farms within coastal waters.

Proposed projects

To date no offshore wind farms have been built in Australia, although Offshore Energy's 'Star of the South Energy Project' is in the initial stages of planning.[23] The company is investigating the potential for an offshore wind farm in Commonwealth waters some 10-20 kilometres off the south coast of Gippsland. The project would involve construction and assembly of up to 250 turbines, a 95-kilometre route for undersea transmission cables, at least two offshore substations and a network of cables to connect

Lifting bioWAVE from installation vessel. Photo: BioPower Systems

The Sandbank Offshore Wind Farm built in the German North Sea and completed in 2017 has 72 turbines providing a total capacity of 288 MW. Photo: MPI Offshore

turbines. Nearby port facilities would also require upgrading to enable construction and later operation and maintenance of the turbines.

The Federal Minister for Energy granted an exploration licence in March 2019, which gives the company permission to investigate wind resources and seabed conditions to see if the project is technically feasible. The licence requires the proponent to undertake extensive consultation with the community and industry before undertaking any activities.

Future use

The installation of offshore wind farms within the three nautical mile limit of Victorian waters will be dependent on the success of the 'Star of the South Energy Project' and outcomes from the associated consultation. The significant height and numbers of turbines required for schemes to be economically viable may raise community opposition, with the main issue likely to be the visual impact to the coastal landscape.

13.2.4 Geothermal

Geothermal energy can be drawn from the hot water circulating among rocks below the earth's surface, or by pumping cold water into the hot rocks and returning the heated water to the surface. These potential sources of energy are normally at depths greater than 200 metres. If resources did occur in offshore areas, they are unlikely to be commercialised because of the additional costs associated with offshore development.

13.2.5 Biofuel

The use of microalgae grown in seawater for production of biofuel has been the subject of research. However, it is unlikely that microalgae or macroalgae (seaweed) would be harvested from the marine environment for production of biofuel, as it would be more reliable to use constructed ponds where growing and harvesting conditions can be controlled. The lower cost benefit of commercial-scale algae farming for energy production in comparison to other sources of energy is a major constraint on its adoption.[24]

13.2.6 Threats to renewable energy

A number of pilot projects have demonstrated the potential for wave and tidal energy in the marine environment, but the technologies tested have not attracted funding to allow development at a commercial scale in Victoria. Without significant investment and support these technologies are unlikely to proceed beyond research projects and trials.

Inherent in the reluctance to invest is the risk associated with construction in the marine environment. The harsh environment, relative isolation from existing services, and higher design and construction costs are all negative factors.

To date there has been limited community consultation to assess the public's willingness to accept visual impacts that may be associated with development of offshore wind farms.

Another issue is that developers feel pressure to focus on utility-scale energy solutions, but opportunities to apply ocean renewable technologies to niche markets (such as the remote-area or coastal-protection applications) may provide a viable path for developing and demonstrating performance.[20]

Ruins of lime burners' kilns, Cape Liptrap Coastal Park, Walkerville. Photo: Parks Victoria

13.3 Mineral resources

There is currently no mining of mineral resources in Victoria's coastal waters. Where minerals of value do occur, their extraction at a commercial scale is not currently economically viable.

Small quantities of precious metals have been found in beach sands at the western end of Waratah Bay. Corner Inlet has been explored for alluvial tin, but no economic concentrations have been found. Similarly, deposits of heavy mineral sands are found adjacent to headlands along the East Gippsland coast, but are not of sufficient economic value.[25]

At various locations along the coast there has been past mining for materials used in construction: including limestone for cement making; granite and bluestone for building, foundations and ballast; and crushed rock and aggregate for roads. In some locations offshore sand deposits are dredged for beach renourishment, although this is not considered to be a mining activity.

Precious or semi-precious stone or gemstones are found in small or non-commercial quantities in Victoria. Several beaches are known by fossickers for their gemstones. Alluvial pebbles of jasper, agate, small sapphires and zircons have been found on beaches around Cape Liptrap and Walkerville, the south coast of Phillip Island, Merricks, and Geelong. Other semi-precious stones have also been found in beach gravel along the Otway coast at Moonlight Head and Pebble Point.[25]

13.4 References

1. Cooper Energy (2018) *Patricia-Baleen environment plan summary – state waters*. PBN-EN-EMP-0004. Accessed 26/9/2018 http://earthresources.vic.gov.au/earth-resources-regulation/licensing-and-approvals/petroleum/environment-plans
2. Earth Resources (2018) *Earth resources – petroleum*. Earth Resources Information Centre. Accessed 17/9/2018 http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/petroleum
3. ExxonMobil Australia (2015) *ExxonMobil Energy lives here*. Company brochure accessed 1/10/2018 https://cdn.exxonmobil.com/~/media/australia/files/publications/publication_emaus2015.pdf
4. Department of Economic Development, Jobs, Transport and Resources (DEDJTR) (2018) *Earth Resources Regulation 2016-17 statistical report*. DEDJTR, Melbourne.
5. Australian Energy Market Operator (2018b) *Victorian gas planning report update – gas transmission network planning for Victoria - March 2018.*
6. Golden Beach Energy (2019) *Golden Beach gas project flyer* https://gbenergy.com.au/wp-content/uploads/2018/10/GBE005_Flyer-3_Regulatory_Processes_3.11.pdf
7. Beach Energy (2019) *Otway Basin Victoria operations* https://www.beachenergy.com.au/vic-otway-basin/
8. Department of Economic Development, Jobs, Transport and Resources (2018) *Victorian gas program. Progress Report No 1*. Geological Survey of Victoria, Melbourne.
9. Department of Industry, Innovation and Science (2018) *Discussion paper – decommissioning offshore petroleum infrastructure in Commonwealth waters*. Offshore Resources Branch. https://consult.industry.gov.au/++preview++/offshore-resources-branch/decommissioning-discussion-paper/supporting_documents/Decommissioning%20Discussion%20Paper.pdf
10. Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) (2018) *Otway research facility*. Accessed 2/10/2018 http://www.co2crc.com.au/otway-research-facility-2/
11. Zhang, P., Minghua, Z., Rajagopal, S. and Retouniotis, F. (2016) Research on prevention of ship collisions with oil rigs. *Journal of Shipping and Ocean Engineering* 6: 279-283.
12. Australian Transport Safety Bureau (2010) *Independent investigation into the rupture of a submarine gas pipeline by the Hong Kong registered container ship APL Sydney in Port Phillip, Victoria 13 December 2008*. ATSB Transport Safety Report Marine Occurrence Investigation MO-2008-012 No. 260 Final. Canberra. Accessed 2/10/2018 http://www.atsb.gov.au/media/1373626/mo2008012.pdf
13. The Sydney Morning Herald (2010) *Global ripples in Port Phillip mishap*. Article by Leonie Wood. Viewed online: https://www.smh.com.au/business/global-ripples-in-port-phillip-mishap-20100323-qu7i.html
14. Victorian Ports Melbourne (2018) *Port Information Guide*, *4th edition.* http://www.vicports.vic.gov.au/publications/Documents/port-info-guide-ed-4.pdf
15. ABC News(2019) *EPA under fire over handling of biosecurity concerns about Ocean Monarch rig*. Article by Lucy MacDonald, 4 January 2019 https://www.abc.net.au/news/2019-01-04/tasmanian-epa-and-biosecurity-laws-criticised-over-ocean-monarch/10683718
16. Flocard, F., Ierodiaconou, D. and Coglan, I.R. (2016) Multi-criteria evaluation of wave energy projects on the south-east Australian coast. *Renewable Energy* 99: 80-94.
17. Manasseh, R., De Chowdhury, S., Hasan, M., Penesis, I., Fleming, A., MacFarlane, G. and Nader, J-R. (2018) *Towards an Australian capability in arrays of ocean wave-power machines*: Project overview and summary of final report, Swinburne University of Technology, Melbourne, Australia.
18. Australian Renewable Energy Agency (2015) *BPS bioWAVE ocean pilot at Port Fairy*. ARENA Project Notice. Accessed 1/10/2018 https://arena.gov.au/projects/biowave-ocean-pilot-at-port-fairy/
19. Geoscience Australia (2015) *Offshore petroleum exploration acreage release Australia 2015 – Gippsland Basin*. Accessed 17/9/2018 https://archive-petroleumacreage.industry.slicedtech.com.au//2015/geology/gippsland-basin/geology
20. Hemer, M.A., Manasseh, R., McInnes, K.L., Penesis, I. and Pitman, T. (2018) Perspectives on a way forward for ocean renewable energy in Australia. *Renewable Energy* 127: 733-745.
21. Simec Atlantis Energy (2018) *Tidal turbines*. Accessed 17/9/2018 https://simecatlantis.com/services/turbines/
22. Messali, E. and Diesendorf M. (2009) Potential Sites for Off-Shore Wind Power in Australia. *Wind Engineering* 33(4): 335-348.
23. Offshore Energy (2019) *Star of the South energy project – towards Australia's first offshore wind farm*. Accessed 29/4/2019 http://www.starofthesouth.com.au/
24. Ullah, K., Ahmad, M., Sofia, Sharma, V.K., Lu, P., Harvey, A., Zafar, M., Sultana, S. and Anyanwu, C.N. (2014) Algal biomass as a global source of transport fuels: overview and development perspectives. *Progress in Natural Science: Materials International* 24(4): 329-339.
25. Birch, W.D. (ed.) (2003) *Geology of Victoria*. Geological Society of Australia, Special publication 23.

14 Classifying Social and Economic Values

Among the guiding principles of the Marine and Coastal Act 2018 are requirements that development be consistent with principles of ecological sustainability, and that planning and management decisions be based on the best available environmental, social and economic information. While systems to classify environmental data and value are relatively well-developed, social and economic values are more challenging to capture, particularly as they relate to the environment.

To determine a process to systematically classify data and an approach to describe social and economic values and uses of Victoria's marine waters as requested in the terms of reference for the assessment, VEAC has reviewed current literature, government policy and global initiatives that relate to ecosystem services. In particular, the Economics of Ecosystems and Biodiversity, the European Marine Strategy Framework Directive, Victoria's State and Benefit reporting framework and the System of Environmental-Economic Accounting have been assessed.

KEY POINTS AT A GLANCE

- Social values are based on people's underlying value orientation (egoistic, social altruistic or biospheric) and expressed through their judgements and preferences, which influence behaviours and attitudes; referred to as held values.
- In practice social values of the marine environment include, for example, using marine waters for recreation, connecting with people and caring for special places; referred to as relational values
- Economic values of the environment can be expressed in monetary terms through market prices, willingness to pay and consumer behaviour; referred to as assigned values.
- Ecosystem services are the contribution of ecosystem components to wellbeing and are comprised of provisioning services, regulating services, cultural service, and a more recently conceptualised fourth category of habitat services.
- The importance of ecosystem services is recognised in the United Nations' 17 sustainable development goals and their underlying targets. For the marine environment goal 14 is the most relevant – conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- The System of Environmental Economic Accounting (SEEA) provides a basis for integrating measurement of environmental conditions and for valuing the benefits environmental services provide through an accounting framework.
- Any set of environmental economic accounts is only as good as the information and data used to populate it. This is particularly challenging in the marine environment where there is comparatively less investment in research and monitoring.
- Given the complexity of the marine environment, a single process is unlikely to adequately classify and assess social and economic values and uses. Approaches complementary to assessing ecosystem services include risk assessment, numerical modelling, scenario testing and expert elicitation.
- To adequately capture the total social, cultural, economic and environmental value of the marine environment, it is critical to include community knowledge.
- Adopting evaluation methods that align with international standards, using bottom-up approaches for engagement, and collating knowledge from a diverse range of sciences will provide the best outcomes for classifying social and economic values and uses of Victoria's marine environment.

14.1 Introduction

A review of available literature has shown that there are processes that can be used to systematically classify and collate information on social and economic values that are derived from the marine environment.

Non-standardised approaches for classifying ecosystem services can be biased by the availability of data and knowledge of existing or perceived issues. Working with a standard classification and set of indicators, and ensuring sufficient data are available, improves objectivity and balance in the assessment of ecosystem services.

Given the ecological complexity of the marine environment, the diversity of benefits and the numerous stakeholders, there is unlikely to be a single process that can be used to systematically classify data and provide an approach to describe social and economic values. Rather, a combination of processes is required to bring together social and economic values in a manner that supports balanced and informed discussion of issues targeted to the purpose and scale of the specific activity.

Adopting evaluation tools and methods that align with international standards, using bottom-up approaches for engagement of stakeholders and seeking knowledge from a diverse range of sciences will provide the best outcomes for classifying social and economic values and uses of Victoria's marine environment.

14.2 Defining social and economic values

As discussed in section 2.1, values can be considered as either held values, relational values or assigned values.

Social values are likely to be relational values such as the ability to use marine waters for recreation (for example surfing, fishing or sailing), connecting with people in nature, a sense of identity tied to places, and caring for and attending to places. Aboriginal cultural values are primarily relational values. Assigned values would include the conservation status of a species or area, cleanliness of places and visitation rates. Held values are expressed by people's judgements and preferences, which subsequently influence their behaviours and attitudes towards, for example, the degree to which they follow rules and regulations.[1]

Economic values of the environment are often expressed in monetary terms through measures such as market prices, willingness to pay (stated preference) and consumer behaviour (revealed preference)[1], and closely align with the definition of assigned values. However, these measures are dependent on the attributes of the environment, such as the fish or other extracted resource, as well as the relationship with the physical place from where the resource is extracted.

14.2.1 Wellbeing as a reflection of social and economic values

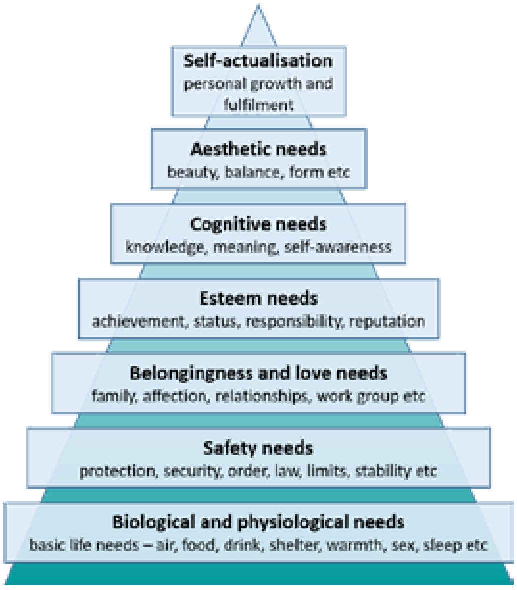
A person's 'wellbeing' can be considered as a held value. Attributes such as a person's health and social relations, as well as their sense of spiritual and cultural fulfilment, are essential to wellbeing.[2] This understanding of wellbeing also aligns human spiritual, social and cultural elements in intimate connection with nature.[3]

Research has shown that degraded environments can have negative impacts on an individual's wellbeing and affect livelihood opportunities, economic outcomes and the resilience of communities.[4]

The postulated hierarchy of human needs[5] can also be used to outline the needs of humans in terms of their biophysical connection with nature (figure 14.1). At the bottom level, people require basic essentials for survival such as clean air, clean water, sufficient food and shelter; while at the top of the hierarchy, people require supportive personal relationships, a sense of spirituality, opportunities to participate in group activities, and prospects for recreation and personal growth. The achievement of each level of the hierarchy is linked with the achievement of wellbeing.[6]

Social and environmental scientists are using these concepts as a framework for studying the relationships between community wellbeing, the connection (or disconnection) from natural environments and ecosystem health. The hypothesis being tested is that exposure to natural environments (also referred to as natural capital) contributes significantly to meeting the higher-level needs of people and thus their wellbeing.

Figure 14.1 An adapted hierarchy of needs diagram based on Maslow's Hierarchy of Needs[4]



The holistic philosophy of Aboriginal culture as held by Traditional Owners has much to offer contemporary ecological, health and social sciences. Their traditional knowledge, derived over thousands of years, is based on an understanding of the connection between ecosystem health and the wellbeing of their people.[3,7]

Various researchers[8,9] have argued that three different underlying value orientations may be relevant for understanding the relationship between natural environments and human wellbeing:

- egoistic orientation – a pro-self value orientation which focuses on optimising outcomes for the individual
- social altruistic orientation – a pro-social value orientation which focus on optimising outcomes for others
- biospheric value orientation – which emphasises the intrinsic worth of outcomes for nature.

A distinction can be made between the underlying held values that shape people's perception of the world (e.g. altruistic or biospheric value orientations), and the values that people assign to things in the world (e.g. natural heritage, money).[10]

There are five areas of consistent findings in the environmental values literature which apply to the management and understanding of ecological systems (and their contributions to wellbeing).[10]

These include:

- values change over time
- values differ between groups of people
- multiple values can be assigned to the same places
- multiple pathways exist between values, attitudes and behaviours towards ecosystems
- values influence people's judgement of management decisions.

Research shows that there are different value-based pathways that people use when valuing a place. For example, people with a biospheric value orientation may value an estuary for the significant number of different species present, while people with a social altruistic value orientation may value the same estuary for the opportunities it provides for family gatherings. People with an egoistic value orientation may value the estuary based on the recreational facilities available to support activities such as paddling or fishing. Understanding the value orientations (held values) of the people using the estuary can help predict which actions or messages are likely to generate negative responses and vice versa. This knowledge can then be used to inform planning and communication processes.[10]

14.3 Assessing economic value

14.3.1 Economic valuation frameworks

Two ways that economists consider economic values are through the total economic value framework and cost benefit analysis framework. The total economic value framework helps to identify the types of economic values that may be associated with a resource, whereas cost benefit analysis focuses on how these values may change under a proposed policy or project.

The total economic value is the sum of all the economic values that can be obtained from a resource. It consists of *use values* and *non-use values* of goods and services, where use values may be direct use (consumptive such as aquaculture, or non-consumptive such as sailing), indirect use arising from ecosystem functions, or option value (retaining the option to obtain future benefits). Non-use values are less tangible and include bequest value (the value of ensuring benefits are available for future generations) and existence value (the value of knowing that a good or service exists without ever using it).[11]

For a cost benefit analysis, only those values that change are actually valued in dollar terms. Provided the aggregate increases in economic value (benefits) to a society are greater than the aggregate decreases in value (costs) to a society, then the society is considered to be better off and the policy or project is desirable on economic grounds. Notwithstanding, an economically desirable policy will have distributional implications. That is, some individuals or groups in the community will bear the costs while a different group in the community (now or are in the future) may get the benefits.

The Victorian Guide to Regulation, prepared by the Commissioner for Better Regulation identifies four economic evaluation approaches that may be used to support economic evaluation of government policies and regulations. These are cost benefit analysis, break even analysis, cost effectiveness analysis and multicriteria analysis. The approaches are listed in declining order of analytical rigour and are also reflective of the quality and accuracy of data that would be required under each approach.[12]

Economic valuation assesses the benefits from tangible goods and services as well as less tangible benefits, such as the satisfaction of knowing that ecosystems exist or are being preserved for future generations. However, it is important to acknowledge the existence and validity of other valuation paradigms. For example, many people believe the environment has intrinsic worth and may be valued in its own right, independent of the value derived by humans. Intrinsic value is an important consideration, but it is not the focus of economic valuation work.[11]

14.3.2 Welfare value versus exchange value

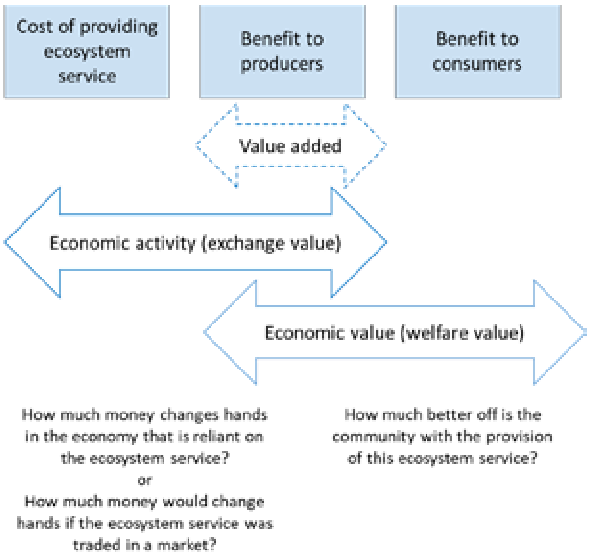
The concepts of exchange values and welfare values are used to distinguish between monetary values developed for economic evaluations (or welfare/benefit analysis) and monetary values that are sought in the context of national accounts.

Welfare values are used by economists to measure the net benefits to the community (or change in welfare) associated with a specific land use, proposed policy or investment.

Exchange values (such as gross output and gross value added) are derived from transactions observed in the economy and are a measure of economic activity. Exchange values are consistent with System of National Accounts definitions and are used to calculate gross state product.

Figure 14.2 summarises the relationship between monetary values developed for environmental valuation and accounting purposes. Welfare values are derived from a snapshot of market demand and supply cost curves. By contrast, exchange values include fixed costs as well as taxes and subsidies. In this way, the economic contribution or value added to an economy can be calculated directly from exchange values measuring profit as the return to labour and capital.[11] Measures of economic activities that provide stimulus to regional economies are different to the economic values considered in the cost benefit analysis framework.

Figure 14.2 Economic activity versus economic value (Source: DELWP[11])



14.3.3 Estimating economic values of environmental benefits

The key techniques available for estimating monetary values of environmental benefits are outlined in table 14.2. Selecting the right technique for each situation will depend on factors such as:

- motivation for the valuation
- type of economic and environmental data available
- ecosystem service (some techniques are suited to particular types of ecosystem service)
- time and budget available
- availability of experienced practitioners.

Table 14.1 Overview of valuation techniques[11]

Valuation technique	Example
Primary research	
Market based *Ecosystem service value estimated using data from existing markets*	Market price approach is used to estimate the value of ecosystem services (usually provisioning services) that are traded in markets, such as fish.
	Replacement cost approach estimates the value of an ecosystem service using cost of the next best option to achieve the same outcome. It is used to value regulating services, such as sewage treatment.
	Avoided cost approach estimates the value of an ecosystem service using the cost of the damage that would occur in society if the service was no longer provided.
	Productivity method is used where an ecosystem service affects production levels, costs or prices. The contribution to output is a proxy for the value of the service.
Revealed preference *Ecosystem service value estimated using observed behaviours and choices in existing related markets*	Travel cost method is used to estimate the value of recreational opportunities by observing visitor travel patterns and expenditure to visit a site.
	Hedonic pricing is used to derive values for amenity and aesthetic qualities of environmental assets by observing how another related market, such as real estate, changes in value due to proximity to such assets.
Stated preference *Ecosystem service value based on individual statements or choices in a hypothetical market*	Stated preference or choice modelling techniques simulate a market and demand for ecosystem services by means of surveys on hypothetical changes in the provision of ecosystem services. These techniques estimate both use and non-use values of ecosystems.
Secondary research	
Benefit transfer *Provides transferable values from other studies.*	Benefit transfer identifies primary valuation studies from similar ecosystems around the world and uses these values to derive an estimate of the benefits provided in the situation under consideration. The primary valuation study can use any of the above valuation techniques.

14.4 Linking social and economic values

14.4.1 Concept of ecosystem services

The United Nations' Millennium Ecosystem Assessment (MEA)[13] defines ecosystem services as the benefits humans derive from nature. The objective of the MEA was to assess how impacts to ecosystems affect human wellbeing. This knowledge is then used to support initiatives for protecting ecosystems, their ecosystem services and consequently human wellbeing.

The MEA provided a system for classifying ecosystem services into four broad groups (table 14.1). The first three – provisioning services, regulating services and cultural services – are all underpinned by the fourth, supporting services. However, valuation of supporting services is now considered to pose a double-counting risk since they may be considered as intermediate effects that then impact the provision of final ecosystem services and goods. Thus recent frameworks, including The Economics of Ecosystems and Biodiversity (TEEB) (see section 14.4.2), subsume supporting services and identify a fourth category of 'habitat services' which provide a final benefit in their own right.[14]

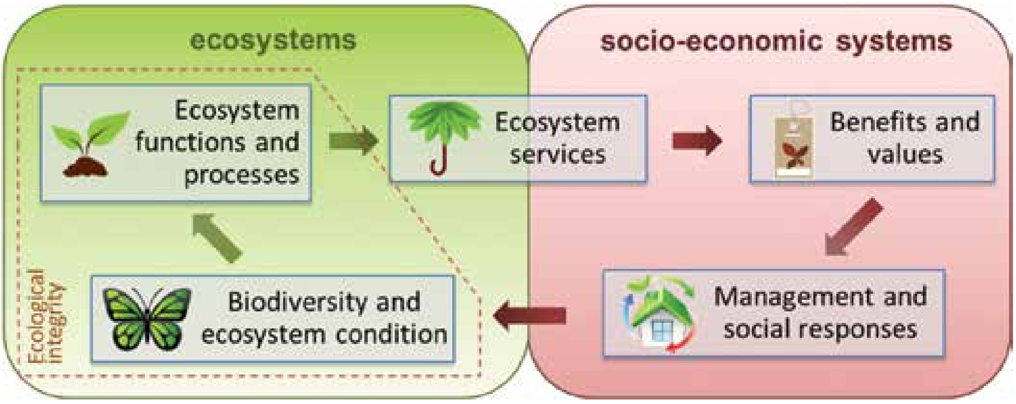
Table 14.2 Types of ecosystem services (from MEA, 2005)[13]

Ecosystem service	Definition
Provisioning services	Material products obtained from ecosystems that benefit humans (e.g. food, fibre)
Regulating services	The regulation of natural processes by ecosystems that benefits humans (e.g. water purification, carbon storage)
Cultural services	The contribution of ecosystems to non-material human benefits (e.g. recreation, cultural connection)
Supporting services	Ecosystem functions that support and enable the maintenance and delivery of final services (e.g. genetic diversity, habitat).

A simplified representation of the cascading framework of ecosystem services has been developed,[14] where ecosystem functions and processes comprise all the biophysical roles that sustain the provision of a specific ecosystem service, thus indicating the natural capacity to provide that service (figure 14.3).

Ecosystem services are the actual contribution of ecosystem components (as goods or services) to people's wellbeing. The benefits and values (relational and assigned) represent the perception or valuation that people place on a specific service. The management and social responses reflect how the political and individual's behaviours act as drivers of change in the environment, affecting ecosystem condition and subsequently the functions and processes it provides.

Figure 14.3 Simplified diagram of the concepts linking natural and social systems through ecosystem services[15]



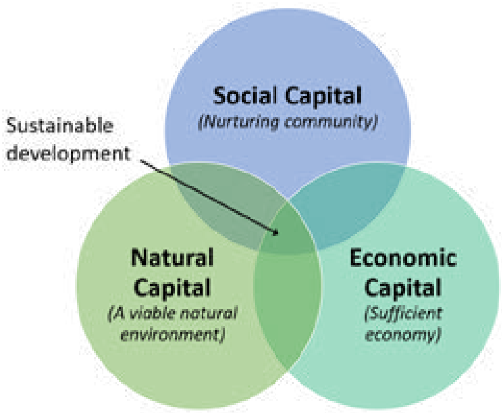
The changing human condition (e.g. economics, socio-political situations, science and technology advances, and cultural/religious preferences and choices) directly and indirectly drives changes in ecosystems (e.g. loss of biodiversity, algal blooms and fishery collapses) and thereby causes changes in wellbeing for people.[13]

The dominance of urbanism and individualism within many contemporary cultures has diminished the awareness of human dependence on the continued good health of the natural environment. This has prompted study of the relationships between sustainability, community resilience and vulnerability, and the different forms of social and environmental capital.[9]

Resilient socio-ecological systems are ecologically, economically and socially sustainable. They are diverse, with built-in processes that help to ensure they can continue to function in the face of shocks and to allow for reserve resources upon which to draw in times of stress and need. Economic, social and natural capitals are the 'glue' that holds communities together and the greatest resilience is achieved when all three capitals are equally well developed (figure 14.4).[9]

The ecosystem services concept has helped raise awareness about the importance of natural environments to society. The complex dynamics of social-ecological systems, and the supply and demand interplay for ecosystem services, require management approaches that consider environmental and community health and wellbeing. Thinking beyond financial considerations to measure and value natural and social capital allows for long-term approaches to investment in planning and policy development.[16]

Figure 14.4 A 'triple-bottom line' diagram, illustrating the relationship between social, economic and natural capital, and the achievement of sustainability when all three overlap[9]



14.4.2 Frameworks for classifying ecosystem services

A challenge in applying the concepts of ecosystem services in management and decision-making is to have a clear assessment framework that allows services to be measured and related to people's wellbeing.[15] To do this in a consistent and repeatable manner requires the development of standard approaches. However, research shows that, in many cases, jurisdictions have developed their own concepts and classifications or developed a variation on a previously used ecosystem service classification system.[17,18]

Most classifications relate back to The Economics of Ecosystems and Biodiversity (TEEB), a global initiative promoted by the United Nations Environment Programme.[19] TEEB provides a framework to recognise, demonstrate and capture the values of ecosystems and biodiversity and incorporate those values into decision-making.

The United Nations Environment Programme advocated a move towards a standard approach to an environmental–economic assessment classification system, to ensure that ecosystem services were being considered when reporting economic activity through the systems of national accounts. The wealth of a country should not be at the expense of the natural environment. This thinking led to development of an international classification system known as the Common International Classification of Ecosystem Services (CICES).

CICES provides a hierarchical and flexible structure built on the three types of ecosystem service – provisioning, regulating and cultural services – making it an ideal classification system for the assessment of ecosystem services.[20] CICES is built upon the previous classification systems of the MEA and TEEB, which allows comparability between them. It is also compatible with the System of Environmental–Economic Accounting (SEEA) developed by the United Nations Statistical Commission.[21]

Elements of these classification systems have been used to prepare a generic ecosystem services classification for the marine environment.[22] The suitability of this classification was assessed using a case study site, Dogger Bank in the North Sea (see box 14.1).

An issue of concern in addition to differentiating between ecosystem functions, services and benefits is that there is an imbalance in the assessment of ecosystem services. While the number of studies on marine ecosystem services is increasing, the number of services being assessed (measured) is limited. The assessment of hidden or distant components of ecological processes may also be inadequate.[23]

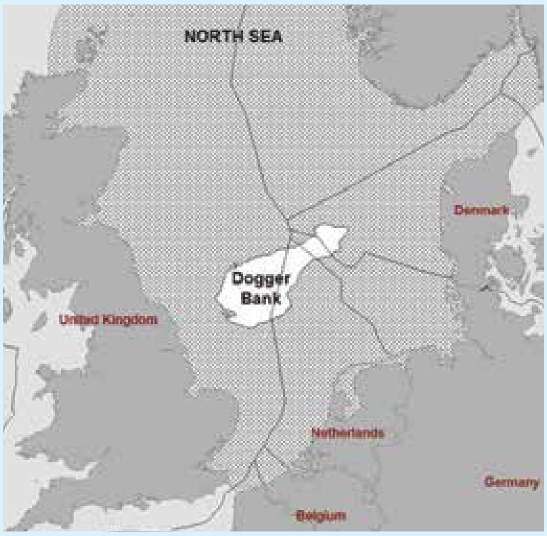
Use of an ecosystem services classification can contribute to other management and reporting processes by defining common service descriptors, indicators and metrics. These include state of the environment reporting for environmental and economic accounting, and monitoring, evaluation, reporting and improvement (MERI) plans for assessment of policy and strategy implementation outcomes.

Box 14.1
Dogger bank case study for marine ecosystem services

Dogger Bank is a large shallow subtidal bank that is within the coastal waters of United Kingdom, Denmark, Germany and Netherlands. The area has significant fisheries, oil and gas, is suitable for ocean wind farms, is used for recreational fishing and diving and provides feeding grounds for marine mammals and seabirds. With multiple uses and the likelihood of conflict, there is a need for an agreed process for measuring the ecosystem services and to use this knowledge to inform sustainable management.

Generic indicators for each marine ecosystem service in the classification were identified through an expert workshop and then tailored to fit the Dogger Bank case study. This classification together with indicators is provided in appendix 10, with some adjustments to align descriptors to a Victorian context.

The workshop process for selection of indicators highlighted an issue with differentiating between ecosystem functions, services and benefits. For example, an ecosystem benefit such as the amount (tonnes) of fish landed for human consumption should not be confused with an ecosystem service 'wild capture sea food'. This is because fishing methods used to land the fish will be highly selective and reflect quota allowances rather than indicating the full potential of the ecosystem to provide the service. The agreed indicators of the 'wild capture sea food' service were population size and quality of the fish stock, each of which are comprised of several measures.



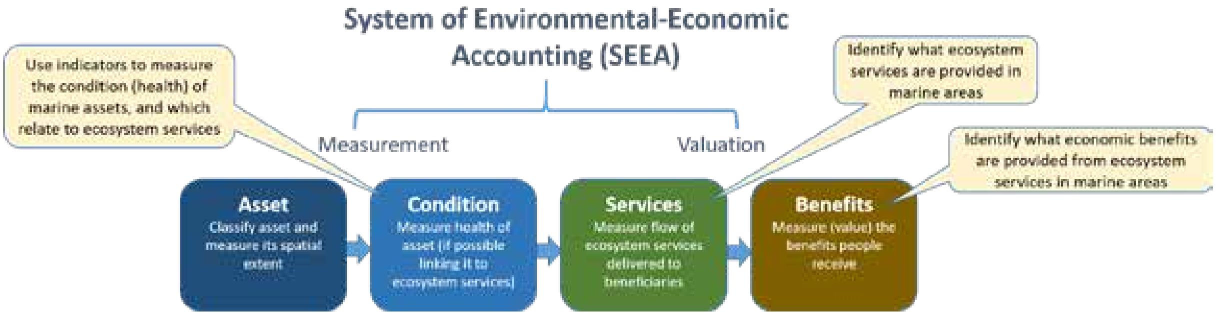
Location of the Dogger Bank (in white) in the North Sea[21]

14.4.3 System of Environmental Economic Accounting

Many values that the marine environment supports, including economic values, are not reflected in organisational or national decision-making frameworks such as the System of National Accounts, the internationally agreed standard set of recommendations on how to compile measures of economic activity at a national scale. The System of National Accounts excludes environmental features such as the atmosphere and ecosystems. This has led to the development of the System of Environmental-Economic Accounting (SEEA) by multiple international organisations including the United Nations, the European Commission, the World Bank Group and others.

SEEA is an established framework for developing ecosystem accounts and expanding the scope of conventional accounts for economic activity. It is used to integrate the measurement of environmental assets and to value the benefits they provide in a consistent manner across many domains of the environment (e.g. water, land, soil, biodiversity, forests) (see figure 14.4). Ideally, as benefits from ecosystem services increase, the condition of environmental assets should not deteriorate.

Figure 14.5 Integrating the measurement of environmental assets and valuation of their benefits[24]



SEEA provides internationally agreed standards on concepts, definitions and classifications to compile environmental, social and economic statistics to derive coherent and comparable indicators and measures of progress for policy goals.[23] It helps in understanding the interactions between the economy and the environment, and for describing stocks (and the changes in stocks) of environmental assets.

In Victoria, the role of environmental-economic accounting is increasingly recognised in policy and strategic documents. *Valuing and accounting for Victoria's environment: strategic plan 2015-2020* prepared by DELWP is a strategic plan for consolidating statewide accounting for environment. The objective is for best practice environmental-economic accounting to be consistently applied and integrated into policy and decision-making by 2020 across all government portfolios.[24]

However, as suggested by the Commissioner for Environmental Sustainability, environmental-economic accounting methods are only as good as the information and data that are used to populate them.[25] This, in turn, is dependent on the level of investment in data collection, management and analysis. This comment is pertinent to the marine environment where investment in research and data analysis is less than for terrestrial ecosystems. The same issue of the government needing to make a firm commitment to adopting environmental-economic accounting methods and to invest in data collection and analysis is reiterated in the Victorian State of the Environment 2018 Report.

It is important to keep in mind the differences between environmental accounting and economic valuation. They are linked but are generally used for different purposes.[11]

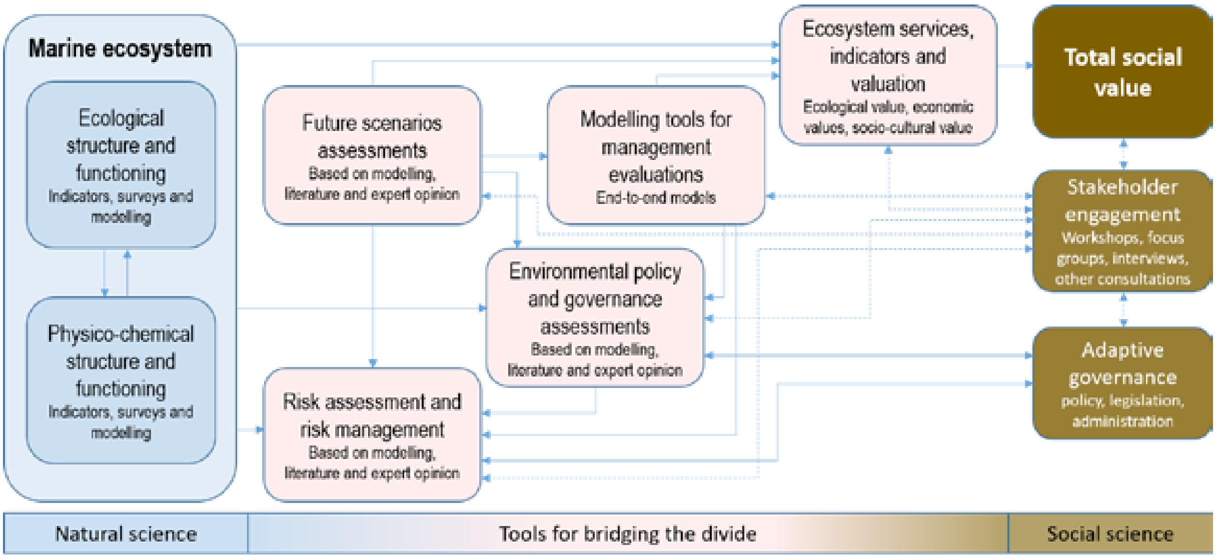
National accounts are focused on market activity and expenditure type of indicators. Extension of these frameworks to include the environment also tends to focus on expenditure type indicators as well as total values rather than marginal values.[11] The purpose of environmental accounting is to provide consistent and comparable information on ecosystem assets and the services they provide, along with performance measures of resource use and emissions in the economy (e.g. water, energy, carbon). Environmental valuation is used to assess the benefits provided by environmental assets and places a value in monetary terms, which enables appraisal of competing use of resources, alternative policies or investments.

Economic values are focused on the wellbeing of people as measured by the surpluses (consumer and producer surpluses) experienced by those who use and provide resources. Measures of expenditure are not economic value estimates but relate to the contribution of a resource to the size of the economy. This information may be relevant for some stakeholders but is not the primary issue of concern when evaluating policy options. Expenditures (including on employment) are costs and as such are detractors from value. Changes in economic value (marginal values), relative to the counter factual, are the relevant measure for the evaluation of policy initiatives.[26]

14.5 Interdisciplinary framework to support integrated management

An interdisciplinary framework has identified five main types of evaluation (tools) that link natural and social sciences research in support of integrated management of marine environments (figure 14.6).[27] The valuation of ecosystem services is just one of these tools. Other tools within the framework include risk assessment, numerical modelling, scenario testing and expert elicitation. The input of community knowledge through stakeholder engagement is considered essential when identifying the total social value of the marine environment and to subsequently developing policy for the future management of marine environments.

Figure 14.6 A framework for linking natural and social sciences for integrated marine management. Solid lines reflect linkages between components; dashed lines reflect two-way aspects of stakeholder engagement[27]



Historically, management of marine environments has been approached on a sector by sector basis. More recently, there has been a desire for more inclusive approaches that aim to protect and enhance the natural structure, processes and functioning while at the same time delivering the ecosystem services from which society can benefit.[27,28]

Adopting a holistic approach to developing policy requires areas of conflict to be identified and understood. For example, areas of conflict may occur between fishers who want to maintain access to all areas, and conservation groups wanting to increase protection of fish and related ecosystems through exclusion.[27] In Victoria, similar conflicts occurred in developing recommendations for marine protected areas and for banning commercial netting in Corio Bay.[29]

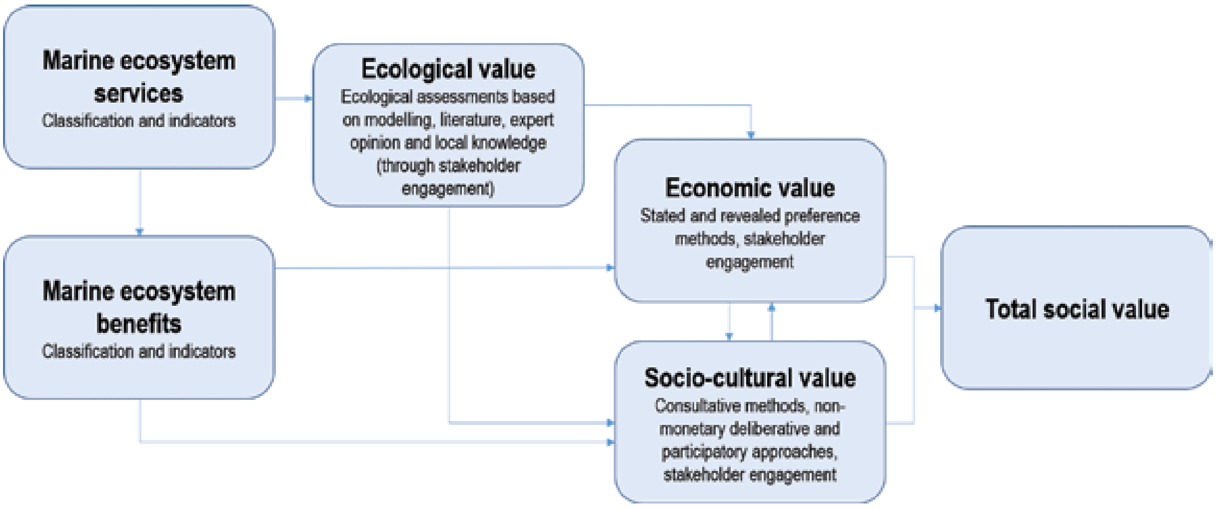
14.5.1 Total social value

A major challenge to the evaluation of ecosystem services is to establish total social value (figure 14.7).[27] This comprises three main value domains:

- ecological value which is the health state of an ecosystem measured using ecological indicators such as diversity and integrity
- economic value which comprises both use and non-use values and can be valued using stated and revealed preference methods
- socio-cultural value which includes the importance people give to, for example, cultural identity and the degree to which that is related to ecosystem services.

Ecological valuation does not feed directly into total social value but is important for providing the basis for both the assessments of economic value and socio-cultural value.[22] This step incorporates both scientific knowledge (through ecological assessments) and local knowledge (through stakeholder engagement) which can feed into the decision-making process.

Figure 14.7 Total social value comprising ecological value, economic value and socio-cultural value[27]



14.6 Sustainable development goals

The Sustainable Development Goals (SDGs), adopted in September 2015 by the United Nations, recognise that the extent and condition of ecosystem assets provide many social, cultural and economic benefits and can be used as basis for monitoring and reporting the effectiveness of environmental management. The 17 SDGs and 169 targets provide a focus for mainstreaming sustainability in all activity's humans undertake.[30]

The main SDGs that are relevant to managing the marine environment include SDG 6 (clean water and sanitation), SDG 13 (climate action) and SDG 14 (life below water). However, there are targets within nearly all the goals that have relevance for management of the marine environment. Work undertaken by the Commissioner for Environmental Sustainability identified 22 biophysical and 30 socio-economic targets from the 169 targets that align with State of the Environment reporting.[25]

In the State of the Environment 2018 report, indicative results were provided for the 52 targets. However, it was stated that data quality for the socio-economic targets was poor and that there is a need to improve data acquisition through innovative methods and better partnerships. Overall, seven of the targets are improving, 25 are stable, six deteriorating and 14 were unclear. Six of the targets and potential indicators for SDG 14 are presented in Table 14.3.

Further work is needed to ensure that targets and indicators of those targets are defined in a context relevant to Victorian conditions. It will also be important to establish baseline conditions as at 2015 when the targets were set. Many of the targets will also require further scientific research, for example achievement of target 14.3 'minimise and address the impacts of ocean acidification …' requires a better understanding of the full extent of impacts to marine values from ocean acidification.

Figure 14.8 Sustainable Development Goals (SDGs), adopted in September 2015 by the United Nations, can be used as basis for guiding sustainable management and reporting of the marine and coastal environment – specifically goals 6, 13, 14 and 15.

Table 14.3 Targets and indicators for goal 14 (Life below water – conserve and sustainably use the oceans, seas and marine resources for sustainable development) from the 2030 Agenda for Sustainable Development that are relevant to Victoria

Targets for SDG 14*	Indicators
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 Index of coastal eutrophication and floating plastic debris density
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas
14.b Provide access for small-scale artisanal fishers to marine resources and markets	14.b.1 Degree of application of a legal/regulatory/policy/institutional framework which recognises and protects access rights for small-scale fisheries

* Four of the 10 targets for SDG 14 from the 2030 Agenda for Sustainable Development were considered as not being appropriate for State of the Environment reporting in Victoria, and are not shown in this table[25]

14.7 References

1. Brown, T.C. (1984) The concept of value in resource allocation. *Land Economics* 60: 231-246.
2. Richardson, H.S. and Schokkaert, E. (2017) How do we measure well-being? *The Conversation* https://theconversation.com/how-do-we-measure-well-being-70967
3. Stephens, C., Parkes, M.W. and Chang, H. (2007) Indigenous perspectives on ecosystem sustainability and health. *EcoHealth* 4: 369-370.
4. Townsend, M. and Weerasuriya, R. (2010) *Beyond blue to green: the benefits of contact with nature for mental health and well-being*. Melbourne, Australia, Beyond Blue Limited.
5. Maslow, A.H. (1943). A theory of human motivation. *Psychological Review* 50: 370-96.
6. Macintyre, S., Ellaway, A. and Cummins, S. (2002) Place effects on health: how can we conceptualise, operationalise and measure them? *Social Science & Medicine* 55: 125-139.
7. Franco, L.S., Shanahan D.F. and Fuller R.A. (2017) A review of the benefits of natural experiences: more than meets the eye. *International Journal of Environmental Research and Public Health* 14: 864.
8. De Groot, J.I.M. and Steg, L. (2008) Value orientations to explain beliefs related to environmental significant behaviour: how to measure egoistic, altruistic, and biospheric value orientations. *Environment and Behaviour* 40: 330-325.
9. Wilson, G.A. (2012) *Community resilience and environmental transitions*. Routledge, Abingdon.
10. Ives, C.D. and Kendall, D. (2014) The role of social values in the management of ecological systems. *Journal of Environmental Management* 144: 67-72.
11. Varcoe, T., Betts O'Shea, H. and Contreras, Z. (2015) *Valuing Victoria's parks – accounting for ecosystems and valuing their benefits: report of first phase findings*. Parks Victoria and Department of Environment, Land, Water and Planning.
12. Commissioner for Better Regulation (2016) *Victorian guide to regulation – a handbook for policy-makers in Victoria*. Prepared by the Commissioner for Better Regulation for the Department of Treasury and Finance, Melbourne, Victoria. http://www.betterregulation.vic.gov.au/Guidance-and-Resources
13. Millennium Ecosystem Assessment (2005) *Ecosystems and human well-being: general synthesis*. http://www.unep.org/maweb/en/Synthesis.aspx.
14. CSIRO (2012) *Assessment of the ecological and economic benefits of environmental water in the Murray–Darling Basin*. CSIRO Water for a Healthy Country National Research Flagship, Australia.
15. Liquete, C., Cid, N., Lanzanova, D., Grizzetti, B. and Reynaud, A. (2016) Perspectives on the link between ecosystem services and biodiversity: the assessment of the nursery function. *Ecological Indicators* 63: 249-257.
16. Mehring, M., Zajonz, U. and Hummel, D. (2017). Social-ecological dynamics of ecosystem services: livelihoods and the functional relation between ecosystem service supply and demand. *Sustainability* 9: Article 1037.
17. B€ohnke-Henrichs, A., Baulcomb, C., Koss, R., Hussain, S.S. and de Groot, R. (2013) Typology and indicators of ecosystem services for marine spatial planning and management. *Environmental Management* 130: 135–145
18. Norton, D., Hynes, S. and Boyd, J. (2018) *Valuing Ireland's coastal, marine and estuarine ecosystem services*. EPA Research Report No 239 (2014-NC-MS-1) Prepared for the Environmental Protection Agency by National University of Ireland, Galway and Galway–Mayo Institute of Technology. Available at: http://www.epa.ie/pubs/reports/research/water/Research_Report_239.pdf
19. TEEB (2010). Biodiversity, ecosystems and ecosystem services. Pages 41-112 in Kumar, P. (ed.) *The economics of ecosystems and biodiversity: ecological and economic foundation.* UNEP/Earthscan, London and Washington.
20. Maes, J., Teller, A., Erhard, M., Liquete, C., Braat, L., Berry, P., Egoh, B., Puydarrieux, P., Fiorina, C., Santos, F., Paracchini, M.L., Keune, H., Wittmer, H., Hauck, J., Fiala, I., Verburg, P.H., Condé, S., Schägner, J.P., San Miguel, J., Estreguil, C., Ostermann, O., Barredo, J.I., Pereira, H.M., Stott, A., Laporte, V., Meiner, A., Olah, B., Royo Gelabert, E., Spyropoulou, R., Petersen, J.E., Maguire, C., Zal, N., Achilleos, E., Rubin, A., Ledoux, L,. Brown, C., Raes, C., Jacobs, S., Vandewalle, M., Connor, D. and Bidoglio, G. (2013) *Mapping and assessment of ecosystems and their services. An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020*. Publications office of the European Union, Luxembourg. http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf (accessed 27 November 2018).
21. UN (United Nations), EC (European Commission), FAO (Food and Agriculture Organization of the United Nations), OECD (Organisation for Economic Co-operation and Development) and the World Bank Group, 2014. *System of environmental–economic accounting 2012: experimental ecosystem accounting.* http://unstats.un.org/unsd/envaccounting/seeaRev/eea_final_en.pdf
22. Hattam, C., Atkins, J.P., Beaumont, N., Borger, T., B€ohnke-Henrichs, A., Burdon, D., De Groot, R., Hoefnagel, E., Nunes, P., Piwowarczyk, J., Sergio, S. and Austen, M. (2015) Marine ecosystem services: linking indicators to their classification. *Ecological Indicators* 49: 61-75.
23. Culhane, F.E., Frid, C.L.J., Gelabert, E.R., White, L. and Robinson, L.A. (2018) Linking marine ecosystems with the services they supply: what are the relevant service providing units? *Ecological Applications* 28: 1740-1751.
24. Department of Environment, Land, Water and Planning (2015) *Valuing and accounting for Victoria's environment: strategic plan 2015-2020*. Available online: https://www.environment.vic.gov.au/__data/assets/pdf_file/0030/49809/DELWP-Strategic-Plan-Valuing-and-accounting-for-the-environment-2016-V7.pdf

25. Commissioner for Environmental Sustainability (2018). *State of the environment 2018 report*. Commissioner for Environmental Sustainability, Melbourne, Victoria.

26. New South Wales Department of Primary Industries (2018) Murray-Darling Basin socio-economic values of native fish and recreational fishing – scoping project final report. NSW Department of Primary Industries, Dubbo.

27. Burdon, D., Boyes, S.J., Elliott, M., Smyth, K., Atkins, J.P., Barnes, R.A. and Wurzel, R.K. (2018) Integrating natural and social sciences to manage sustainably vectors of change in the marine environment: Dogger Bank transnational case study. *Estuarine, Coastal and Shelf Science* 201: 234-247

28. Boyes, S.J. and Elliott, M. (2015) The excessive complexity of national marine governance systems has this decreased in England since the introduction of the Marine and Coastal Access Act 2009? *Marine Policy* 51: 57-65.

29. King, T.J. and O'Meara, D. (2018) 'The people have spoken': how cultural narratives politically trumped the best available science (BAS) in managing the Port Phillip Bay fishery in Australia. *Maritime Studies* https://doi.org/10.1007/s40152-018-0097-5

30. Ntona, M. and Morgera, E. (2018) Connecting SDG 14 with the other sustainable development goals through marine spatial planning. *Marine Policy* 93: 214-222.

15 Data Inventory and Knowledge Gaps

The terms of reference include preparing an inventory of available knowledge and data on existing values, uses and threats and advising on any significant gaps. Throughout the preceding chapters the available knowledge, key references and datasets have been discussed and evaluated in terms of their relevance to understanding the values and threats to these values. The entire assessment report and the accompanying atlas can therefore be considered as an inventory of available knowledge and data.

The focus of this chapter is on providing a summary of key datasets across all themes, references to collation activities, drivers for data collection and knowledge gaps identified through VEAC's assessment process.

KEY POINTS AT A GLANCE

- To improve knowledge and understanding there is a need to have in place processes for data collection, data management, data analysis and decision support systems and tools to support planning and management.
- DELWP's marine knowledge framework is used for collating and storing scientific observations and monitoring data, information sources and supporting materials, including imagery, in a centralised relational database.
- The marine knowledge framework, once fully developed, will facilitate data sharing and dashboard reporting on conditions and trends in marine health.
- Australia's Integrated Marine Observing System (IMOS) covers physical, biological, and chemical variables to address themes of multi-decadal ocean change, climate variability and weather extremes, boundary currents and inter-basin flows, continental shelf processes and ecosystem responses.
- Ongoing research, data collection and monitoring of the key drivers of climate and oceanography and their collective impact on coastal geomorphology and ecosystem services is required to inform sustainable management of the marine and coastal environment.
- Better understanding of ecosystem linkages and processes, particularly for subtidal environments, is essential for assigning value and significance, identifying hotspots and predicting consequences of change and response to threats.
- Biotope mapping provides a valuable reference set for assessing marine health and impacts of climate change and human activities. Further investment in mapping of broad habitats and biotope complexes is needed to fill gaps and establish a baseline.
- The nature of Aboriginal culture and knowledge means that there is not a well-documented inventory of information on cultural values available to decision makers and investment is required to support Traditional Owners in mobilising this knowledge.
- The reliance on accurate stock assessments to inform fisheries management means that estimates of the total recreational catch are required for assessment of fisheries, especially where the recreational component is significant.
- Government agencies need to continue to invest in a range of research and monitoring to inform operational and planning requirements that support evidence-based decision making.

15.1 Drivers for data collection, collation and analysis

Knowledge of how marine ecosystems operate and how they respond to changing conditions is critical for informing management decisions. To improve knowledge there is a need to have in place processes for data collection, data management, data analysis and decision support systems to support planning and management.[1]

The Victorian State of the Environment 2018 Report recognises that a spatial information resource that can be used as a single source of truth, that is regularly and routinely updated and can be assessed broadly will help mitigate confusion associated with outdated and unreliable data and reduce misinformation in the public domain. Internationally, it is recognised that for data to have significant benefit they need to be easily discoverable, accessible and usable.[2]

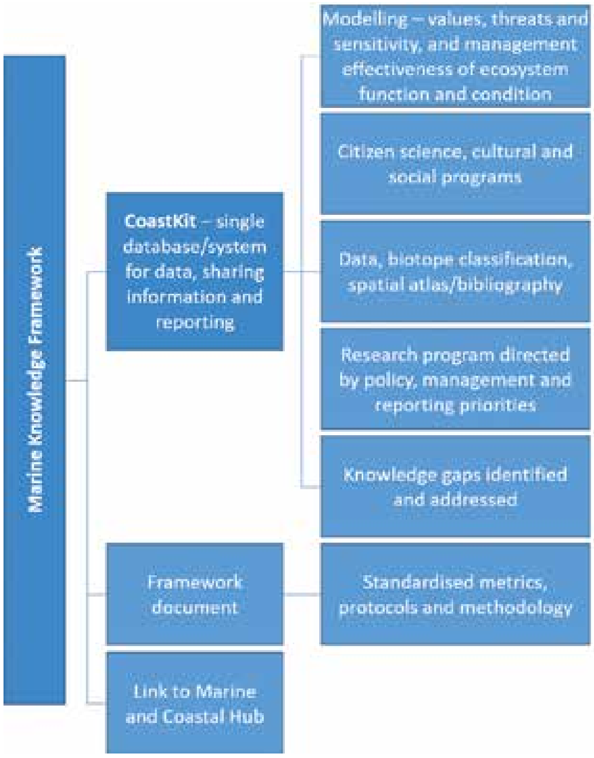
Citizen science has an important role to play in building knowledge and understanding of marine values and threats to those values. Citizen scientists can assist with routine monitoring, data collation and analysis, highlighting issues that require further research and building awareness of the marine environment in the wider community. In addition to supporting citizen science programs, continued investment is required in key research projects and long-term monitoring by research institutions and government agencies.

15.1.1 Marine knowledge framework

DELWP is investing in development of a marine knowledge framework to support evidence-based decision making. The framework provides for marine research and monitoring efforts to be integrated and directed towards sustainable management priorities driven by policy. It can be used to identify knowledge gaps, reduce uncertainties, consolidate data into one database/system and provide an evidence base for evaluating management interventions.[3]

The framework builds on DELWP's existing CoastKit Resources system. Scientific observations and monitoring data, information sources and supporting materials, including imagery, will continue to be collated and stored in a centralised relational database (known as q-Core), with access provided through a variety of web interfaces. The CoastKit website, once fully developed, will facilitate data sharing and dashboard reporting on trends, condition and health using metrics agreed by the scientific community and government agencies.

Figure 15.1 Outline of features in the marine knowledge framework[3]



The marine knowledge framework will support strategic and on-ground management, improved reporting and greater understanding of the values of and threats to the marine environment. A key component will be the development of a values-threats-sensitivities assessment tool and the required information to support this tool. The tool will:

- define the key marine environmental values, ecosystem function and services, and the activities, threats and pressures impacting on biotope state and condition
- enable users to explore what is known about marine biotopes and their sensitivity/tolerance to pressures and the types of activities that cause these pressures
- act as a starting point to identify potential management requirements and indicate where resources should be prioritised (outcome and cost-effectiveness)
- highlight knowledge gaps where there are limited data or uncertainty in expert confidence
- consider cumulative impacts.

The marine knowledge framework is well advanced in that it already contains extensive mapped biotope and monitoring data in the CoastKit database. Data are classified according to the CBiCS scheme and the presence of habitats is readily determined as parent classes of biotopes (see chapter 6 for discussion of CBiCS and biotope mapping). Most of the mapped records are stored in the biotope atlas within the relational database of CoastKit.

A features atlas is proposed as part of the marine knowledge framework. It will include spatially-referenced biotic (living organisms) features of significance such as bird rookeries, seal colonies, records of listed species and the like, and abiotic (non-living chemical and physical parts of the environment) features of significance such as canyons, pinnacles, outcrops, upwellings and artificial structures. The features atlas will also include drivers that have potential to affect features. Examples include pipelines, outfalls, management areas such as aquaculture zones or anchorages, and the location of incidents and events, such as storm/cyclone damage, shipwrecks and oil spills.

15.1.2 Integrated Marine Observing System (IMOS)

Australia's Integrated Marine Observing System (IMOS) is a collection of measurement devices and instruments established to provide an enduring observing program for Australian oceanic waters. The observations cover physical, biological, and chemical variables to address themes of multi-decadal ocean change, climate variability and weather extremes, boundary currents and inter-basin flows, continental shelf processes and ecosystem responses.[4]

Governments and other organisations are investing in the IMOS because ocean observations satisfy many management requirements, for example as inputs/validation for oceans hydrodynamic and water quality modelling, studying climate variability, contributing to environmental assessments and monitoring, commercial fishing, and to aid design of marine and coastal infrastructure.

However, observing the ocean is relatively expensive due to the spatial and temporal extents to be sampled, and the range of variables to measure. While technological advances have made it possible to collect vast quantities of data, managing and distributing these data effectively is a challenge in itself. Hence there is a need for a collaborative approach and investment in data collection, storage, analysis and reporting.

The South East Australian IMOS node, which is sponsored by Deakin University and supported by government agencies and other research organisations, has been established to facilitate long term monitoring programs for ocean systems in Bass Strait (http://imos.org.au/nodes/nodes/seaimos/).

15.2 Key datasets

Table 15.1 lists the key datasets that support the assessment of environmental, economic, social and cultural values of Victoria's marine environment and threats to those values.

Table 15.1 Key datasets that support the assessment of environmental, economic, social and cultural values of Victoria's marine environment and threats to those values

Name	Description	Custodian & coverage	Comment
Baselines and boundaries			
Australian Maritime Boundaries – includes terrestrial sea baseline and the extent of Victoria's coastal waters	The terrestrial sea baseline is a line of low tide along the open coast, crosses river mouths and entrances to embayments and encloses nearshore islands. It is basis for determining the location of the three nautical mile extent of Victorian waters	Geoscience Australia National	The line has not been defined by survey positioning methods, but the digital map product has authoritative status
SmartLine_Victoria_2008	This dataset defines the coastline and is presented as a single line feature with multitude of attributes, such as subtidal or intertidal information, landform and geology. Each 50 metre section describes a unique segment of the coast and demonstrates significant changes in the characteristics of the coastal strip. SmartLine was used for the Victorian Coastal Hazard Assessment 2017	DELWP Statewide	Spatial accuracy is high, but it shows where the coastline was in 2008. Attributes, such as erodibility and instability, were created in 2012 by Geoscience Australia. It is considered the most accurate representation of mean sea level
Vicmap data – Oceans and estuaries, Hydro, Features of interest (http://services.land.vic.gov.au/SpatialDatamart)	Vicmap data is the authoritative spatial data for the state, providing foundation layers for mapping and GISs – includes waterways, coastal features, bathymetry, municipal boundaries, roads and property boundaries	DELWP Statewide	Spatial accuracy is high, but currency is variable depending on frequency of update and field checking
Victorian Coastal Nearshore Bathymetric Elevation dataset	Provides 5 metre contour intervals derived from LiDAR for coastal and nearshore areas, generally extending out to the 20 metre depth contour	DELWP Statewide	Spatial accuracy is high, but currency is variable depending on frequency of update. Higher resolution bathymetry is required for modelling of coastal processes
Regional marine biounit boundaries	There are 26 regional marine biounit areas along the coast that extend from the shore to the seaward extent of Victorian waters, and are typically separated by dominant physiographical settings. Unit names and boundaries were determined as part of DELWP's marine biotope mapping program	DELWP Statewide	Boundaries not defined by survey positioning methods, but digital map product has authoritative status
Victorian marine assets database	Marine assets are defined in this context as tangible biophysical elements of the environment that are valuable for their ecosystem services (eg Bonney Upwelling)	DELWP Statewide	Expert advice used to identify assets in 2011-12. No further work to review or test accuracy of advice, as such data are for guidance only
Index of Estuary Condition https://www.ari.vic.gov.au/research/rivers-and-estuaries/index-of-estuary-condition	The Index of Estuary Condition (IEC) is a condition assessment method being applied to estuaries throughout Victoria to document their current condition and establish a baseline for future monitoring. The IEC focuses on five components of estuaries: fauna, flora, water quality, physical form (e.g. size and shape) and hydrology	DELWP Statewide	Quality is variable – based on fieldwork over 5-year period. By 2020, most Victorian estuaries will have been assessed using the IEC method

Name	Description	Custodian & coverage	Comment
Climate, oceanography and geomorphology			
Climate Data Online - daily and monthly statistics, historical weather observations, rainfall, temperature and solar tables, graphs and data http://www.bom.gov.au/climate/cdo/about/cdo-selecting-data.shtml	Climate Data Online provides access to a range of statistics, recent weather observations and climate data from the Australian Data Archive for Meteorology (ADAM), a database which holds weather observations dating back to the mid 1800s for some sites	Bureau of Meteorology National	Increasingly, observations are being automated, giving continuous data.. Observations must pass rigorous quality control processes before being archived in ADAM
Climate change – trends and extremes http://www.bom.gov.au/climate/change/#tabs=Datasets&tracker=timeseries	Climate change tracker uses the Australian Climate Observations Reference Network – Surface Air Temperature dataset and other high-quality datasets (rainfall, cloud amount and pan evaporation) to develop products that highlight climate variability and change across regions	Bureau of Meteorology National	When using trend analysis, users should be aware of averaging processes and periods over which comparisons are made as this may limit the conclusions that can be drawn from the data
Sea surface temperature and salinity http://www.bom.gov.au/oceanography/forecasts/idyoc300.shtml?region=VICTAS&forecast=SST	The Bureau has provided forecasts (Bluelink Ocean Forecasts) for temperature, currents, sea level anomaly and sea surface salinity using the Bureau's ocean model (OceanMAPS) on a grid size approximately 10 by 10 kilometres	Bureau of Meteorology National	Model outputs are less accurate in the nearshore region where the model resolution cannot replicate local features
Wave height forecasts http://www.bom.gov.au/marine/waves.shtml	The Bureau operates a 7-day Global wave model called Auswave. Wave forecasts are available for sub-regions, includes Bass Strait and coast of Victoria	Bureau of Meteorology National	Model outputs are less accurate in the nearshore region where the model resolution cannot replicate local features
Australian Wave Energy Atlas https://nationalmap.gov.au/renewables/#share=s-gGd5ztFcxe2ysy9f	Atlas provides a 4D interactive wave map of the greater Australian coastal area relative to available infrastructure and spatial constraints in the marine domain – includes wave heights, direction, period and energy from the CAWCR Wave Hindcast dataset	Australian Renewable Energy Agency National	Based on model outputs using data from 1980-2010
Climate Change in Australia https://www.climatechangeinaustralia.gov.au/en/	CSIRO have created a website for information and data on climate change projections – includes sea level rise, sea surface temperature, salinity and ocean acidification	CSIRO National	Model outputs are less accurate in the nearshore region where the model resolution cannot replicate local features
Coastal sediment compartments https://data.gov.au/dataset/	In 2012 coastal science experts split the coastal zone into primary and secondary coastal sediment compartments to represent regional (1:250 000 - 1:100 000) and sub-regional (1:100 000 - 1:25 000) scale spatial units within (and between) which sediment movement processes are significant at scales relevant to coastal management	Geoscience Australia National	Spatial accuracy for compartment boundaries is high, but accuracy and currency of attributes is variable as it is based on data older than 2011 and expert opinion

Name	Description	Custodian & coverage	Comment
Victorian Coastal Monitoring Program https://www.coastsandmarine.vic.gov.au/coastal-programs/victorian-coastal-monitoring-program	The Coastal Monitoring Program provides information on coastal condition, change, hazards, and impacts associated with climate change. Delivered through partnerships with community groups (citizen science) and institutions – monitoring of waves, sediment and shoreline vegetation	DELWP Statewide	Ongoing program, dependent on funding, co-investment and priorities
Australian Ocean Data Network (AODN) Portal https://portal.aodn.org.au/search	AODN Portal provides access to available Australian marine and climate science data and provides the primary access to IMOS data including access to the IMOS metadata	IMOS National	Accuracy of data and limitations are well defined
Biodiversity			
Victorian Biodiversity Atlas (VBA) https://www.environment.vic.gov.au/biodiversity/victorian-biodiversity-atlas	The VBA includes a dynamic list of species found in Victoria and provides information including conservation status. There are more than seven million records of species distribution and abundance collated from many different data providers	DELWP Statewide	Observational records are historical and do not indicate if the species is still present at that location
World Register of Marine Species (WoRMS) http://www.marinespecies.org/index.php	The World Register of Marine Species (WoRMS) provides an authoritative and comprehensive list of names of marine organisms, including information on synonymy – over 500,000 specie listed	LifeWatch Belgium International	Continually updated and peer reviewed
AlgaeBase http://www.algaebase.org	AlgaeBase is a database of information on algae that includes terrestrial, marine and freshwater organisms. For convenience, sea-grasses are included, even though they are flowering plants	National University of Ireland International	Data are mainly from published information and compromises taxonomic opinions
Atlas of Living Australia http://www.ala.org.au	The Atlas of Living Australia (ALA) aggregates biodiversity data from multiple sources and makes it available and usable online – species pages display text descriptions, images, location, taxonomic details and links to literature	hosted by CSIRO National	Observational records are historical and do not indicate if the species is still present at that location
Australian Faunal Directory Australian Biological Resources Study, Canberra https://www.environment.gov.au/science/abrs/online-resources/fauna	The Australian Faunal Directory (AFD) is an online database that provides taxonomic and biological information	Dept of the Environment and Energy National	It is constantly being updated and expanded with addition of new data sets. At present about 98% of described species are listed in the directory
Australian Marine Zooplankton: a taxonomic guide and atlas http://www.imas.utas.edu.au/zooplankton/home	Used to identify common zooplankton species and provide information on zooplankton. Includes images and notes to identify group and ultimately species. Species-level taxonomic sheets describe diagnostic characteristics and include photographs, diagrams, distribution maps, information on ecology and key references	UTAS National	Website and guide are works in progress and might contain some errors

Name	Description	Custodian & coverage	Comment
Shorebirds 2020 http://awsg.org.au/about-us/shorebirds-2020/	Shorebirds 2020 program is a collaborative enterprise between BirdLife Australia and Australasian Wader Studies Group. The database comprises the most complete shorebird count data available in Australia for approximately 150 roosting and feeding sites, mainly in coastal Australia, going back to 1981 for key areas. Data are provided as species counts for each Shorebird Area and its respective Count Areas with observation date in rows and species in columns	Birdlife Australia National	Data have been vetted but no overall indication of correctness is provided. BirdLife Australia charges an extraction fee for making data from the database available to commercial or government organisations
Fishes of Australia (Museums Victoria and OzFishNet) http://fishesofaustralia.net.au/	Fishes of Australia provides information on the diversity and biology of Australia's marine and freshwater fishes – includes 'Fish Family Finder' to identify different species	Hosted by Museums Victoria on behalf of the OzFishNet community	The total number of Australian fishes continues to rise as new species are discovered or when species known to occur elsewhere are found
Reef Life Survey https://reeflifesurvey.imas.utas.edu.au/static/landing.html	Reef Life Survey (RLS) coordinates surveys of rocky and coral reefs, and makes data publicly available, to assess existing conditions and track changes over time for local reefs	UTAS International	Reliance on volunteers and their interest in undertaking repeat surveys. Data can be locally rich in some areas and poor in others
VICFLORA Flora of Victoria https://vicflora.rbg.vic.gov.au/	VICFLORA is a guide to the wild plants of Victoria, with plant profiles and identification, the Royal Botanic Gardens Victoria provides this resource free-of-charge for land managers, scientists, students and others with an interest in Victorian plants	Royal Botanic Gardens Victoria Statewide	The list is being continuously updated
Victorian Marine and Coastal Geo-Bibliography http://dev-coastkit.cbics.org/bib_geo	The Victorian Marine and Coastal Geo-Bibliography, within CoastKit, provides a GIS tool for displaying and searching marine and coastal ecological studies. It includes biological, ecological and environmental data. Citations are attributed with bounding polygons of the study location(s) and, where available, survey transects and sites. The bibliography presently contains larger-scale and public domain studies with reported sampling locations	DELWP Statewide	Citations will be progressively added and refined
Subtidal reef monitoring program for marine protected areas https://parkweb.vic.gov.au/park-management/environment/research-and-scientific-management/marine-monitoring/subtidal-reef-monitoring	The shallow subtidal reef monitoring program (SRMP) established in 1998 at Wilsons Promontory, then expanded to include marine protected areas. Underwater diver-mediated visual survey methods of macroalgae, invertebrates and fish, generally at a depth of less than 10 metres are used to monitor suite of flora and fauna associated with reefs in shallow waters	Parks Victoria Marine protected areas	Monitoring outputs have been incorporated into the marine biotopes program

Name	Description	Custodian & coverage	Comment
Victorian Marine Biotopes http://dev-coastkit.cbics.org/vic_biotope	Marine biotopes are recognisable assemblages of species that occur within particular environments and habitats. Each biotope has specific values and responses to environmental changes and their mapping and monitoring is useful for assessing the status of ecosystems. Field observations of Victorian marine biotopes are recorded in the CoastKit database, combining records from habitat mapping, monitoring and historical ecological surveys	DELWP Statewide	Accuracy, quality and completeness of mapping is dependent on field observations and modelling used in mapping. Ability to assess trends in biological changes dependent on frequency and extent of repeat surveys, which is currently limited
Aboriginal cultural values			
Victorian Aboriginal Heritage Register – part of the ‘Aboriginal Cultural Heritage Register and Information System’ (ACHRIS), which is a publicly available online tool https://w.www.vic.gov.au/aboriginalvictoria/heritage/ https://achris.vic.gov.au/#/onlinemap	Victorian Aboriginal Heritage Register holds known information about Aboriginal cultural heritage places and objects within Victoria, with their location and a detailed description. Users can request further information about Aboriginal cultural heritage places and objects through ACHRIS	Victorian Aboriginal Heritage Council Statewide	The register is not complete as many places and objects are unknown. Accuracy will be variable as it dependent on individual assessments
Non-Aboriginal heritage			
Australian National Shipwreck Database http://www.environment.gov.au/heritage/historic-shipwrecks/australian-national-shipwreck-database	The Australian National Shipwrecks Database (ANSDB) launched in 2009 includes known shipwrecks in Australian waters. Features include the capacity to attach images to shipwrecks, link shipwrecks to relics recovered from shipwreck sites, site environment information for divers and site managers and a history field with the ability to attach documents. Also included in the ANSDB is an integrated management system to facilitate online permit applications and notifications	Department of the Environment and Energy National	Information has been collected by state and territory historic shipwreck agencies or supplied by collecting institutions holding historic shipwreck objects
Victorian Heritage Database https://vhd.heritagecouncil.vic.gov.au/	The Victorian Heritage Database is home to the Victorian Heritage Register which lists significant heritage places, objects and shipwrecks. It's also home to the Victorian Heritage Inventory which lists known historical archaeological sites in Victoria	Heritage Council Victoria State	The register is not complete and many records are out-of-date or incomplete
Coastal development			
Coastal Protection Structures https://discover.data.vic.gov.au/dataset/coastal-protection-structures	A dataset depicting coastal protective structures collated for the Future Coasts Program in 2011 using aerial photography. Information on the condition of a number of protection structures is available as a separate (restricted) database that links to this spatial dataset. The data was reviewed in 2017, adding asset IDs to enable linking to asset management data	DELWP Statewide	Completeness and currency of data is unclear and there are limited attribute data

Name	Description	Custodian & coverage	Comment
Coastal erosion vulnerability score	As part of the 2017 Victorian Coastal Hazard Assessment undertaken by Spatial Vision for DELWP, a coastal erosion vulnerability rating was generated for 50 metre coastal segments by combining the coastal erosion impact and coastal adaptive datasets	DELWP Statewide	Sensitivity testing of the modelling showed that increasing the importance of some components varied the level and extents of vulnerability
Coastal Spaces Landscape Assessment Study http://www.eastgippsland.vic.gov.au/files/27a451bf-4b8e-49e9-96af-a3e100f78d06/Coastal_Spaces_Landscape_Assessment_Study_State_Overview_Report_2006.pdf	Coastal Spaces Landscape Assessment Study identifies and maps individual landscape characteristics within coastal regions, identifies significant landscapes and provides an implementation framework to assist local government in managing coastal development	DELWP Statewide (excludes Port Phillip Bay and Western Port)	Assessment based on consultation in 2005, but still holds relevance. DELWP is currently reviewing the framework through the Distinctive Areas and Landscapes program
Victorian Coastal Inundation https://discover.data.vic.gov.au/dataset/victorian-coastal-inundation	The Victorian Coastal Inundation Dataset consists of eight spatial layers modelling the extent of land subject to coastal inundation due to projected sea level rise from 2009 to 2100. Used bathtub modelling techniques	DELWP Statewide	For use at a scale of 1:75,000 or less detail to reflect the limitations in the modelling. Not suitable for property scale assessments
Coastal Acid Sulfate Soils http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soil_acid_sulfate_soils_list	Coastal acid sulfate soils (CASS) occur naturally along many parts of Victoria's coastal zone and, if left undisturbed, are largely benign. However, if disturbed i.e. water drains from the soil and air enters, they can react with oxygen and produce sulfuric acid	Agriculture Victoria Statewide	Mapping of prospective CASS was updated in 2010
National Introduced Marine Pest Information System http://www.marinepests.gov.au/pests/nimpis	Provides information on identification and biology of marine pest species – those already present and potential invaders	Dept of Agriculture and Water Resources (Cwth) National	Database is being rebuilt with new version available in August 2019
National Litter Index http://kab.org.au/litter-research/national-litter-index/	National Litter Index (NLI) provides annual estimate of what litter occurs where and in what volume. Litter counts twice annually across 983 sites nationally to report on litter in each state. The research is both by volume and item and covers beaches, car parks, highways, shopping centres as well as other urban areas	Keep Australia Beautiful National	Survey has an urban focus – generalisation of findings to coastal areas may not be accurate. Includes 16 beaches in Victoria
Australian Marine Debris Initiative https://www.tangaroablue.org/database/	The Australian Marine Debris Database enables those running beach cleanup events to also collect data on debris using consistent methodology. Data is available for research on dispersal patterns and identification of sources to develop strategies for reducing marine debris at its many sources	Tangaroa Blue National	Data collection and entry are well documented. Spatial distribution of sites and volumes of litter collected are dependent on volunteer effort, which can vary between sites.

Name	Description	Custodian & coverage	Comment
Ocean outfall wastewater discharge https://portal.epa.vic.gov.au/irj/portal	Water corporations provide Annual Performance Statements that report environmental compliance for wastewater treatment plants and outfalls, includes water quality and volume of treated water discharged via ocean outfalls. These reports are available on the EPA Interaction Portal	EPA Site specific	Information is limited to parameters and sampling intervals in EPA Discharge Licence. Monitoring reports for assessment of environmental impact are not published online but can be requested
Tourism and recreation			
Regional Tourism Satellite Accounts https://www.business.vic.gov.au/tourism-industry-resources/research/economic-significance	Regional Tourism Satellite Accounts (RTSA) provide estimate of economic value of tourism to regions in terms of Gross Regional Product (GRP) and employment generated, among other metrics	Tourism Research Australia National	Regional data produced annually, but difficult to separate marine and coastal related tourism value
Regional visitation https://www.business.vic.gov.au/tourism-industry-resources/research/regional-visitation	Provide key tourism data for Victoria's 12 tourism regions (6 coastal) – information on domestic and international visitor numbers and visitor expenditure from the National and International Visitor Surveys	DJPR Events and Visitor Economy (TEVE) research unit	Regional data produced annually, but difficult to separate marine and coastal related tourism values
Beaches of the Victorian Coast and Port Phillip Bay	Assessment of 560 beaches – includes details on location, access, facilities, dimensions and character of the beach and surf zone, together with suitability of the beach for swimming, surfing and fishing	Surf Life Saving Australia Statewide	Well researched book (298 pages) published in 1996. Information has been republished on the Beachsafe website
Beachsafe Website https://beachsafe.org.au/	The site includes information and conditions for every beach in Australia. It shows patrol services, hazards and facilities as well as weather, swell and tide details	Surf Life Saving Australia National	Good general information with links to forecast weather and water conditions
Fisheries			
Fish Stocking Database https://vfa.vic.gov.au/db	VFA database that records fish stocking events from 1990 to the present day. Search by water, species, date range or by map	VFA Statewide	Includes stocking in estuaries
Commercial Fish Production https://vfa.vic.gov.au/commercial-fishing/commercial-fish-production	Annual VFA commercial fish production information is compiled from catch and effort data supplied by commercial fishery access licence holders on monthly fishing returns and from aquaculture licence holders on 6-monthly aquaculture returns	VFA Statewide	Market price data are unavailable for the majority of species since 2010-11

Name	Description	Custodian & coverage	Comment
Recreational Fishing Licence Trust Account 2017/18 https://vfa.vic.gov.au/__data/assets/pdf_file/0014/443111/Final-2017-18-RFL-Trust-Account-Report-artwork-for-email.pdf	Annual report prepared by VFA on the disbursement of recreational fishing licence revenue	VFA Statewide	Report tabled in Parliament each year concerning all RFL Trust Account revenue and expenditure
Game fishing Victorian records http://www.gfav.com.au/index.php/victorian-records	GFAV compiles and maintains Victorian records for each recognised species	Game Fishing Association of Victoria	Routinely updated
Ports and shipping			
Marine Traffic https://www.marinetraffic.com	Marine Traffic provides vessel tracking and ship information. Features a 'free' live map of vessel movements and type, with options to upgrade for more detailed information and features	Marine Traffic International	Larger vessel positional information is automated, where as smaller vessels is occasional
Ship movements http://www.vicports.vic.gov.au/operations/Pages/ship-movements.aspx	Provides expected ship movements in Port of Melbourne – arrivals, departures and in port – ship name, berth and agent	Victorian Ports Melbourne Port of Melbourne	Updated hourly
Modernised Australian Ship Tracking and Reporting System (MASTREP)	MASTREP is a ship reporting system that provides positional data on vessels transiting Australia's region through automatic identification system (AIS) technology	AMSA National	MASTREP replaced AUSREP in 2012
Energy and earth resources			
Oil and gas permits, leases and licences https://earthresources.vic.gov.au/licensing-approvals/oil-and-gas-permits-leases-and-licences	Earth Resources maintain information on oil and gas development in Victoria – includes maps and information on areas identified for potential exploration	DJPR Statewide	Routinely updated
Environment Plans https://earthresources.vic.gov.au/licensing-approvals/oil-and-gas-permits-leases-and-licences/environment-plans	The Offshore Petroleum and Greenhouse Gas Storage Regulations 2011 require authority holders to submit an environment plan for approval before any work can commence - submission details and summaries of accepted environment plans are available	DJPR Statewide	Routinely updated

15.3 Key knowledge gaps

Ecosystem-based management, which is a requirement of the Marine and Coastal Act, requires a broad understanding of all of the components and functions of the ecosystem. However, the marine ecosystem is extremely complex, and complete knowledge is not practicable or feasible. Hence, priority is given to monitoring, analysis and research that underpin key management decisions. The act also supports evidence-based decision making that is based on best available and relevant environmental, social and economic understanding.

What follows is a summary of key knowledge gaps identified in the process of completing VEAC's assessment of values, threats and emerging uses of Victoria's marine environment. It also draws on previous marine studies and reviews that identify knowledge gaps and research priorities, such as those undertaken by the Victorian Coastal Council and Victorian National Parks Association.[5,6]

15.3.1 Climate and physical environment

Ongoing research, data collection and monitoring of the key drivers of climate and oceanography and their collective impact on coastal geology and geomorphology is required to inform the long-term sustainable management of the marine and coastal environment.

There is a need to understand the magnitude and extent of changes in currents, water quality (includes water temperature) as these will have implications for key ecosystem services. Implications include changes in species range, larval dispersion patterns and primary productivity.

15.3.2 Biodiversity

Biotope mapping

There has been a significant investment by DELWP in the collation, classification and mapping of marine biotopes.[7] However, much of this has come from historical information and isolated surveys. Consequently, the biotope mapping is incomplete for much of the coast, with considerable variation in mapping effort between regional biounits. Within the marine protected areas system, the mapping is more extensive.[8]

Where marine habitats are poorly mapped, there is limited recognition of local ecological significance, which inhibits management and planning of surveys and monitoring. This can result in more conservative approval processes, in that decision makers are unsure what values are at risk in these areas.

Marine taxonomy

The identification, classification and description of marine species is an area that requires more work, particularly for subtidal species and invertebrates more generally. The level of local and regional endemism and rarity is poorly known. Taxonomy is important as scientists need to be able to identify species to understand the complex relationships and responses of ecosystems threatened by human activities.

Rare and threatened taxa

There is a knowledge gap in the recognition and listing of rare and threatened taxa in the marine environment.[9,10] Similarly, understanding the degree of isolation and vulnerability of species/communities is critical to biodiversity management.

There are also unequal patterns of listing across species; there are many more large, charismatic species listed (e.g. marine mammals and birds) than invertebrates. This is not an indication of the conservation status of marine invertebrates. Rather, it reflects the existing state of knowledge and priorities for listing.

It is likely that many more invertebrates require conservation listing as numerous species appear to have highly localised distributions.[11] The sheer number of undescribed and unknown species makes it challenging to adequately protect marine invertebrates.

Population dynamics and community structure

There is a lack of information on marine-dependent species, including ecological values, population dynamics and community structure, recruitment source communities and keystone species. The exceptions to this are for those species of commercial value such as abalone. This information is necessary to identify areas of conservation value based on population, community and ecological values. Having this type of knowledge, takes the management focus off conservation-listed species, given poor listing effort, and allows an ecosystem-based management approach to be applied.

Climate change

Several research question have been posed relating to the impacts of climate change on biodiversity. How will the distribution and abundance of marine species alter with climate change? Which species are candidate indicators for climate change? How would reduction in non-climate related stresses increase ecosystem resilience to climate change?

Ecosystem linkages and processes

Better understanding of ecosystem linkages and processes, particularly subtidal, is needed for assigning value and significance, identifying hotspots and predicting consequences of change and response to threats. Without this knowledge, environmental assessment processes are constrained.

Long-term monitoring and time series data for only selected community types and sentinel stations limits the ability to undertake comparative assessments of changes over time, which in turn limits the ability to detect declines/deterioration of populations/communities and to manage threatening processes.

Specific research requirements include:

- role of rhodolith beds in larval settlement
- distribution of different saltmarsh EVCs
- influence of artificial substrates on marine biodiversity
- impact of long-term water quality changes on benthic communities.

15.3.3 Aboriginal cultural values

The nature of Aboriginal culture and knowledge means that there is not a well-documented inventory of information on cultural values relating to sections of the Victorian coast available to decision makers. The 'strategic framework for healing Sea Country and culture through the application of knowledge and practice' outlined in chapter 7 articulates the measures that Traditional Owners say are needed to fill knowledge gaps and avoid threats to natural and cultural values.

The State of the Environment 2018 report lists a series of themes and potential indicators for assessing cultural landscape health and management, and recommends that data collection methods be put in place for reporting.

15.3.4 Non-Aboriginal heritage

Many heritage values are not well known or documented. For example, shipwrecks are some of the most readily recognisable sites of maritime archaeology but fewer than half of the 780 shipwrecks along the Victorian coast have been located. This knowledge gap could be addressed through increased collaboration between maritime archaeologists and those groups and organisations undertaking seabed investigations for marine projects. For example, multibeam sonar surveys used for gas exploration and seabed mapping can detect shipwrecks on the seabed or buried beneath the sand.

Victoria's maritime heritage has been the basis for touring exhibitions of artefacts, underwater and land-based shipwreck heritage trails, virtual dives and underwater wreck panoramas. Further investment in research and preservation activities provides an opportunity to improve understanding, awareness and appreciation of maritime history and to develop education and tourism products.

15.3.5 Coastal development

Stormwater pollutants of emerging concern include endocrine-disrupting compounds, flame retardants, pesticides and microplastics. Systematic monitoring and research is required to understand the concentrations and potential impacts of these compounds on marine plants and animals, and potential risks for human consumption.[12]

Monitoring and research undertaken as a licence requirement for assessing the environmental impact of wastewater discharges could be integrated into broader marine monitoring programs. This would require increased collaboration between EPA, water corporations, DELWP and other agencies such as Parks Victoria.

Similarly, the data and knowledge gained from the monitoring program for the Victorian Desalination Plant at Wonthaggi, which includes potentially impacted and unimpacted reference sites, could be incorporated into the broader marine monitoring programs.

Further knowledge on ecological processes is required to support the design of eco-engineered marine structures (e.g. 'living seawalls') and to help reduce the spread of non-indigenous species. Similarly, the value of natural systems to support coastal defences requires further research and testing.[13]

15.3.6 Tourism and recreation

Knowledge on current visitor numbers and recreational use of marine areas and coastal infrastructure, such as piers and jetties, is limited at a finer scale. These data would help to inform investment and prioritisation in maintenance and planning for new coastal infrastructure and for activities such as beach renourishment.

The number of charter boat operators in Victoria was estimated as between 80 and 130 in 2002. However, current numbers are unavailable because there is no government agency with responsibility for overseeing these businesses. Without knowledge of the size and number of operators it is unclear what investment is required to support the sustainable management of this industry.

15.3.7 Fisheries

Stock assessment

As discussed in chapter 11, stock assessment involves synthesising data on life history, fishery monitoring, and resource surveys for estimating stock size and harvest rate relative to predetermined reference points. Because of the amount of data required for stock assessment, fish stocks are challenging to establish accurately, even for commercially-targeted species in developed countries. For example, in Victoria further information is required on the stock structure of gummy shark and silver trevally, and the stock composition of southern calamari, rock flathead, flounder species, southern garfish and King George whiting.[14]

The stock composition, distribution and spatial structure of non-target species is even more poorly understood. Non-target catch is comprised of byproduct (non-target species that are retained for sale) and bycatch (species that are discarded). While there is some information on non-target species for individual fisheries, generally non-target captures are unknown. In Victoria, byproduct catches are reported but reporting of the amount and type of bycatch is not mandatory. The VFA provides commercial operators with logbooks to record all species landed, but does not collect information on the type or amount of bycatch species unless it involves protected species interactions.[14]

There is no sound estimate of recreational catches and, as stock assessments rely on data including total catches, underestimating the total catch could underestimate the actual biomass of the species, with flow-on impacts for sustainability.[15,16]

Aquaculture

Because aquaculture is a relatively new and growing industry, several important knowledge gaps exist. While some gaps are being addressed through experimental work, existing gaps include improving survivorship of seed abalone through predator control and better artificial reef design; better understanding the risks of finfish culture, particularly the impacts of accumulation of wastes below cages; developing commercial pelleted diets for species that require feeding (e.g. finfish, caged abalone) to reduce reliance on wild caught stocks. This information will reduce risks associated both with supply and disease transfer, as well as reducing pressure on sources of wild stock.[17]

Aquaculture research is also continuing on the development of microalgae and macroalgae (seaweeds) as food for human consumption, agricultural stock feed and soil enhancement.

Number of recreational fishers

Getting an accurate estimate of the number of recreational fishers active in Victoria in any year is difficult. The last comprehensive survey – the National Recreational and Indigenous Fishing Survey – was conducted almost 20 years ago.[18] Sales of recreational fishing licences can give some indication of the number of recreational fishers. However, people who purchase three-year licences are not captured in the second and third years of their licence, and people may purchase more than one short-term licence in a year. Many recreational fishers are exempt from licensing requirements, but the absolute number of exempt fishers is also unknown. In response to this unknown figure, researchers recommended that compulsory free licences be issued to all exempt fishers.[19] This would make contact details for these fishers part of the recreational fishing database, which could be used for improving communications with recreational fishers. Researchers also recommend the collection of key profiling data (such as estimates of how often people fish) with recreational fishing licence applications, as these data improve efficiency in stratification of screening surveys and reduce future survey costs.[20]

Recreational harvest

Estimates of the total recreational catch of fish stocks are required for assessment of fisheries where the recreational component is significant, fisheries that require decisions concerning resource allocation between commercial and recreational sectors, and development, implementation and review of fishery management plans.[20]

Catch and release fishing

At a national level, it was estimated in 2000-01 that almost half (44 per cent) of all fish caught in Australia by recreational anglers are returned to the water.[18] However, the survival of released fish appears to be highly dependent on a complex interplay between fisher behaviour (gear selection, bait type, handling time), environmental features (capture depth, water temperature) and biological features (hook location, fish size, species) and further research is needed to better understand the impacts and actions and behaviours needed to improve survival rates.[21]

Marine stocking

Research is required to better understand the potential genetic and ecological consequences of marine stocking. This includes investigation of potential hybridisation effects, loss of genetic diversity in broodstock, potential interactions with threatened species and biosecurity risks.[22]

Aboriginal fishing

The extent of Aboriginal fishing is currently unknown. No separate data are available on Indigenous catches except where it forms part of a customary fishing agreement.

15.3.8 Ports and shipping

While port authorities may collect extensive monitoring data around specific impacts or activities, often this information is either unavailable to the public because it is commercial in confidence or is not broadly informative because it was collected for a very targeted purpose. This is less a knowledge gap than an issue of data sharing. Similarly, the information collected for environmental impact assessment is so focused on the construction area that it does not establish background information that can address broader management issues.

Marine pests

Further research is required to understand the risk of marine pests to port operations and shipping. The Marine Pest Plan 2018-2023 highlights the need to strengthen marine pest surveillance systems, support marine pest biosecurity research and develop better education/awareness products.

15.3.9 Energy and earth resources

Further research and investigations are needed to assess and test the suitability of depleted oil and gas wells for offshore carbon storage and sequestration, such as that being undertaken for the CarbonNet Project.

Marine renewable energy, such as that provided by offshore wind, wave and tidal energy converters have been well proven. However, there is a need to better understand what the barriers are for adoption in Victoria.

Further research is needed on the extent to which the marine environment would benefit from using decommissioned infrastructure, such as oil rigs, cables and construction platforms, as artificial reefs and what risk mitigation strategies are needed to facilitate such use.[23]

15.3.10 Marine biotechnology

The potential for marine biotechnology in Victoria has not been fully investigated. This includes opportunities to develop technologies and products for sustainable and profitable seafood and functional foods, marine bioproducts and biomaterials, biomedicine and marine biofuel industries.

15.4 References

1. Stamoulis, K.A. and Delevaux, J.M.S. (2015) Data requirements and tools to operationalize marine spatial planning in the United States. *Ocean & Coastal Management* 116: 214–223.
2. de La Beaujardière, J., Beegle-Krause, C., Bermudez, L., Hankin, S., Hazard, L., Howlet, E., Le, S., Proctor, R., Signell, R.P., Snowden, D. and Thomas, J. (2010) *Ocean and coastal data management.* Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 1), Venice, Italy, 21–25 September 2009.
3. Edmunds, M. and Flynn, A. (2018) *Victorian marine knowledge framework: review and design*. Report to Department of Environment, Land, Water and Planning. Australian Marine Ecology Report No. 563, Melbourne.
4. Hidas, M.G., Proctor, R., Atkins, N., Atkinson, J., Besnard, L., Blain, P., Bohm, P., Burgess, J., Finney, K., Fruehauf, D., Galibert, G., Hoenner, X., Hope, J., Jones, C., Mancini, S., Pasquer, B., Nahodil, D., Reid, K. and Tattersall, K. (2016) Information infrastructure for Australia's Integrated Marine Observing System. *Earth Sciences Informatics* 9: 525-534.
5. Edmunds, M., Mustoe, S., Stewart, K., Sheedy, E. and Ong, J. (2010) *VNPA nature conservation review: marine conservation priorities and issues for Victoria*. Report to Victorian National Parks Association. Australian Marine Ecology Report 405, Melbourne.
6. Holper, P., Torok, S. and Pearce, K. (2018) *Victoria's coast and marine environments under projected climate change: impacts, research gaps and priorities*. Prepared for Victorian Coastal Council, East Melbourne.
7. Edmunds, M. and Flynn, A. (2018) *CBiCS classification of Victorian biotopes*. Australian Marine Ecology Report 560 to Department of Environment, Land, Water and Planning, Melbourne.
8. Power, B. and Boxshall, A. (2007) *Marine national park and sanctuary monitoring plan 2007-2012*. Parks Victoria Technical Series No. 54. Parks Victoria, Melbourne.
9. O'Hara, T.D. (2002) Endemism, rarity and vulnerability of marine species along a temperate coastline. *Invertebrate Systematics* 16: 671-684.
10. Butler, A.J., Rees, T., Beesley, P. and Bax, N.J. (2010) Marine biodiversity in the Australian region. *PLoS ONE* 5: e11831.

11 O'Hara, T. and Barmby, V. (2000) *Victorian marine species of conservation concern: molluscs, echinoderms and decapod crustaceans.* Parks, Flora and Fauna Division, Department of Natural Resources and Environment, East Melbourne.

12 Barbee, N. Longmore, A., Townsend, K., Pettigrove, V. and Swearer, S. (2016) *Science knowledge synthesis of nutrient cycling, marine pests and pollutants: informing the development of the new Port Phillip Bay environmental management plan.* CAPIM Technical Report No. 60, Centre for Aquatic Pollution Identification and Management, University of Melbourne, Victoria, Australia.

13. Bishop, M.J., Mayer-Pinto, M., Airoldi, L., Firth, L.B., Morris, R.L., Loke, L.H.L., Hawkins, S.J., Naylor, L.A., Coleman, R.A., Chee, S.Y. and Dafforn, K.A. (2017) Effects of ocean sprawl on ecological connectivity: impacts and solutions. *Experimental Marine Biology and Ecology* 492: 7-30.
14. Department of the Environment and Energy (DEE) (2017) *Assessment of the Victorian Corner Inlet fishery.* Commonwealth of Australia, Canberra. http://www.environment.gov.au/system/files/pages/e74d6451-56a5-4857-a67e-89f4e2f825a3/files/assessment-report-2017.pdf
15. Van Beveren, E., Duplisea, D., Castonguay, M., Doniol-Valcroze, T., Plourde, S. and Cadigan, N. (2017) How catch underreporting can bias stock assessment of and advice for northwest Atlantic mackerel and a possible resolution using censored catch. *Fisheries Research* 194: 146-154.
16. Maunder, M.N. and Piner, K.R. (2015) Contemporary fisheries stock assessment: many issues still remain. *ICES Journal of Marine Science* 72: 7–18.
17. Department of Economic Development, Jobs, Transport and Resources (DEDJTR) (2017) *Victorian aquaculture strategy 2017-2022*. Department of Economic Development, Jobs, Transport and Resources, Melbourne. https://vfa.vic.gov.au/operational-policy/strategy-and-policy/aquaculture-strategy#
18. Henry, G.W. and Lyle, J.M. (2003) *The national recreational and indigenous fishing survey*. FRDC Project No. 99/158. NSW Fisheries Final Report Series No. 48. http://www.frdc.com.au/project/1999-158
19. Ford, J. and Gilmour, P. (2013) *The state of recreational fishing in Victoria: a review of ecological sustainability and management options*. Report to the Victorian National Parks Association, Melbourne. https://vnpa.org.au/wp-content/uploads/2017/02/The-State-of-Recreational-Fishing-in-Victoria.pdf
20. Ryan, K.L., Morison, A.K. and Conron, S. (2009) *Evaluating methods of obtaining total catch estimates for individual Victorian bay and inlet recreational fisheries*. Final report to Fisheries Research and Development Corporation Project No. 2003/047. Department of Primary Industries, Queenscliff. http://www.frdc.com.au/project/2003-047
21. Bartholomew, A. and Bohnsack, J.A. (2005) A review of catch-and-release angling mortality with implications for no-take reserves. *Review in Fish Biology and Fisheries* 15: 129-154.
22. Department of Primary Industries New South Wales (2014) *Marine fish stocking fishery management strategy*. Department of Primary Industries, Sydney. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/630683/marine-fish-stocking-fishery-management-strategy.pdf
23. Department of Industry, Innovation and Science (DIIS) (2018) *Discussion paper – decommissioning offshore petroleum infrastructure in Commonwealth waters.* Offshore Resources Branch. https://consult.industry.gov.au/++preview++/offshore-resources-branch/decommissioning-discussion-paper/supporting_documents/Decommissioning%20Discussion%20Paper.pdf

APPENDIX 1
Estuaries List

The following table lists estuaries along Victoria's coast from South Australia in the west to New South Wales in the east. Estuaries included in DELWP's index of estuary condition (IEC) program and estuaries that meet the Victorian Waterway Management Strategy (VWMS) definition are indicated.

	Estuary (location)	Abutting waters	Entrance opening	Entrance type	Listed for IEC assessment	Meets VWMS definition
1	Glenelg River (Nelson)	Open coast	Permanent	Natural	Yes	Yes
2	Fawthrop Lagoon/Wattle Hill Creek (Portland)	Open coast	Permanent	Constructed	Yes	Yes
3	Surrey River (Narrawong)	Open coast	Intermittent	Natural	Yes	Yes
4	Fitzroy River	Open coast	Intermittent	Natural	Yes	Yes
5	Eumeralla River/Yambuk Lake	Open coast	Intermittent	Natural	Yes	Yes
6	Moyne River (Port Fairy)	Open coast	Permanent	Constructed	Yes	Yes
7	Merri River (Warrnambool)	Open coast	Permanent	Constructed	Yes	Yes
8	Hopkins River (Warrnambool)	Open coast	Permanent	Natural	Yes	Yes
9	Curdies Inlet (Peterborough)	Open coast	Intermittent	Natural	Yes	Yes
10	Port Campbell Creek (Port Campbell)	Open coast	Intermittent	Natural	Yes	No
11	Sherbrook River	Open coast	Intermittent	Natural	Yes	No
12	Gellibrand River (Princetown)	Open coast	Permanent	Natural	Yes	Yes
13	Johanna River	Open coast	Intermittent	Natural	Yes	No
14	Aire River	Open coast	Intermittent	Natural	Yes	Yes
15	Barham River (Apollo Bay)	Open coast	Intermittent	Natural	Yes	Yes
16	Wild Dog Creek	Open coast	Intermittent	Natural	No	No
17	Skenes Creek	Open coast	Intermittent	Natural	No	No
18	Kennett River	Open coast	Intermittent	Natural	Yes	No
19	Wye River	Open coast	Intermittent	Natural	Yes	No
20	Saint George River	Open coast	Intermittent	Natural	Yes	No
21	Erskine River (Lorne)	Open coast	Intermittent	Natural	Yes	Yes
22	Painkalac Creek (Aireys Inlet)	Open coast	Intermittent	Natural	Yes	Yes
23	Anglesea River (Anglesea)	Open coast	Intermittent	Natural	Yes	Yes
24	Spring Creek (Torquay)	Open coast	Intermittent	Natural	Yes	Yes
25	Thompson Creek (Breamlea)	Open coast	Intermittent	Natural	Yes	Yes
26	Barwon River (Barwon Heads/ Ocean Grove)	Open coast	Permanent	Natural	Yes	Yes
27	Limeburners Bay/Hovells Creek (Geelong/Avalon)	Port Phillip Bay/ Corio Bay	Permanent	Natural	Yes	Yes
28	Little River (Western Treatment Plant)	Port Phillip Bay	Permanent	Constructed	Yes	Yes
29	Werribee River (Werribee South)	Port Phillip Bay	Permanent	Constructed	Yes	Yes
30	Skeleton Creek (Cheetham Wetlands)	Port Phillip Bay	Permanent	Natural	Yes	Yes
31	Laverton Creek (Altona)	Port Phillip Bay	Intermittent	Natural	Yes	Yes
32	Kororoit Creek (Williamstown)	Port Phillip Bay	Permanent	Natural	Yes	Yes
33	Stony Creek (Spotswood)	Yarra River	Permanent	Constructed	No	Yes
34	Maribyrnong River	Yarra River	Permanent	Constructed	No	Yes
35	Moonee Ponds Creek	Yarra River	Permanent	Constructed	No	Yes
36	Yarra River	Port Phillip Bay/ Hobsons Bay	Permanent	Constructed	Y	Yes
37	Elwood Canal/Elster Creek	Port Phillip Bay	Permanent	Constructed	Yes	Yes
38	Mordialloc Creek	Port Phillip Bay	Permanent	Constructed	Yes	Yes

	Estuary (location)	Abutting waters	Entrance opening	Entrance type	Listed for IEC assessment	Meets VWMS definition
39	Patterson River (Patterson Lakes)	Port Phillip Bay	Permanent	Constructed	Yes	Yes
40	Kananook Creek (Frankston)	Port Phillip Bay	Permanent	Constructed	Yes	Yes
41	Balcombe Creek (Mt Martha)	Port Phillip Bay	Intermittent	Natural	Yes	Yes
42	Brokil Creek/Martha Cove	Port Phillip Bay	Permanent	Constructed	No	Yes
43	Chinamans Creek (Tootgarook)	Port Phillip Bay	Intermittent	Natural	No	No
44	Merricks Creek (Balnarring Beach/Somers)	Western Port	Intermittent	Natural	Yes	Yes
45	Warringine Creek (Hastings)	Western Port	Permanent	Natural	Yes	Yes
46	Kings Creek (Hastings)	Western Port	Permanent	Natural	No	Yes
47	Olivers Creek (Hastings)	Western Port	Permanent	Natural	No	Yes
48	Watsons Creek (Somerville)	Western Port	Permanent	Natural	Yes	Yes
49	Sawtells Inlet (Tooradin)	Western Port	Permanent	Natural	No	Yes
49	Cardinia Creek	Western Port	Permanent	Constructed	Yes	Yes
50	Deep Creek	Western Port	Permanent	Constructed	Yes	Yes
51	Bunyip River	Western Port	Permanent	Constructed	Yes	Yes
52	Yallock Creek	Western Port	Permanent	Natural	Yes	Yes
53	Yallock Drain	Western Port	Permanent	Constructed	Yes	Yes
54	Lang Lang River	Western Port	Permanent	Natural	Yes	Yes
55	Bass River	Western Port	Permanent	Natural	Yes	Yes
56	Saltwater Creek (Ventnor, Phillip Island)	Western Port	Intermittent	Natural	Yes	Yes
57	Bourne Creek (Kilcunda)	Open coast	Intermittent	Natural	Yes	Yes
58	Powlett River (Wonthaggi)	Open coast	Intermittent	Natural	Yes	Yes
59	Coal Creek (Harmers Haven)	Open coast	Intermittent	Natural	No	No
60	Wreck Creek (Inverloch)	Open coast	Intermittent	Natural	Yes	No
61	Tarwin River/Anderson Inlet	Open coast	Intermittent	Natural	Yes	Yes
62	Shallow Inlet	Open coast	Permanent	Natural	Yes	Yes
63	Darby River (Wilsons Promontory)	Open coast	Intermittent	Natural	Yes	Yes
64	Tidal River (Wilsons Promontory)	Open coast	Intermittent	Natural	Yes	Yes
65	Growler Creek (Wilsons Promontory)	Open coast	Intermittent	Natural	Yes	No
66	Sealers Creek (Wilsons Promontory)	Open coast	Intermittent	Natural	Yes	Yes
67	Miranda Creek (Wilsons Promontory)	Open coast	Intermittent	Natural	Yes	Yes
68	Chinaman Creek (Wilsons Promontory)	Corner Inlet	Intermittent	Natural	Yes	Yes
69	Old Hat Creek/Poor Fellow Me Creek	Corner Inlet	Permanent	Natural	Yes	Yes
70	Stockyard Creek (Foster)	Corner Inlet	Permanent	Natural	Yes	Yes
71	Bennison Creek (Foster)	Corner Inlet	Permanent	Natural	Yes	Yes
72	Franklin River (Port Franklin)	Corner Inlet	Permanent	Natural	Yes	Yes
73	Agnes River	Corner Inlet	Permanent	Natural	Yes	Yes
74	Shady Creek (Port Welshpool)	Corner Inlet	Permanent	Natural	Yes	Yes
75	Nine Mile Creek	Corner Inlet	Permanent	Natural	Yes	Yes
76	Albert River (Alberton/Langsborough)	Corner Inlet	Permanent	Natural	Yes	Yes
77	Tarra River (Robertsons Beach)	Corner Inlet	Permanent	Natural	Yes	Yes
78	Neils Creek	Corner Inlet	Permanent	Natural	Yes	Yes

	Estuary (location)	Abutting waters	Entrance opening	Entrance type	Listed for IEC assessment	Meets VWMS definition
79	Bruthen Creek (McLoughlins Beach)	Corner Inlet	Permanent	Natural	Yes	Yes
80	Jack Smith Lake	Open coast	Intermittent	Natural	Yes	No
81	Lake Dennison	Open coast	Intermittent	Natural	Yes	No
82	Merriman Creek (Seaspray)	Open coast	Intermittent	Natural	Yes	Yes
83	Latrobe River	Lake Wellington, Gippsland Lakes	Permanent	Natural	Yes	Yes
84	Lake Wellington Main Drain	Lake Wellington, Gippsland Lakes	Permanent	Constructed	Yes	Yes
85	Diamond Creek	Lake Wellington, Gippsland Lakes	Permanent	Natural	No	Yes
86	Avon River	Lake Wellington, Gippsland Lakes	Permanent	Natural	Yes	Yes
87	Perry River	Lake Wellington, Gippsland Lakes	Permanent	Natural	No	Yes
88	Toms Creek	Lake Victoria, Gippsland Lakes	Permanent	Natural	Yes	Yes
89	Toms Roberts Creek	Lake Victoria, Gippsland Lakes	Permanent	Natural	Yes	Yes
90	Forge Creek/Newlands Arm	Lake Victoria, Gippsland Lakes	Permanent	Natural	Yes	Yes
91	Mitchell River	Lake King, Gippsland Lakes	Permanent	Natural	Yes	Yes
92	Nicholson River	Lake King, Gippsland Lakes	Permanent	Natural	Yes	Yes
93	Slaughterhouse Creek	Lake King, Gippsland Lakes	Permanent	Natural	Yes	Yes
94	Tambo River	Lake King, Gippsland Lakes	Permanent	Natural	Yes	Yes
95	Maringa Creek/Bancroft Bay	Gippsland Lakes	Permanent	Natural	Yes	Yes
96	Mississippi Creek/North Arm	Gippsland Lakes	Permanent	Natural	Yes	Yes
97	Lake Bunga/Bunga River	Open coast	Intermittent	Natural	Yes	Yes
98	Lake Tyers	Open coast	Intermittent	Natural	Yes	Yes
99	Snowy River (Marlo)	Open coast	Permanent	Natural	Yes	Yes
100	Yeerung River	Open coast	Intermittent	Natural	Yes	Yes
101	Sydenham Inlet/Bemm River	Open coast	Intermittent	Natural	Yes	Yes
102	Tamboon Inlet/Cann River	Open coast	Intermittent	Natural	Yes	Yes
103	Thurra River	Open coast	Intermittent	Natural	Yes	Yes
104	Mueller River	Open coast	Intermittent	Natural	Yes	Yes
105	Wingan Inlet	Open coast	Intermittent	Natural	Yes	Yes
106	Easby Creek	Open coast	Intermittent	Natural	Yes	No
107	Red River	Open coast	Intermittent	Natural	Yes	Yes
108	Benadore River	Open coast	Intermittent	Natural	Yes	Yes
109	Seal Creek	Open coast	Intermittent	Natural	Yes	No
110	Shipwreck Creek	Open coast	Intermittent	Natural	Yes	No
111	Betka River	Open coast	Intermittent	Natural	Yes	Yes
112	Davis Creek	Open coast	Intermittent	Natural	Yes	No
113	Mallacoota Inlet/ Wallagaraugh River	Open coast	Permanent	Natural	Yes	Yes
114	Lake Wau Wauka	Open coast	Intermittent	Natural	Yes	No

APPENDIX 2
Victorian Marine Assets

To help inform natural resource management across the state, DELWP developed a system of asset identification. Approximately 140 significant marine asset areas were identified by scientific experts, many of which were nested within larger assets. Assets are defined in this context as tangible biophysical elements of the environment that are valuable for their ecosystem services.

The following list taken from Kent and Jenkins[1] provides a description of the largest and most significant assets. Potential threats to each asset have been considered in VEAC's assessment and key threats included within the assessment atlas.

Area	Category	Name	Description
Western Victoria	Major assets	Blue whale feeding zone/ Bonney upwelling	Hub of productivity in generally nutrient-poor region. Phytoplankton abundance attracts swarms of krill and in turn blue whales. Feeding ground also for seabirds, fishes, fur seals, penguins. Sustains rich and diverse fishery.
Western Victoria	State significance	Cape Bridgewater	Huge underwater cliffs, sea caves, blow holes and a 'petrified forest.' One of Australia's largest fur seal colonies, and only breeding colony on Australian mainland.
Western Victoria	State significance	Portland Bay (Minerva Reef)	Most extensive beds of seagrass Amphibolis antarctica on coast of Victoria. Seagrass ecosystem highly productive, provides shelter and feeding habitat for fish and invertebrates, nursery habitat for a variety of fish species, and helps stabilise sediment.
Western Victoria	State significance	Deen Maar (Lady Julia Percy) Island and Georgia's Peak	Island surrounded by cliffs, rock platforms and reefs. Unique pinnacles in waters. Breeding populations of Australian fur seals and a number of seabirds. New Zealand fur seals, Australian sealions and eephant seals also occur.
Western Victoria	State significance	Southern right whale nursery area	Southern right whales give birth in sheltered bays along the Victorian coast. Logan's Beach an important calving site.
Western Victoria	State significance	Little penguin colonies – Port Campbell	Little penguins nest in rocks and dunes at base of steep cliffs, and in nearby vegetated sand dunes.
Western Victoria	State significance	Middle Island and surrounds	Two small offshore islands are remains of ancient fossilised sand dune. Breeding grounds for seabirds including little penguins.
Western Victoria	Bioregional significance	Discovery Bay	Influenced by nutrient-rich upwelling, highly productive area supports many fish and invertebrate species. Wetlands provide habitat for a large number of birds, including threatened species.
Port Phillip Bay	Major assets	Port Phillip Bay sediment basin (> 10 metres)	Soft sediments have efficient nutrient-cycling capabilities, protecting the bay from eutrophication.
Port Phillip Bay	State significance	Mud Islands	Islands provide significant habitat and feeding areas for local and migratory birds. Seagrass beds highly productive and support a diverse range of fauna, improve water quality, and play an important role in carbon, nitrogen and phosphorus cycles.
Port Phillip Bay	State significance	Port Phillip Heads Canyon	Strong, nutrient rich currents and low light levels create unique environment large proportion of sponges are endemic. Area has high taxonomic significance and conservation value.
Port Phillip Bay	State significance	Swan Bay	Intertidal mudflats and seagrass beds support a large array of wildlife, including rare and endangered orange-bellied parrot and rare fairy tern.
Port Phillip Bay	State significance	Western Treatment Plant Coastline	Ramsar-listed site a haven for over 270 bird species including brolga and orange-bellied parrot. Habitats also include seagrass bed and soft sediment habitat. The plant treats approximately 52 per cent of Melbourne's sewage and forms single largest nutrient input into Port Phillip Bay.
Port Phillip Bay	State significance	Altona-Point Cook reefs	Temperate reef habitats biologically complex, highly productive, high species diversity, and support key fishery species. Wetlands provide habitat and feeding areas for shorebirds. Saltmarsh is habitat for orange-bellied parrot, and improves water quality by trapping sediments.
Port Phillip Bay	State significance	Mushroom Reef	Supports one of the most diverse intertidal reef communities in the state, providing habitat for species which are rare/ restricted in distribution.

Area	Category	Name	Description
Western Port	State significance	Summerland Peninsula and Seal Rocks	Habitat for important and iconic species including little penguins and Australian fur seal.
Western Port	State significance	Crawfish Rock	Small intertidal/subtidal reef with unusual reef formation (pinnacles, canyons, and underwater channels) of high conservation value.
Western Port	State significance	Southeast basin	Most important nursery area in south-eastern Australia and only confirmed egg laying area for elephant fish. Seagrass beds identified as key school shark pupping grounds.
Western Port	State significance	Rhodolith beds in channel and San Remo FFG community	Rhodolith beds ecologically important and of high scientific and conservation value due to high biodiversity of associated organisms. San Remo marine community FFG-listed due to high species richness, including large number of rare opisthobranch molluscs and bryozoans.
Western Port	Bioregional significance	Rhyll/Churchill Island	Sandy beaches, mudflats, seagrass beds, mangroves and salt marsh inhabited by diverse range of invertebrate and fish communities. Mangrove communities most extensive in Australia, and of state significance.
Gippsland Region	State significance	South Walkerville intertidal area	Complex and diverse geology and landforms including grey/brown mudstones and sandstones, grey/cream limestones, and greenstones. Rocky reefs support diverse marine life including a gastric brooding seastar of conservation concern.
Gippsland Region	State significance	Bunurong Marine National Park	Complex topography of intertidal rock platforms promotes high floral and faunal density, particularly red and brown algae. Seagrass beds occur in sheltered coves. Eagles Nest is of national geological significance due to importance as fossil excavation site.
Gippsland Region	State significance	Venus Bay Beach	Habitat for pipis, feeding and roosting habitat for important waders, and important nesting and feeding habitat for rare hooded plover. Popular tourism destination.
Gippsland Region	State significance	Corner Inlet/Nooramunga mudflat environment	Mudflat ecosystem important feeding areas for waders which consume large range of marine plants and invertebrates. Corner Inlet designated as wetland of national importance. Microalgae within intertidal sediments extremely important for primary production.
Gippsland Region	State significance	Corner Inlet Posidonia habitat and Corner Inlet to Nooramunga Zostera habitat	Supports at least four species of seagrass, only place in Victoria where broad-leaf Posidonia seagrass forms large meadows. Seagrass beds stabilise sediments, reduce erosion, influence oxygen concentrations in sediment, and provide shelter and food for variety of fauna.
Gippsland Region	State significance	Wilsons Promontory deep water habitat	Temperate reef habitats highly productive ecosystems, with high species diversity. Reef fishes contribute to ecosystem function. Many species of flora and fauna occur at their eastern/western distributional limits here.
Gippsland Region	State significance	Wilsons Promontory southern islands	Four groups of relatively high (65-138 metres) islands (Shellback Island, Norman Island, Glennie Group and Anser Group), provide range of exposed and sheltered conditions and unique habitat for a large variety of marine species.
Gippsland Region	Bioregional significance	Corner Inlet mangroves	World's most southerly population of mangroves. Mangroves highly productive ecosystems, provide habitat for a high diversity of animals, plants and microbes, trap and stabilise sediment, and contribute to fish production as nursery areas.

1. Kent, J. and Jenkins, G.P. (2012) *Ecological descriptions of the significant marine environmental assets of Victoria: interim report.* Fisheries Victoria Technical Report No. 177. Department of Primary Industries, Queenscliff, Victoria.

APPENDIX 3
Conservation-Listed Species

DELWP maintains non-statutory threatened species advisory lists for vertebrates,[1] invertebrates[2] and rare or threatened plants.[3] Species may be listed as critically endangered (cr: extremely high risk of extinction in the wild), endangered (en: facing a very high risk of extinction in the wild), vulnerable (vu: high risk of extinction in the wild), near threatened (nt: close to qualifying for, or likely to qualify for a threatened category in the near future) or data deficient (dd: more information is required and future research may show that threatened classification is appropriate). There are no direct legal requirements or consequences that flow from inclusion of a species in advisory lists, but listed species are afforded some protection through Victoria's Native Vegetation Management Framework and being considered in Environmental Effects Statement processes.

Species and communities may be listed on the *Flora and Fauna Guarantee Act 1988* (FFG Act) Threatened List. This list includes only those species or communities that have been nominated, assessed by the Scientific Advisory Committee and approved for listing by the Minister for Energy, Environment and Climate Change and the Minister for Agriculture and Food Security.

Marine species may also be listed in Victoria under the *Fisheries Act 1995* as Protected Aquatic Biota (PAB). Any marine species that is not a mammal, bird, reptile or amphibian may be listed as PAB. Any species meeting these criteria that is listed under the FFG Act is automatically classified as PAB. Furthermore, species in the family Syngnathidae (which includes seahorses, sea dragons and pipefish) are declared PAB. A person must not take, injure, damage, destroy, possess, keep, display for reward, release into Victorian waters or sell any PAB unless otherwise authorised.

Federally, species may be listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as threatened, migratory, marine and/or cetacean. Different provisions apply to each listing. For a species to be listed as threatened under the EPBC Act, a rigorous scientific assessment of the species' threat status is undertaken by the Threatened Species Scientific Committee to determine if the item is eligible for listing against a set of criteria. Species may be listed as critically endangered (CR: extremely high risk of extinction in the wild in the immediate future), endangered (EN: very high risk of extinction in the wild in the near future), vulnerable (VU: high risk of extinction in the wild in the medium-term future) or conservation dependent (CD: a species is the focus of a specific conservation program, the cessation of which would result in the taxon becoming vulnerable, endangered or critically endangered within five years). Once a species is listed under the EPBC Act its recovery is promoted using conservation advice, recovery plans, and the EPBC Act's assessment and approval provisions. In particular, listed threatened species are matters of national environmental significance (protected matters) under the assessment and approval provisions of the EPBC Act. A person must not take an action that has, will have, or is likely to have, a significant impact on a listed threatened species without Ministerial approval.

Marine species are declared under s248 of the EPBC Act. The initial list of marine species included all species in the families Hydrophiidae (sea-snakes), Laticaudidae (sea-snakes), Otariidae (eared seals), Phocidae ('true' seals), Cheloniidae (marine turtles), Syngnathidae (seahorses, sea dragons and pipefish), and Solenostomidae (ghost pipefish); all species in the genera Crocodylus (crocodiles) and Dugong (dugong); the species *Dermochelys coriacea* (leatherback turtles), and all species in the Class Aves (birds) that occur naturally in Commonwealth marine areas. Further species may be added to the list by the Minister with advice from the Scientific Committee.

Migratory species are established under section 209 of the EPBC Act. The migratory species list comprises:

- migratory species which are native to Australia and are included in the appendices to the Bonn Convention,
- migratory species included in annexes established under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA), and
- native, migratory species identified in a list established under, or an instrument made under, an international agreement approved by the Minister, such as the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Cetaceans (whales, dolphins and porpoises) are protected in Australian waters under section 224 of the EPBC Act. The Australian Whale Sanctuary includes all Commonwealth waters from the 3 nautical mile state waters boundary out to the boundary of the Exclusive Economic Zone (i.e. out to 200 nautical miles and further in some places). Within the sanctuary it is an offence to kill, injure or interfere with a cetacean without a permit. Within Victorian state waters, similar protection is afforded under Part X of the Wildlife Act 1975.

1. Department of Environment and Primary Industries (DEPI) (2014) *Advisory list of rare or threatened plants in Victoria - 2014*. Department of Environment and Primary Industries, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists
2. Department of Sustainability and Environment (DSE) (2009) *Advisory list of threatened invertebrate fauna in Victoria*. Department of Sustainability and Environment, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists
3. Department of Sustainability and Environment (2013) *Advisory list of threatened vertebrate fauna in Victoria*. Department of Sustainability and Environment, Melbourne. https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists

Conservation-listed species in Victorian waters

CD= conservation dependent, CE= critically endangered, DD= data deficient, EN= endangered, L= listed, NT= near threatened, R= rare, VU= vulnerable

Taxa	Common name	Scientific name	State			Federal				International			
			DELWP advisory list	FFG Act	Fisheries Act	EPBC Act Threatened	EPBC Act Marine	EPBC Act Cetacean	EPBC Act Migratory	Bonn	JAMBA	CAMBA	ROK-AMBA
Cnidaria	Stalked hydroid	*Ralpharia coccinea*	VU	L	Y	N	N		N	N			
Cnidaria	Brackish sea jelly	*Australon-medusa baylii*	VU	N	N	N	N		N	N			
Crustacea	Ghost shrimp	*Eucalliax tooradin*	VU	L	Y	N	N		N	N			
Crustacea	Ghost shrimp	*Michelea microphylla*	VU	L	Y	N	N		N	N			
Crustacea	Southern hooded shrimp	*Athanopsis australis*	VU	L	Y	N	N		N	N			
Echinoderm	Brittle star	*Amphiura triscacantha*	VU	L	Y	N	N		N	N			
Echinoderm	Brittle star	*Ophiocomina australis*	VU	L	Y	N	N		N	N			
Echinoderm	Corio sea-cucumber	*Thyone nigra*	VU	L	Y	N	N		N	N			
Echinoderm	Sea-cucumber	*Apsolidium densum*	VU	L	Y	N	N		N	N			
Echinoderm	Sea-cucumber	*Apsolidium handrecki*	VU	L	Y	N	N		N	N			
Echinoderm	Sea-cucumber	*Pentocnus bursatus*	VU	L	Y	N	N		N	N			
Echinoderm	Sea-cucumber	*Trochodota shepherdi*	VU	L	Y	N	N		N	N			
Echinoderm	Sea-cucumber	*Apsolidium falconeri*	VU	N	N	N	N		N	N			
Mollusca	Marine opisthobranch	*Platydoris galbana*	VU	L	Y	N	N		N	N			
Mollusca	Marine opisthobranch	*Rhodope* species	VU	L	Y	N	N		N	N			
Mollusca	Port Phillip chiton	*Bassethullia glypta*	VU	L	Y	N	N		N	N			
Chondrychthian	Great white shark	*Carcharodon carcharias*	VU	L	Y	VU	N		Y	Y			
Chondrychthian	Grey nurse shark	*Carcharias taurus*	DD	L	Y	CE	N		N	N			
Chondrychthian	Whale shark	*Rhincodon typus*	N	N	N	VU	N		Y	Y			
Chondrychthian	Harrison's dogfish	*Centrophorus harrissoni*	N	N	N	CD	N		N	N			

Taxa	Common name	Scientific name	State			Federal				International			
			DELWP advisory list	FFG Act	Fisheries Act	EPBC Act Threatened	EPBC Act Marine	EPBC Act Cetacean	EPBC Act Migratory	Bonn	JAMBA	CAMBA	ROK-AMBA
Chondrychthian	School shark	*Galeorhinus galeus*	N	N	N	CD	N		N	N			
Chondrychthian	Southern dogfish	*Centrophorus zeehaani*	N	N	N	CD	N		N	N			
Chondrychthian	Mako shark	*Isurus oxyrinchus*	N	N	N	N	N		Y	Y			
Chondrychthian	Porbeagle	*Lamna nasus*	N	N	N	N	N		Y	Y			
Chondrychthian	Giant manta ray	*Manta birostris*	N	N	N	N	N		Y	Y			
Chondrychthian	Basking shark	*Cetorhinus maximus*	N	N	N	N	N		Y	Y			
Teleost fish	Australian mudfish	*Neochanna cleaveri*	CE	L	Y	N	N		N	N			
Teleost fish	Australian whitebait	*Lovettia sealii*	CE	L	Y	N	N		N	N			
Teleost fish	Australian grayling	*Prototroctes maraena*	EN	L	Y	VU	N		N	N			
Teleost fish	Empire gudgeon	*Hypseleotris compressa*	EN	L	Y	N	N		N	N			
Teleost fish	Yarra pygmy perch	*Edelia obscura*	VU	L	Y	VU	N		N	N			
Teleost fish	Pale mangrove goby	*Mugiligobius platynotus*	VU	L	Y	N	N		N	N			
Teleost fish	Southern bluefin tuna	*Thunnus maccoyii*	N	L	Y	CD	N		N	N			
Teleost fish	Trout galaxias	*Galaxias truttaceus*	N	N	N	CE	N		N	N			
Teleost fish	Black rockcod	*Epinephelus daemelii*	N	N	N	VU	N		N	N			
Teleost fish	Blue warehou	*Seriolella brama*	N	N	N	CD	N		N	N			
Teleost fish	Eastern gemfish	*Rexea solandri*	N	N	N	CD	N		N	N			
Teleost fish	Briggs pipefish	*Histiogamphelus briggsii*	N	N	Y	N	Y		N	N			
Teleost fish	Brushtail pipefish	*Leptoichthys fistularius*	N	N	Y	N	Y		N	N			
Teleost fish	Bullneck seahorse	*Hippocampus minotaur*	N	N	Y	N	Y		N	N			
Teleost fish	Common sea dragon	*Phyllopteryx taeniolatus*	N	N	Y	N	Y		N	N			
Teleost fish	Half-banded pipefish	*Mitotichthys semistriatus*	N	N	Y	N	Y		N	N			
Teleost fish	Knife-spout pipefish	*Hypselognathus rostrus*	N	N	Y	N	Y		N	N			
Teleost fish	Long-snout pipefish	*Vanacampus poecilolaemus*	N	N	Y	N	Y		N	N			
Teleost fish	Mollisons pipefish	*Mitotichthys mollisoni*	N	N	Y	N	Y		N	N			
Teleost fish	Mother-of-pearl pipefish	*Vanacampus margaritifer*	N	N	Y	N	Y		N	N			
Teleost fish	Port Phillip pipefish	*Vanacampus phillipi*	N	N	Y	N	Y		N	N			
Teleost fish	Potbelly seahorse	*Hippocampus abdominalis*	N	N	Y	N	Y		N	N			
Teleost fish	Pug-nose pipefish	*Pugnaso curtirostris*	N	N	Y	N	Y		N	N			

Taxa	Common name	Scientific name	State			Federal				International			
			DELWP advisory list	FFG Act	Fisheries Act	EPBC Act Threatened	EPBC Act Marine	EPBC Act Cetacean	EPBC Act Migratory	Bonn	JAMBA	CAMBA	ROK-AMBA
Teleost fish	Ring-backed pipefish	*Stipecampus cristatus*	N	N	Y	N	Y		N	N			
Teleost fish	Sawtooth pipefish	*Marroubra perserrata*	N	N	Y	N	Y		N	N			
Teleost fish	Short-headed seahorse	*Hippocampus breviceps*	N	N	Y	N	Y		N	N			
Teleost fish	Smooth pipefish	*Lissocampus caudalis*	N	N	Y	N	Y		N	N			
Teleost fish	Spiny pipehorse	*Solegnathus spinosissimus*	N	N	Y	N	Y		N	N			
Teleost fish	Spotted pipefish	*Stigmatopora argus*	N	N	Y	N	Y		N	N			
Teleost fish	Upside-down pipefish	*Heraldia nocturnia*	N	N	Y	N	Y		N	N			
Teleost fish	Wide-body pipefish	*Stigmatopora nigra*	N	N	Y	N	Y		N	N			
Seabird	Wandering albatross	*Diomedea exulans*	EN	L		VU	Y		Y	Y	N	N	N
Seabird	Fairy tern	*Sterna nereis nereis*	EN	L		VU	N		N	N	N	N	N
Seabird	Gull-billed tern	*Gelochelidon nilotica*	EN	L		N	Y		Y	N	N	Y	N
Seabird	Grey-headed albatross	*Thalassarche chrysostoma*	VU	L		EN	Y		Y	Y	N	N	N
Seabird	Southern giant-petrel	*Macronectes giganteus*	VU	L		EN	Y		Y	Y	N	N	N
Seabird	Shy albatross	*Thalassarche cauta*	VU	L		VU	Y		Y	Y	N	N	N
Seabird	Southern royal albatross	*Diomedea epomophora*	VU	L		VU	Y		Y	Y	N	N	N
Seabird	Little tern	*Sternula albifrons*	VU	L		N	Y		Y	Y	Y	Y	Y
Seabird	White-bellied sea-eagle	*Haliaeetus leucogaster*	VU	L		N	Y		N	N	N	Y	N
Seabird	Black-browed albatross	*Thalassarche melanophris*	VU	N		VU	Y		Y	Y	N	N	N
Seabird	Fairy prion	*Pachyptila turtur*	VU	L		N	Y		N	N	N	N	N
Seabird	White-faced storm-petrel	*Pelagodroma marina*	VU	L		N	Y		N	N	N	N	N
Seabird	Yellow-nosed albatross	*Thalassarche chlororhynchos*	VU	N		N	Y		Y	Y	N	N	N
Seabird	Northern giant petrel	*Macronectes halli*	NT	L		VU	Y		Y	Y	N	N	N
Seabird	Caspian tern	*Hydroprogne caspia*	NT	L		N	Y		Y	N	N	Y	N
Seabird	Black-faced cormorant	*Phalacrocorax fuscescens*	NT	L		N	Y		N	N	N	N	N
Seabird	Common diving-petrel	*Pelecanoides urinatrix*	NT	L		N	Y		N	N	N	N	N
Seabird	Pacific gull	*Laurus pacificus pacificus*	NT	L		N	Y		N	N	N	N	N
Seabird	Whiskered tern	*Chlidonias hybridus*	NT	L		N	Y		N	N	N	N	N
Seabird	White-fronted tern	*Sterna striata*	NT	L		N	Y		N	N	N	N	N
Seabird	White-winged black tern	*Chlidonias leucopterus*	NT	N		N	Y		Y	N	Y	Y	Y

Taxa	Common name	Scientific name	State			Federal				International			
			DELWP advisory list	FFG Act	Fisheries Act	EPBC Act Threatened	EPBC Act Marine	EPBC Act Cetacean	EPBC Act Migratory	Bonn	JAMBA	CAMBA	ROK-AMBA
Seabird	Pied cormorant	*Phalacrocorax varius*	NT	L		N	N		N	N	N	N	N
Seabird	Buller's albatross	*Diomedea bulleri*	N	L		VU	Y		Y	Y	N	N	N
Seabird	Sooty albatross	*Phoebetria fusca*	N	L		VU	Y		Y	Y	N	N	N
Seabird	Blue petrel	*Halobaena caerulea*	N	L		VU	Y		N	N	N	N	N
Seabird	Soft-plumaged petrel	*Pterodroma mollis*	N	L		VU	Y		N	N	N	N	N
Seabird	Arctic jaeger	*Stercorarius parasiticus*	N	N		N	Y		Y	N	Y	Y	Y
Seabird	Common tern	*Sterna hirundo*	N	N		N	Y		Y	N	Y	Y	Y
Seabird	Flesh-footed shearwater	*Ardenna carneipes*	N	N		N	Y		Y	N	Y	N	Y
Seabird	Kelp gull	*Larus dominicanus*	N	N		N	Y		N	N	N	N	N
Seabird	Little penguin	*Eudyptula minor*	N	N		N	Y		N	N	N	N	N
Seabird	Pomarine jaeger	*Stercorarius pomarinus*	N	N		N	Y		Y	N	Y	Y	N
Seabird	Short-tailed shearwater	*Ardenna tenuirostris*	N	N		N	Y		Y	N	Y	Y	Y
Seabird	Sooty shearwater	*Ardenna grisea*	N	N		N	Y		Y	N	Y	Y	N
Seabird	Wedge-tailed shearwater	*Ardenna pacifica*	N	N		N	Y		Y	N	Y	N	N
Seabird	Wilson's storm-petrel	*Oceanites oceanicus*	N	N		N	Y		Y	N	Y	N	N
Seabird	Brown booby	*Sula leucogaster*	N	N		N	N		Y	N	Y	Y	Y
Shorebird	Australian painted snipe	*Rostratula australis*	CE	L		EN	Y		N	N	N	Y	N
Shorebird	Grey-tailed tattler	*Heteroscelus brevipes*	CE	L		N	Y		Y	Y	Y	Y	Y
Shorebird	Lesser sand plover	*Charadrius mongolus*	CE	N		EN	Y		Y	Y	Y	Y	Y
Shorebird	Greater sand plover	*Charadrius leschenaultii*	CE	N		VU	Y		Y	Y	Y	Y	Y
Shorebird	Curlew sandpiper	*Calidris ferruginea*	EN	L		CE	Y		Y	Y	Y	Y	Y
Shorebird	Great knot	*Calidris tenuirostris*	EN	L		CE	Y		Y	Y	Y	Y	Y
Shorebird	Australasian bittern	*Botaurus poiciloptilus*	EN	L		N	Y		N	N	N	N	N
Shorebird	Terek sandpiper	*Xenus cinereus*	EN	L		N	Y		Y	Y	Y	Y	Y
Shorebird	Red knot	*Calidris canutus*	EN	N		EN	Y		Y	Y	Y	Y	Y
Shorebird	Grey plover	*Pluvialis squatarola*	EN	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Eastern curlew	*Numenius madagas-cariensis*	VU	L		CE	Y		Y	Y	Y	Y	Y
Shorebird	Hooded plover	*Thinornis rubricollis rubricollis*	VU	L		VU	Y		N	N	N	N	N
Shorebird	Black-tailed godwit	*Limosa limosa*	VU	N		N	Y		Y	Y	Y	Y	Y

Taxa	Common name	Scientific name	State			Federal				International			
			DELWP advisory list	FFG Act	Fisheries Act	EPBC Act Threatened	EPBC Act Marine	EPBC Act Cetacean	EPBC Act Migratory	Bonn	JAMBA	CAMBA	ROK-AMBA
Shorebird	Common greenshank	*Tringa nebularia*	VU	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Common sandpiper	*Actitis hypoleucos*	VU	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Marsh sandpiper	*Tringa stagnatilis*	VU	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Pacific golden plover	*Pluvialis fulva*	VU	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Ruddy turnstone	*Arenaria interpres*	VU	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Whimbrel	*Numenius phaeopus*	VU	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Wood sandpiper	*Tringa glareola*	VU	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Latham's snipe	*Gallinago hardwickii*	NT	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Long-toed stint	*Calidris subminuta*	NT	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Pectoral sandpiper	*Calidris melanotos*	NT	N		N	Y		Y	Y	Y	N	Y
Shorebird	Sanderling	*Calidris alba*	NT	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Sooty oystercatcher	*Haematopus fuliginosus*	NT	N		N	N		N	N	N	N	N
Shorebird	Little bittern	*Ixobrychus minutus*	N	L		N	N		N	N	N	N	N
Shorebird	Bar-tailed godwit	*Limosa lapponica*	N	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Broad-billed sandpiper	*Limicola falcinellus*	N	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Buff-breasted sandpiper	*Tryngites subruficollis*	N	N		N	Y		N	N	Y	N	Y
Shorebird	Common greenshank	*Tringa nebularia*	N	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Red-necked phalarope	*Phalaropus lobatus*	N	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Red-necked stint	*Calidris ruficollis*	N	N		N	Y		Y	Y	Y	Y	Y
Shorebird	Ringed plover	*Charadrius hiaticula*	N	N		N	Y		Y	N	Y	Y	Y
Shorebird	Sharp-tailed sandpiper	*Calidris acuminata*	N	N		N	Y		Y	Y	Y	Y	Y
Other bird	Orange-bellied parrot	*Neophema chrysogaster*	CE	L		CE	Y		N	N	N	N	N
Other bird	Intermediate egret	*Ardea intermedia*	EN	L		N	Y		N	N	N	N	N
Other bird	Little egret	*Egretta garzetta*	EN	L		N	Y		N	N	N	N	N
Other bird	Baillon's crake	*Porzana pusilla*	VU	L		N	Y		N	N	N	N	N
Other bird	Eastern great egret	*Ardea modesta*	VU	L		N	Y		N	N	Y	Y	N
Other bird	Brolga	*Grus rubicunda*	VU	L		N	N		N	N	N	N	N
Other bird	Musk duck	*Biziura lobata*	VU	N		N	Y		N	N	N	N	N
Other bird	Hardhead	*Aythya australis*	VU	N		N	N		N	N	N	N	N

Taxa	Common name	Scientific name	State			Federal				International			
			DELWP advisory list	FFG Act	Fisheries Act	EPBC Act Threatened	EPBC Act Marine	EPBC Act Cetacean	EPBC Act Migratory	Bonn	JAMBA	CAMBA	ROK-AMBA
Other bird	Magpie goose	*Anseranas semipalmata*	NT	L		N	Y		N	N	N	N	N
Other bird	Glossy ibis	*Plegadis falcinellus*	NT	N		N	Y		Y	Y	N	N	N
Other bird	Nankeen night heron	*Nycticorax caledonicus*	NT	N		N	Y		N	N	N	N	N
Other bird	Royal spoonbill	*Platalea regia*	NT	N		N	N		N	N	N	N	N
Other bird	Asian dowitcher	*Limnodromus semipalmatus*	N	N		N	Y		Y	Y	Y	Y	Y
Other bird	Cattle egret	*Ardea ibis*	N	N		N	Y		N	N	N	N	N
Other bird	Eastern reef egret	*Egretta sacra*	N	N		N	Y		N	N	N	Y	N
Reptile	Leatherback turtle	*Dermochelys coriacea*	CE	L		N	Y		Y	Y			
Reptile	Loggerhead turtle	*Caretta caretta*	N	N		N	Y		Y	Y			
Reptile	Pacific ridley turtle	*Lepidochelys olivacea*	N	N		N	Y		Y	Y			
Reptile	Green turtle	*Chelonia mydas*	N	Y		VU	Y		Y	Y			
Reptile	Hawksbill turtle	*Eretmochelys imbricata*	N	Y		VU	Y		Y	Y			
Reptile	Yellow-bellied sea snake	*Pelamis platurus*	N	Y		N	Y		N	N			
Mammal	Blue whale	*Balaenoptera musculus*	CE	L		EN	N	Y	Y	Y			
Mammal	Southern right whale	*Eubalaena australis*	CE	L		EN	N	Y	Y	Y			
Mammal	Burrunan dolphin	*Tursiops australia*	EN	L		N	N	N	N	N			
Mammal	Humpback whale	*Megaptera novaeangliae*	VU	L		VU	N	Y	Y	Y			
Mammal	Long-nosed fur seal	*Arctocephalus forsteri*	VU	N		N	Y	N	N	N			
Mammal	Fin whale	*Balaenoptera physalus*	DD	N		VU	N	Y	Y	Y			
Mammal	Sei whale	*Balaenoptera borealis*	DD	N		VU	N	Y	Y	Y			
Mammal	Bryde's whale	*Balaenoptera edeni*	DD	N		N	N	Y	Y	Y			
Mammal	Subantarctic fur seal	*Arctocephalus tropicalis*	N	N		EN	Y	N	N	N			
Mammal	Australian sea lion	*Neophoca cinerea*	N	N		VU	Y	N	N	N			
Mammal	Southern elephant seal	*Mirounga leonina*	N	N		VU	Y	N	N	N			
Mammal	Australian fur seal	*Arctocephalus pusillus*	N	N		N	Y	N	N	N			
Mammal	Crab-eater seal	*Lobodon carcinophagus*	N	N		N	Y	N	N	N			
Mammal	Leopard seal	*Hydrurga leptonyx*	N	N		N	Y	N	N	N			
Mammal	Bottlenose dolphin	*Tursiops truncatus*	N	N		N	N	Y	N	N			
Mammal	Common dolphin	*Delphinus delphis*	N	N		N	N	Y	N	N			

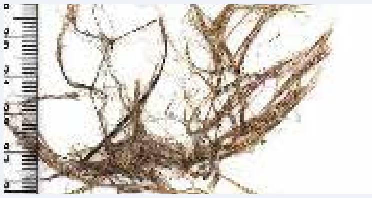
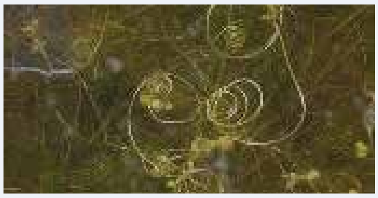
Taxa	Common name	Scientific name	State			Federal				International			
			DELWP advisory list	FFG Act	Fisheries Act	EPBC Act Threatened	EPBC Act Marine	EPBC Act Cetacean	EPBC Act Migratory	Bonn	JAMBA	CAMBA	ROK-AMBA
Mammal	Cuvier's beaked whale	*Ziphius cavirostris*	N	N		N	N	Y	N	Y			
Mammal	False killer whale	*Pseudorca crassidens*	N	N		N	N	Y	N	N			
Mammal	Gray's beaked whale	*Mesoplodon grayi*	N	N		N	N	Y	N	N			
Mammal	Killer whale	*Orcinus orca*	N	N		N	N	Y	Y	Y			
Mammal	Long-finned pilot whale	*Globicephala melas*	N	N		N	N	Y	N	N			
Mammal	Minke whale	*Balaenoptera acutorostrata*	N	N		N	N	Y	N	N			
Mammal	Risso's dolphin	*Grampus griseus*	N	N		N	N	Y	N	Y			
Mammal	Sperm whale	*Physeter macrocephalus*	N	N		N	N	Y	Y	Y			
Mammal	Strap-toothed whale	*Mesoplodon layardii*	N	N		N	N	Y	N	N			
Community	Port Phillip Bay Entrance Deep Canyon Marine Community		N	L		N							
Community	San Remo Marine Community		N	L		N							
Community	Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria		N	N		EN							
Community	Giant Kelp Marine forest of South East Australia		N	N		EN							
Community	Subtropical and temperate coastal saltmarsh		N	N		VU							
Plant	Sea Water-mat	*Althenia marina*	VU	L		N							
Plant	Eelgrass (seagrass)	*Zostera tasmanica*	R	N		N							
Plant	Eelgrass (seagrass)	*Zostera nigricaulis*	R	N		N							
Plant	Strap weed (Seagrass)	*Posidonia australis*	R	N		N							
Plant	White mangrove	*Avicennia marina australasica*	R	N		N							
Plant	Eelgrass (seagrass)	*Zostera capricorni*	DD	N		N							
Plant	Estuary grass	*Ruppia tuberosa*	DD	N		N							
Plant	Paddlegrass (Seagrass)	*Halophila australis*	DD	N		N							
Plant	Sea nymph (Seagrass)	*Amphibolis antarctica*	DD	N		N							

APPENDIX 4
Seagrasses and related species in Victoria

Seagrasses are flowering plants adapted to grow in intertidal and subtidal zones of bays, inlets and estuaries where they bind sandy and muddy sediments. Many epiphytic organisms (hydroids, red algae, bryozoans) live on the stems and leaves of seagrasses. Seagrass beds support a rich infauna and epifauna and form a key nursery habitat for many commercially and recreationally important fish.

Taxonomy in the following table from Kuo[1] and Jacobs and Les.[2] Distribution and occurrence are sourced from Warry and Hindell[3] and Flora of Victoria (https://vicflora.rbg.vic.gov.au)

Scientific name	Common name	Distribution and habitat	Image
Zostera muelleri	Eelgrass	Widespread in Victoria, also in South Australia, Tasmania and New South Wales Mainly occurs in intertidal areas or very shallow subtidal areas on mud and sand in calm waters	
Z. capricornia	Eelgrass	Common from tropical Queensland to the Victoria/New South Wales border. Recorded in Victoria at Mallacoota Occurs in shallow coastal waters to a depth of about 2 metres on mud and sand Very similar to *Z. muelleri*, possibly a subspecies	
Z. tasmanica (formerly *Heterozostera tasmanica*) *Z. nigricaulis* (formerly *H. nigricaulis*)	Eelgrass	*Z nigricaulis* is widespread from Western Australia to New South Wales. *Z. tasmanica* has not been recorded east of Wilsons Promontory Occurs subtidally to a depth of up to 8 metres (depending on local turbidity and light levels) on mudflats. With *Z. mulleri*, these are the dominant species of seagrass in Port Phillip Bay Morphologically *Z. tasmanica* and *Z. nigricaulis* are very similar and may serve similar ecological functions	
Amphibolis antarctica	Wireweed/sea nymph	Widespread Occurs in coarse sandy sediments, rock pools or as patches on flat rock in subtidal waters (to depths of about 20 metres) that are exposed to moderate to strong wave energy. It forms extensive meadows close to the entrance of Port Phillip Bay and in Western Port	
Halophila australis	Paddlegrass	Usually occurring in calm water, in fine silty and muddy substrates from low tide to depth of about 23 metres. Often in association with *Zostera* at the deeper margins of *Zostera* distribution.	
Posidonia australis	Strap weed	Common in temperate New South Wales waters. Restricted in Victoria to Corner Inlet, Nooramunga, Barwon Heads and Great Glennie Island Most extensive in Corner Inlet. Occurs in shallow, subtidal waters up to about 15 metres deep, in sandy soil	

Althenia marina (formerly *Lepilaena marina*)	Water mat	Recorded from Port Phillip Bay and Lake Reeve in Victoria. Also in South Australia and Tasmania Occurs in shallow protected marine waters of on muddy substrates with *Z. muelleri* and *Ruppia maritima*	
A. cylindrocarpa (formerly *L. cylindrocarpa*)	Water mat	Distributed from South Australia to the Yarra River estuary in Port Phillip Bay Occurs in marine estuaries, swamps and lakes, also in brackish water and sometimes in fresh water	
Ruppia megacarpa	Estuary grass	Distributed widely across Australia except the Northern Territory Occurs in brackish to saline coastal lagoons and lakes, estuaries and inland lakes	
R. tuberosa	Estuary grass	Distributed widely across Australia except for Queensland Occurs in small brackish swamps, saline lakes and marshes, or on the tidal flats of sheltered bays	
R. polycarpa	Estuary grass	*Distributed widely across temperate southern Australia *Occurs in freshwater dams, ditches and small creeks, as well as in brackish water and saline coastal lakes and lagoons	

1. Kuo, J. (2005) A revision of the genus *Heterozostera* (Zosteraceae). *Aquatic Botany* 81: 97–140.
2. Jacobs, S.W.L. and Les, D.H. (2009) New combinations in *Zostera* (Zosteraceae). *Telopea* 12: 419–423.
3. Warry, F.Y. and Hindell, J.S. (2009) *Review of Victorian seagrass research with emphasis on Port Phillip Bay*. Arthur Rylah Institute for Environmental Research. Department of Sustainability and Environment, Heidelberg.

APPENDIX 5
Coastal Saltmarsh Communities

Coastal saltmarsh grows on intertidal sand and mud flats. Saltmarsh is subject to periodic inundation. Salt-tolerant succulent shrubs and herbs, grasses and sedges form a dense, low vegetation layer which provides food and cover for a range of water birds and waders. The descriptions in the following table are taken from Boon et al.[1]

Name	Description
Wet saltmarsh herbland	Low herbland dominated by succulent salt-tolerant (halophytic) herbs or semi-shrubs that occupies low-lying areas subject to regular inundation. Often very few species occur in this community and beaded glasswort dominates. This community is widespread but confined to restricted areas of suitable habitat in sheltered parts of the Victorian coast.
Wet saltmarsh shrubland	Dominated by halophytic species and subject to regular tidal inundation. Often very few species occur in this community and shrubby glasswort dominates. It is largely confined to the area between Breamlea and Corner Inlet.
Coastal saline grassland	Dominated by rhizomatous grasses and occurs towards the upper zones of coastal saltmarsh. This grassland is frequently very species poor and is typically dominated by either Australian salt-grass on heavier soils or marine couch (*Sporobolus virginicus*) on sandier soils. It mostly occurs between the Bellarine Peninsula and Western Port.
Coastal dry saltmarsh	*Herbland to low shrubland occurring in upper coastal saltmarsh zones. It only occurs in lower rainfall areas that are subject to relatively infrequent tidal inundation. The dominant plants include thick-head glasswort (Sarcocornia blackiana), southern sea-heath, rounded noon-flower, common cup flower (Angianthus preissianus) or, very rarely, white sebaea (Sebaea albidiflora). This saltmarsh is localised and severely depleted in Bellarine Peninsula, western Port Phillip Bay, the head of Western Port and Lake Reeve in Gippsland.*
Coastal hypersaline saltmarsh	Low shrubland dominated by succulent chenopods that occurs in highly hypersaline coastal saltmarsh habitat above the zone of regular tides. This community can be very species poor and is often dominated by black-seeded glasswort (*Tecticornia pergranulata*), grey glasswort (*T. halocnemoides*) or thorny lawrencia (*Lawrencia squamata*). It is extremely localised in Western Port Phillip Bay and on the Bellarine Peninsula. A community dominated by black-seeded glasswort also occurs at Lake Reeve in Gippsland.
Coastal tussock saltmarsh	Occurs in upper coastal saltmarsh zones and is dominated by robust tussocks. Dominant plant species are often chaffy saw-sedge or coast spear-grass. A range of halophytic species have low levels of cover and beaded glasswort is typically present. It has a scattered distribution along the Victorian coast.
Saltmarsh-grass swamp	Inundation-prone grassland on highly saline sites. It is dominated by Australian saltmarsh-grass or plains saltmarsh-grass (*Puccinellia stricta* or *P. perlaxa*). For coastal areas, there are only restricted occurrences of this grass swamp in the Barwon River estuary.

1. Boon, P., Allen, T., Brook, J., Carr, G., Frood, D., Harty, C., Hoye, J., McMahon, A., Matthews, S., Rosengren, N., Sinclair, S., White, M. and Yugovic, J. (2011) *Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management.* Institute for Sustainability and Innovation, Victoria University, Melbourne.

APPENDIX 6
Fisheries Offshore Constitutional Settlement Srrangements

Offshore constitutional settlement arrangements between Victoria and the Commonwealth for fisheries are listed in the following table.[1,2]

Agreement	Commencement date
Arrangement between the Commonwealth and State of Victoria in relation to the trawl fishery to be managed under state law in waters relevant to Victoria	1/11/1997
Arrangement between the Commonwealth and State of Victoria in relation to the trawl fishery to be managed under Commonwealth law in waters relevant to Victoria	1/11/1997
Arrangement between the Commonwealth and State of Victoria in relation to the fishery for finfish to be managed under state law in waters relevant to Victoria	1/11/1997
Arrangement between the Commonwealth and State of Victoria in relation to the fishery for finfish to be managed under Commonwealth law in waters relevant to Victoria	1/11/1997
Arrangement between the Commonwealth and State of Victoria in relation to the fishery for invertebrates to be managed under state law in waters relevant to Victoria	1/11/1997
Arrangement between the Commonwealth and State of Victoria in relation to the fishery for royal red prawns and associated species to be managed under Commonwealth law in waters relevant to Victoria	1/11/1997
Instrument of termination of arrangements made between the Commonwealth and the State of Victoria	1/11/1997
Memorandum of Understanding Between the Commonwealth of Australia, the Australian Fisheries Management Authority and the State of Victoria with respect to the fisheries in waters relevant to Victoria.	1/11/1997
Arrangement between the Commonwealth and State of Victoria in relation to the bycatch fishery for school and gummy shark to be managed under state law in waters relevant to Victoria	7/3/2001
Arrangement between the Commonwealth and State of Victoria in relation to the fishery for school and gummy shark to be managed under Commonwealth law in waters relevant to Victoria	7/3/2001

1. Commonwealth of Australia (1997) Offshore Constitutional Settlement. Commonwealth Gazette. Special No. S436, Friday 31 October 1997. https://www.legislation.gov.au/content/HistoricGazettes1997
2. Commonwealth of Australia (2001) Offshore Constitutional Settlement. Commonwealth Gazette. No. GN 9, 7 March 2001. https://www.legislation.gov.au/content/HistoricGazettes2001

APPENDIX 7
Species Subject to Offshore Constitutional Settlement Fisheries Arrangements

Species subject to offshore constitutional settlement arrangements for Victoria are listed in the following table.

Fishery	Jurisdiction	Target species		Allowed bycatch species	
Trawl (including but not limited to board trawling, midwater or pelagic trawling and Danish seining)	State	Bay bug	Family Scyllaridae	Any other fish species excepting :	
		Eastern king prawn	*Penaeus plebejus*	Billfish	Families Istiophoridae and Xiphiidae
		Giant crab	*Pseudocarcinus gigas*	Northern bluefin tuna	*Thunnus thynnus*
		Sand crab	*Portunus pelagicus*	Southern bluefin tuna	*Thunnus maccoyii*
		School prawn	*Metapenaeus macleayi*		
		Abalone	Family Haliotidae		
		Rock lobster	Family Palinuridae		
Trawl (including but not limited to board trawling, midwater or pelagic trawling and Danish seining)	Commonwealth	Any species taken by trawling, excepting		Bay bug	Family Scyllaridae
		Bay bug	Family Scyllaridae	Eastern king prawn	*Penaeus plebejus*
		Eastern king prawn	*Penaeus plebejus*	Giant crab	*Pseudocarcinus gigas*
		Giant crab	*Pseudocarcinus gigas*	Sand crab	*Portunus pelagicus*
		Sand crab	*Portunus pelagicus*	School prawn	*Metapenaeus macleayi*
		School prawn	*Metapenaeus macleayi*	Abalone	Family Haliotidae
		Abalone	Family Haliotidae	Rock lobster	Family Palinuridae
		Rock lobster	Family Palinuridae		
Finfish (all methods of fishing other than trawling)	State	Australian anchovy	*Engraulis australis*	Any other fish species excepting :	
		Australian salmon	Genus *Arripis*	Black oreo	*Allocyttus niger*
		Barracouta	*Thyrisites atun*	Billfish	Families Istiophoridae & Xiphiidae
		Blue sprat	*Spratelloides robustus*	King dory	*Cyttus traversi*
		King George whiting	*Sillaginodes punctata*	Northern bluefin tuna	*Thunnus thynnus*
		Leatherjacket, all species	Family Monocanthidae	Orange roughy	*Hoplostethus atlanticus*
		Pilchard	*Sardinops neopilchardus*	Ox-eye oreo	*Oreosoma atlanticum*
		Snapper	*Pagrus auratus*	Smooth oreo	*Pseudocyttus maculatus*
		Sprat	*Clupea bassensis*	Southern bluefin tuna	*Thunnus maccoyii*
		Striped trumpeter	*Latris lineata*	Spiky oreo	*Neocyttus rhomboidalis*
		Wrasses, all species	Family Labridae	Warty oreo	*Allocyttus verrucosus*
		Yellowtail kingfish	*Seriola lalandi*		
		Flathead, all species	Family Platycephalidae		
		Silver trevally	*Pseudocaranx dentex*		
		School whiting	*Sillago flindersi*		

Fishery	Jurisdiction	Target species		Allowed bycatch species	
Finfish (all methods of fishing other than trawling)	Commonwealth	Albacore tuna	*Thunnus alalunga*	Any other fish species excepting	
		Bigeye tuna	*Thunnus obesus*	Abalone	Family Haliotidae
		Longtail tuna	*Thunnus tonggol*	Rock lobster	Family Palinuridae
		Skipjack tuna	*Katsuwonus pelamis*		
		Yellowfin tuna	*Thunnus albacares*		
		Billfish Families	Istiophoridae and Xiphiidae		
		Northern bluefin tuna	*Thunnus thynnus*		
		Southern bluefin tuna	*Thunnus maccoyii*		
		Blue-eye trevalla	*Hyperoglyphe antarctica*		
		Blue warehou	*Seriolella brama*		
		Jackass morwong	*Nemadactylus macropterus*		
		John dory	*Zeus faber*		
		Mirror dory	*Zenopsis nebulosus*		
		Ocean perch	*Helicolenus spp*		
		Pink ling	*Genypterus blacodes*		
		Rays bream (or pomfret)	Family Bramidae		
		Redfish	*Centroberyx affinis*		
		Spotted warehou	*Seriolella punctata*		
		Yelloweye nannygai	*Centroberyx australis*		
		Bass	*Polyprion americanus*		
		Bass groper	*Polyprion moene*		
		Blackoreo	*Allocyttus niger*		
		Blue grenadier	*Macruronus novaezelandiae*		
		Gemfish	*Rexea solandri*		
		Hapuku	*Polyprion oxygeneios*		
		King dory	*Cyttus traversi*		
		Orange roughy	*Hoplostethus atlanticus*		
		Ox-eye oreo	*Oreosoma atlanticum*		
		Smooth oreo	*Pseudocyttus maculatus*		
		Spiky oreo	*Neocyitus rhomboidalis*		
		Warty oreo	*Allocyttus verrucosus*		
		Flathead, all species	Family Platycephalidae		
		Silver trevally	*Pseudocaranx dentex*		
		School whiting	*Sillago flindersi*		

Fishery	Jurisdiction	Target species		Allowed bycatch species	
Invertebrates (by any fishing method other than trawling)	State	Any species from Phylum Crustacea, Phylum Mollusca, Phylum Echinodermata except:		Arrow squid	*Nototodarus gouldi*
		Deepwater prawn	*Haliporoides cristatus*	Red ocean squid	*Ommastrephes bartrami*
		Red prawn	*Aristeomorpha foliacea*	Southern ocean arrow squid	*Todarodes filippovae*
		Royal red prawn	*Haliporoides sibogae*	Yellowback squid	*Sthenoieuthis oualaniensis*
		Scarlet prawn	*Plesiopenaeus edwardsianus*	Abalone	Family Haliotidae
		Prawns	Genus *Aristeus*	Rock lobster	Family Palinuridae
		Carids	Family Pandalidae	Scallops	Family Pectinidae
		Arrow squid	*Nototodarus gouldi*		
		Red ocean squid	*Ommastrephes bartrami*		
		Southern ocean arrow squid	*Todarodes filippovae*		
		Yellowback squid	*Sthenoieuthis oualaniensis*		
		Scallops	Family Pectinidae		
Invertebrates (by any fishing method other than trawling)	Commonwealth	Deepwater prawn	*Haliporoides cristatus*	Any other fish species excepting	
		Red prawn	*Arisleomorpha foliacea*	Abalone	Family Haliotidae
		Royal red prawn	*Haliporoides sibogae*	Rock lobster	Family Palinuridae
		Scarlet prawn	*Plesiopenaeus edwardsianus*		
		Prawns	Genus *Arisleus*		
		Carids	Family Pandalidae		
Shark	Commonwealth	School shark	*Galeorhinus galeus*	School shark	Galeorhinus galeus
		Gummy shark	*Mustelus antarcticus*	Gummy shark	Mustelus antarcticus

APPENDIX 8
Stock Status for Fish Caught in Victorian Waters

Stock status for fish caught in Victorian waters in Commonwealth and Victorian fisheries is provided in the following table.

Fishery	Type	Species and stock	Scientific name	Status	Source
Victoria: Inshore trawl fishery	Crustacean	Balmain bugs, Victoria	*Ibacus alticrenatus, I. brucei, I. chacei, I. peronii, I. species*	Negligible	FRDC 2018[1]
Victoria: Inshore trawl fishery	Crustacean	Eastern school prawn, Victoria	*Metapenaeus macleayi*	Undefined	FRDC 2018
Victoria: Giant crab fishery	Crustacean	Giant crab, Giant crab fishery Victoria	*Pseudocarcinus gigas*	Sustainable	FRDC 2018
Victoria	Crustacean	Sand crab	*Ovalipes australiensis*	Undefined	VFA 2017[2]
Victoria: Victorian rock lobster fishery	Crustacean	Southern rock lobster, Southern Australia	*Jasus edwardsii*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Australian herring, Southern Australia	*Arripis georgianus*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Australian herring, Southern Australia	*Arripis georgianus*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Australian herring, Southern Australia	*Arripis georgianus*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Australian herring, Southern Australia	*Arripis georgianus*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Australian salmon, eastern Australia	*Arripis trutta, A. truttaceus*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Australian salmon, eastern Australia	*Arripis trutta, A. truttaceus*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Australian salmon, eastern Australia	*Arripis trutta, A. truttaceus*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Australian salmon, western Australia	*Arripis trutta, A. truttaceus*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Australian salmon, western Australia	*Arripis trutta, A. truttaceus*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Australian sardine, south eastern stock	*Sardinops sagax*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes bait fishery	Finfish	Australian sardine, south eastern stock	*Sardinops sagax*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Australian sardine, south eastern stock	*Sardinops sagax*	Sustainable	FRDC 2018
Victoria: Ocean purse seine fishery	Finfish	Australian sardine, south eastern stock	*Sardinops sagax*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Australian sardine, south eastern stock	*Sardinops sagax*	Sustainable	FRDC 2018
Victoria: Banded morwong fishery	Finfish	Banded morwong, Victorian banded morwong fishery	*Cheilodactylus spectabilis*	Recovering	FRDC 2018
Victoria: Ocean fishery	Finfish	Banded morwong, Victorian banded morwong fishery	*Cheilodactylus spectabilis*	Recovering	FRDC 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Victoria: Rock lobster fishery	Finfish	Banded morwong, Victorian banded morwong fishery	*Cheilodactylus spectabilis*	Recovering	FRDC 2018
Victoria: Ocean fishery	Finfish	Bastard trumpeter, Victoria	*Latridopsis forsteri*	Negligible	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Black bream, eastern estuaries	*Acanthopagrus butcheri*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Black bream, Gippsland lakes	*Acanthopagrus butcheri*	Depleting	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Black bream, western estuaries	*Acanthopagrus butcheri*	Sustainable	FRDC 2018
Victoria: Ocean purse seine fishery	Finfish	Blue mackerel, east	*Scomber australasicus*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Blue warehou, east	*Seriolella brama*	Depleted	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Blue warehou, east	*Seriolella brama*	Depleted	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Blue warehou, east	*Seriolella brama*	Depleted	FRDC 2018
Victoria: Ocean fishery	Finfish	Blue warehou, east	*Seriolella brama*	Depleted	FRDC 2018
Victoria: Ocean fishery	Finfish	Blue warehou, west	*Seriolella brama*	Depleted	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Blue warehou, west	*Seriolella brama*	Depleted	FRDC 2018
Victoria: Ocean fishery	Finfish	Bluethroat wrasse, Victoria	*Notolabrus tetricus*	Sustainable	FRDC 2018
Victoria: Ocean Wrasse fishery	Finfish	Bluethroat wrasse, Victoria	*Notolabrus tetricus*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Bluethroat wrasse, Victoria	*Notolabrus tetricus*	Sustainable	FRDC 2018
Victoria: Victorian Rock Lobster fishery	Finfish	Bluethroat wrasse, Victoria	*Notolabrus tetricus*	Sustainable	FRDC 2018
Victoria: Gippsland lakes fishery	Finfish	Dusky flathead, Victoria	*Platycephalus fuscus*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Eastern school whiting, southeast Australia	*Sillago flindersi*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Eastern school whiting, southeast Australia	*Sillago flindersi*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Eastern school whiting, southeast Australia	*Sillago flindersi*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Elephantfish, southern Australia	*Callorhinchus milii*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Elephantfish, southern Australia	*Callorhinchus milii*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Elephantfish, southern Australia	*Callorhinchus milii*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	John dory, south eastern Australia	*Zeus faber*	Sustainable	FRDC 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Victoria: Corner Inlet fishery	Finfish	King George whiting, Victoria	*Sillaginodes punctatus*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	King George whiting, Victoria	*Sillaginodes punctatus*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	King George whiting, Victoria	*Sillaginodes punctatus*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	King George whiting, Victoria	*Sillaginodes punctatus*	Sustainable	FRDC 2018
Victoria: Ocean Wrasse fishery	Finfish	King George whiting, Victoria	*Sillaginodes punctatus*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	King George whiting, Victoria	*Sillaginodes punctatus*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Luderick, east Australia	*Girella tricuspidata*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Ocean jacket, Victoria	*Nelusetta ayraud*	Undefined	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Ocean jacket, Victoria	*Nelusetta ayraud*	Undefined	FRDC 2018
Victoria: Ocean fishery	Finfish	Ocean jacket, Victoria	*Nelusetta ayraud*	Undefined	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Ocean jacket, Victoria	*Nelusetta ayraud*	Undefined	FRDC 2018
Victoria: Victorian rock lobster fishery	Finfish	Ocean jacket, Victoria	*Nelusetta ayraud*	Undefined	FRDC 2018
Victoria	Finfish	Purple wrasse	*Notolabrus fucicola*	Sustainable	VFA 2017
Victoria: Corner Inlet fishery	Finfish	Rock flathead	*Platycephalus laevigatus*	Sustainable	VFA 2017
Victoria: Corner Inlet fishery	Finfish	Silver trevally, Victoria	*Pseudocaranx georgianus, P.* sp. *'dentex,' P. wrighti, P. dinjerra*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Silver trevally, Victoria	*Pseudocaranx georgianus, P.* sp. *'dentex,' P. wrighti, P. dinjerra*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Silver trevally, Victoria	*Pseudocaranx georgianus, P.* sp. *'dentex,' P. wrighti, P. dinjerra*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Silver trevally, Victoria	*Pseudocaranx georgianus, P.* sp. *'dentex,' P. wrighti, P. dinjerra*	Sustainable	FRDC 2018
Victoria: Ocean purse seine fishery	Finfish	Silver trevally, Victoria	*Pseudocaranx georgianus, P.* sp. *'dentex,' P. wrighti, P. dinjerra*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Silver trevally, Victoria	*Pseudocaranx georgianus, P.* sp. *'dentex,' P. wrighti, P. dinjerra*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Snapper, eastern stock	*Chrysophrys auratus*	Undefined	FRDC 2018
Victoria: Gippsland lakes fishery	Finfish	Snapper, eastern stock	*Chrysophrys auratus*	Undefined	FRDC 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Victoria: Inshore trawl fishery	Finfish	Snapper, eastern stock	*Chrysophrys auratus*	Undefined	FRDC 2018
Victoria: Ocean fishery	Finfish	Snapper, eastern stock	*Chrysophrys auratus*	Undefined	FRDC 2018
Victoria: Ocean purse seine fishery	Finfish	Snapper, eastern stock	*Chrysophrys auratus*	Undefined	FRDC 2018
Victoria: Victorian rock lobster fishery	Finfish	Snapper, eastern stock	*Chrysophrys auratus*	Undefined	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Snapper, western stock	*Chrysophrys auratus*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Snapper, western stock	*Chrysophrys auratus*	Sustainable	FRDC 2018
Victoria: Ocean Wrasse fishery	Finfish	Snapper, western stock	*Chrysophrys auratus*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Snapper, western stock	*Chrysophrys auratus*	Sustainable	FRDC 2018
Victoria: Victorian rock lobster fishery	Finfish	Snapper, western stock	*Chrysophrys auratus*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Snook, Victoria	*Sphyraena novahollandiae*	Undefined	FRDC 2018
Victoria: Gippsland lakes fishery	Finfish	Snook, Victoria	*Sphyraena novahollandiae*	Undefined	FRDC 2018
Victoria: Ocean fishery	Finfish	Snook, Victoria	*Sphyraena novahollandiae*	Undefined	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Snook, Victoria	*Sphyraena novahollandiae*	Undefined	FRDC 2018
Victoria	Finfish	Southern bluespotted flathead	*Platycephalus speculator*	Sustainable	VFA 2017
Victoria: Corner Inlet fishery	Finfish	Southern garfish, Victoria	*Hyporhamphus melanochir*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Southern garfish, Victoria	*Hyporhamphus melanochir*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Southern garfish, Victoria	*Hyporhamphus melanochir*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Southern sand flathead, Corner Inlet	*Platycephalus bassensis*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Southern sand flathead, other Victorian	*Platycephalus bassensis*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Southern sand flathead, other Victorian	*Platycephalus bassensis*	Sustainable	FRDC 2018
Victoria: Victorian rock lobster fishery	Finfish	Southern sand flathead, other Victorian	*Platycephalus bassensis*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Southern sand flathead, Port Phillip Bay	*Platycephalus bassensis*	Recovering	FRDC 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Victoria: Corner Inlet fishery	Finfish	Tailor, eastern Australia	*Pomatomus saltatrix*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Tailor, eastern Australia	*Pomatomus saltatrix*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Tailor, eastern Australia	*Pomatomus saltatrix*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Finfish	Tailor, eastern Australia	*Pomatomus saltatrix*	Sustainable	FRDC 2018
Victoria: Ocean purse seine fishery	Finfish	Tailor, eastern Australia	*Pomatomus saltatrix*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Tailor, eastern Australia	*Pomatomus saltatrix*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Tiger flathead, southern Australia	*Platycephalus richardsoni*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Finfish	Tiger flathead, southern Australia	*Platycephalus richardsoni*	Sustainable	FRDC 2018
Victoria: Corner Inlet fishery	Finfish	Yellow-eye mullet, Victoria	*Aldrichetta forsteri*	Recovering	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Yellow-eye mullet, Victoria	*Aldrichetta forsteri*	Recovering	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Finfish	Yellow-eye mullet, Victoria	*Aldrichetta forsteri*	Recovering	FRDC 2018
Victoria: Gippsland Lakes fishery	Finfish	Yellowfin bream	*Acanthopagrus australia*	Sustainable	FRDC 2016
Victoria: Central zone fishery	Mollusc	Blacklip abalone, Central zone	*Haliotis rubra rubra*	Depleting	FRDC 2018
Victoria: Eastern zone fishery	Mollusc	Blacklip abalone, Eastern zone	*Haliotis rubra rubra*	Depleting	FRDC 2018
Victoria: Western zone fishery	Mollusc	Blacklip abalone, Western zone	*Haliotis rubra rubra*	Sustainable	FRDC 2018
Victoria: Ocean scallop fishery	Mollusc	Commercial scallop, Ocean scallop	*Pecten fumatus*	Depleted	FRDC 2018
Victoria: Port Phillip Bay dive scallop fishery	Mollusc	Commercial scallop, Port Phillip Bay dive scallop	*Pecten fumatus*	Sustainable	FRDC 2018
Victoria: Central zone fishery	Mollusc	Greenlip abalone, Central zone	*Haliotis laevigata*	Undefined	FRDC 2018
Victoria: Western zone fishery	Mollusc	Greenlip abalone, Western zone	*Haliotis laevigata*	Undefined	FRDC 2018
Victoria: Corner Inlet fishery	Mollusc	Pale octopus, Victoria	*Octopus pallidus*	Undefined	FRDC 2018
Victoria: Inshore trawl fishery	Mollusc	Pale octopus, Victoria	*Octopus pallidus*	Undefined	FRDC 2018
Victoria: Ocean fishery	Mollusc	Pale octopus, Victoria	*Octopus pallidus*	Undefined	FRDC 2018
Victoria: Port Phillip Bay fishery	Mollusc	Pale octopus, Victoria	*Octopus pallidus*	Undefined	FRDC 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Victoria: Victorian rock lobster fishery	Mollusc	Pale octopus, Victoria	*Octopus pallidus*	Undefined	FRDC 2018
Victoria: Bait fishery	Mollusc	Pipi, Victoria	*Donax deltoides*	Undefined	FRDC 2018
Victoria: Ocean fishery	Mollusc	Pipi, Victoria	*Donax deltoides*	Undefined	FRDC 2018
Victoria: Corner Inlet fishery	Mollusc	Southern calamari, Victoria	*Sepioteuthis australis*	Sustainable	FRDC 2018
Victoria: Gippsland Lakes fishery	Mollusc	Southern calamari, Victoria	*Sepioteuthis australis*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Mollusc	Southern calamari, Victoria	*Sepioteuthis australis*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Mollusc	Southern calamari, Victoria	*Sepioteuthis australis*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Mollusc	Southern calamari, Victoria	*Sepioteuthis australis*	Sustainable	FRDC 2018
Victoria	Mollusc	Wavy periwinkle, Victoria	*Lunella undulata*	Negligible	FRDC 2018
Victoria: Corner Inlet fishery	Shark	Gummy shark, Southern Australia	*Mustelus antarcticus*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Shark	Gummy shark, Southern Australia	*Mustelus antarcticus*	Sustainable	FRDC 2018
Victoria: Ocean fishery	Shark	Gummy shark, Southern Australia	*Mustelus antarcticus*	Sustainable	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Shark	Gummy shark, Southern Australia	*Mustelus antarcticus*	Sustainable	FRDC 2018
Victoria: Victorian rock lobster fishery	Shark	Gummy shark, Southern Australia	*Mustelus antarcticus*	Sustainable	FRDC 2018
Victoria: Inshore trawl fishery	Shark	School shark, southern Australia	*Galeorhinus galeus*	Depleted	FRDC 2018
Victoria: Ocean fishery	Shark	School shark, southern Australia	*Galeorhinus galeus*	Depleted	FRDC 2018
Victoria: Port Phillip Bay and Western Port fishery	Shark	School shark, southern Australia	*Galeorhinus galeus*	Depleted	FRDC 2018
Victoria: Rock lobster fishery	Shark	School shark, southern Australia	*Galeorhinus galeus*	Depleted	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Crustacean	Royal red prawn, south eastern Australia	*Haliporoides sibogae*	Sustainable	FRDC 2018
Commonwealth: Eastern tuna and billfish fishery	Finfish	Albacore tuna, South Pacific	*Thunnus alulunga*	Sustainable	FRDC 2018
Commonwealth: Small pelagic	Finfish	Australian sardine, eastern Australia	*Sardinops sagax*	Sustainable	FRDC 2018
Commonwealth: Small pelagic	Finfish	Australian sardine, South eastern Australia	*Sardinops sagax*	Sustainable	FRDC 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Australian sardine, South eastern Australia	*Sardinops sagax*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Bastard trumpeter, Commonwealth	*Latridopsis forsteri*	Negligible	FRDC 2018
Commonwealth: Eastern tuna and billfish fishery	Finfish	Bigeye tuna, Pacific Ocean	*Thunnus obesus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Blue grenadier, Commonwealth trawl sector	*Macruronus novaezelandiae*	Sustainable	FRDC 2018
Commonwealth: Small pelagic	Finfish	Blue mackerel, east	*Scomber australasicus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Blue warehou, east	*Seriolella brama*	Depleted	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Blue warehou, west	*Seriolella brama*	Depleted	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Blue-eye trevalla, eastern Australia	*Hyperoglyphe antarctica*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Eastern school whiting, southeast Australia	*Sillago flindersi*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Flathead	*Neoplatycephalus richardsoni* and four other species	Sustainable	AFMA 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Gemfish, eastern zone	*Rexea solandri*	Depleted	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Gemfish, western zone	*Rexea solandri*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Grey morwong, eastern Australia	*Nemadactylus douglasii*	Depleted	FRDC 2018
Commonwealth: Small pelagic	Finfish	Jack mackerel, east	*Trachurus declivis*	Sustainable	AFMA 2018[3]
Commonwealth: Small pelagic	Finfish	Jack mackerel, west	*Trachurus declivis*	Sustainable	AFMA 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Jackass morwong, eastern	*Nemadactylus macropterus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Jackass morwong, western	*Nemadactylus macropterus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	John dory, south eastern Australia	*Zeus faber*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Mirror dory, south eastern Australia	*Zenopsis nebulosa*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Ocean jacket, Southeast scalefish and shark fishery	*Nelusetta ayraud*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Ocean perch, Victoria	*Helicolenus barathri, H. percoides*	Undefined	AFMA 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Orange roughy, Cascade Plateau	*Hoplostethus atlanticus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Orange roughy, eastern zone	*Hoplostethus atlanticus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Orange roughy, southern zone	*Hoplostethus atlanticus*	Depleted	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Orange roughy, western zone	*Hoplostethus atlanticus*	Depleted	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Other oreodories	*Allocyttus niger, Neocyttus rhomboidalis, A. verrucosus, Neocyttus* spp.	Undefined	AFMA 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Pink ling, eastern	*Genypterus blacodes*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Pink ling, western	*Genypterus blacodes*	Sustainable	FRDC 2018
Commonwealth: Small pelagic	Finfish	Redbait, east	*Emmelichthys nitidus*	Sustainable	AFMA 2018
Commonwealth: Small pelagic	Finfish	Redbait, west	*Emmelichthys nitidus*	Sustainable	AFMA 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Redfish, south eastern Australia	*Centroberyx affinis*	Depleted	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Ribaldo, south eastern Australia	*Mora moro*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Silver trevally, Commonwealth	*Pseudocaranx georgianus, P.* sp. *'dentex,' P. wrighti, P. dinjerra*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Silver warehou, southern and eastern Australia	*Seriolella punctata*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Smooth oreodory, Cascade Plateau	*Pseudocyttus maculatus*	Sustainable	AFMA 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Smooth oreodory, non-Cascade Plateau	*Pseudocyttus maculatus*	Sustainable	AFMA 2018
Commonwealth: Southern bluefin tuna fishery	Finfish	Southern bluefin tuna, global	*Thunnus maccoyii*	Recovering	FRDC 2018
Commonwealth: Eastern tuna and billfish fishery	Finfish	Striped marlin	*Kajikia audax*	Sustainable	AFMA 2018
Commonwealth: Eastern tuna and billfish fishery	Finfish	Swordfish, south-west Pacific Ocean	*Xiphias gladius*	Undefined	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Tiger flathead, southern Australia	*Platycephalus richardsoni*	Sustainable	FRDC 2018
Commonwealth: Eastern tuna and billfish fishery	Finfish	Yellowfin tuna, western and central Pacific Ocean	*Thunnus albacares*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Finfish	Yellowtail kingfish, eastern Australia	*Seriola lalandi*	Undefined	FRDC 2018
Commonwealth: Bass Strait central zone scallop fishery	Mollusc	Commercial scallop, Bass Strait central zone scallop	*Pecten fumatus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Mollusc	Gould's squid, southeastern Australia	*Nototodarus gouldi*	Sustainable	FRDC 2018
Commonwealth: Southern squid jig fishery	Mollusc	Gould's squid, southeastern Australia	*Nototodarus gouldi*	Sustainable	FRDC 2018

Fishery	Type	Species and stock	Scientific name	Status	Source
Commonwealth: Southern and eastern scalefish and shark fishery	Mollusc	Southern calamari, Commonwealth	*Sepioteuthis australis*	Undefined	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Shark	Deepwater sharks, eastern zone	*multiple species*	Undefined	AFMA 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Shark	Deepwater sharks, western zone	multiple species	Undefined	AFMA 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Shark	Elephantfish, southern Australia	*Callorhinchus milii*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Shark	Gulper sharks	*Centrophorus harrissoni, C. moluccensis, C. zeehaani*	Undefined	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Shark	Gummy shark, Southern Australia	*Mustelus antarcticus*	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Shark	Sawsharks, southern Australia	*Pristiophorus* species	Sustainable	FRDC 2018
Commonwealth: Southern and eastern scalefish and shark fishery	Shark	School shark, southern Australia	*Galeorhinus galeus*	Depleted	FRDC 2018

1. Stewardson, C., Andrews, J., Ashby, C., Haddon, M., Hartmann, K., Hone, P., Horvat, P., Klemke, J., Mayfield, S., Roelofs, A. Sainsbury, K., Saunders, T., Stewart, J., Nicol, S. and Wise, B. (eds) (2018) *Status of Australian fish stocks reports 2018*. Fisheries Research and Development Corporation (FRDC), Canberra.

2. Victorian Fisheries Authority (VFA) (2017) *Review of key Victorian fish stocks — 2017*. Victorian Fisheries Authority Science Report Series No. 1.

3. Patterson, H., Larcombe, J., Nicol, S. and Curtotti, R. (2018) *Fishery status reports 2018*. Australian Bureau of Agricultural and Resource Economics and Sciences for the Australian Fisheries Management Authority (AFMA), Canberra.

APPENDIX 9
Commonwealth-managed Fisheries

Commonwealth-managed fisheries that encompass or abut Victorian coastal waters are listed in the following table.

Fishery	Technique	Previous season (2016 or 2016-17)			Most recent season (2017 or 2017-18)		
		Permits/ statutory fishing rights (SFR[1])	Active vessels	Effort	Permits/ statutory fishing rights (SFR)	Active vessels	Effort
Fisheries that encompass Victorian coastal waters							
Southern and eastern scalefish and shark fishery	Otter trawl	57	34	52,303 trawl hours	57	32	57,747 trawl hours
	Danish-seine		16	10,038 shots		18	9,965 shots
	Scalefish hook	37	17	3.205 mil hooks	37	29	3.547 mil hooks
	Shark gillnet	61	36	31,827 km net hauled	61	38	34,493 km net hauled
	Shark hook	13	27	1.099 mil hooks	13	38	2.094 mil hooks
Southern bluefin tuna fishery	Purse-seine	89	6	906 search hours, 127 shots	85	6	852 search hours, 112 shots
	Pelagic longline		19	bycatch only		16	bycatch only
Fisheries that abut Victorian coastal waters							
Bass Strait central zone scallop fishery	Scallop dredge	62	12	6,894 dredge hours	63	12	5,274 dredge hours
Eastern tuna and billfish fishery[2]	Longline	86 SFR	37	7.82 mil hooks	85 SFR	39	8.73 mil hooks
	Mirror line	93 SFR	2	na	93 SFR	2	na
Skipjack tuna fishery[3]	Purse-seine	31	0	0	31	0	0
Small pelagic fishery	Purse seine	32	2	133 search hours	30	2	152 search hours
	Midwater trawl		1	184 shots		1	223 shots
Southern squid jig fishery	Squid jig	5,100 SFR	7	1,733 jig hours	4,900 SFR[4]	8	1,332 jig hours

[1] SFRs: Statutory fishing rights allow fishers to use a defined type and quantity of fishing gear.
[2] This fishery encompasses Victorian coastal waters, but fishing effort only occurs beyond 3 nautical miles from the Victorian coast.
[3] The last effort in this fishery occurred in 2008-2009 in South Australian waters. There is currently no domestic market for the species.
[4] In 2017, operators required 9.09 SFRs to be nominated to their boat for each standard squid jigging machine they use.

Appendix 10
Preliminary Classification of Marine Ecosystem Services and Potential Indicators

The following table is a preliminary classification of marine ecosystem services, their description and potential indicators that can be compared over time and space to denote change in the ecosystem (adapted from B€ohnke-Henrichs et al.[1] and Hattam et al.[2]).

Ecosystem service	Description	Potential indicator	Metric
Provisioning services			
1 Sea food:			
a) Wild capture sea food	All permissible marine fauna and flora extracted from marine environments for consumption by humans	Fish and shellfish populations, seaweed stock Quality of the fish, shellfish, seaweed stock	Biomass (tonnes/km^2) or abundance (no/km^2) Species composition, age profile; length profile; percentage affected by disease; mortality rates
b) Farmed sea food	Food from aquaculture for consumption by humans	Fish and shellfish populations, seaweed stock Quality of the fish, shellfish, seaweed stock	Biomass (tonnes/km^2) or abundance (no/km^2) Percentage affected by disease; mortality rates
2 Biotic raw materials (non-food):			
a) Genetic resources	Provision/extraction of genetic material from marine flora and fauna for use in non-medicinal contexts	Presence and diversity of species with potential/actual useful genetic material Quality of species with potential/actual useful genetic material	Presence/absence of desirable species; diversity of desirable species Endemism and uniqueness of species
b) Medicinal resources	Any material that is extracted from or used in the marine environment for its ability to provide medicinal benefits	Quantity of available raw material Quality of raw materials	Total quantity available in a fixed area (g/raw material) Concentration of raw material (g/l seawater, g/m^3 sediment)
c) Ornamental resources	Any material that is extracted for use in decoration, fashion, handicrafts, souvenirs, etc.	Quantity of raw material Quality of raw materials	Biomass available in a fixed area (t/km^2) Concentration (g/l seawater, t/km^2 sediment); purity
d) Other biotic raw materials	Extraction of all other renewable biotic resources - includes seaweed as fertilizer or mulch	Quantity of raw material Quality of raw materials	Biomass available in a fixed area (t/km^2) Concentration (g/l seawater, t/km^2 sediment); purity
3 Seawater	Marine water extracted for human, industrial or shipping use – includes seawater desalination, cooling water, land-based aquaculture and ballast water for shipping	Volume extracted	Annual and daily volume (ML)
Regulating services			
4 Air purification	Influence of a marine ecosystem on concentration of pollutants from the atmosphere	Air–sea flux of pollutants	Modelled or empirically determined pollutant air–sea flux rates and direction

Ecosystem service	Description	Potential indicator	Metric
5 Climate regulation	Contribution of a marine ecosystem to maintenance of a favourable climate through impacts on the hydrological cycle, temperature regulation, and contribution to climate-influencing substances in the atmosphere	Air–sea and sediment–water fluxes of carbon and CO_2	Modelled or empirically determined (mg $C/m^2/d$, mg $CO_2/m^2/d$)
		Levels of carbon in different components of the marine ecosystem	Modelled or empirically determined carbon levels: biomass of carbon (g/m^2); dissolved organic or inorganic carbon; suspended organic or inorganic carbon; buried particulate organic or inorganic carbon
		Permanence of carbon sequestration	Percentage of annual carbon turnover from sediments
6 Disturbance prevention or moderation	Contribution of marine ecosystem structures and functions to dampening the intensity of environmental disturbances such as storm floods, tsunamis, and cyclones	Capacity of water storage of habitat	Water storage capacity (m^3/area) for different intertidal habitats (e.g., sediment, saltmarsh, mangrove)
		Reduction of wave energy by near shore and intertidal habitats	Change in wave energy (J/m^2) attributed to different intertidal and near shore habitats
		Changing shoreline	Change in beach profile (slope (gradient) and width (m) and stability)
7 Regulation of water flows	Contribution of marine ecosystems to the maintenance of localised coastal current structures	Salinity/freshwater input	Change in salinity, tidal and freshwater flow rates (m^3/s)
		Changing shoreline	Change in beach profile (slope (gradient) and width (m) and stability)
		Rates of tidal and wind driven currents	Direct measures of flow and currents (m^3/s) and turbidity (mg/m^3 or NTU)
		Seabed morphology	Changes in seabed morphology using side-scan sonar
8 Waste treatment and assimilation	Removal of contaminant and organic nutrient inputs to marine environments from humans	Absolute levels of waste in the water column	Contaminant concentrations and visual analysis
		Presence of pathogens	Enterococci orgs/100 mL
		Benthic biodiversity levels/ratios/no. of sensitive species	Different biodiversity indices
		Toxicity levels within species	Contaminant concentrations and toxicity
		Shellfish area closures	Number of closures
		Harmful algal bloom outbreaks	Remote sensing, water sampling to detect frequency and extent; modelling to determine future frequency and extent

Ecosystem service	Description	Potential indicator	Metric
9 Coastal erosion prevention	Contribution of marine ecosystems to coastal erosion prevention	Beach profile (slope and width); extent of maintenance and improvement required to provide protection Presence and elevation of biogenic habitat e.g., saltmarsh beds; seagrass beds; bivalve and polychaete reefs	Change in beach profile (slope (gradient) and width (m) and stability) Volume (m^3), or area covered (m^2), density (biomass or abundance /m^2) and elevation (height above mean seawater level)
10 Biological control	Contribution of marine ecosystems to the maintenance of population dynamics, resilience through food web dynamics, disease and pest control	Presence/absence/ frequency of pests (e.g., algae blooms, sea jelly)	Biomass or abundance
Cultural services			
11 Leisure, recreation and tourism	Provision of opportunities for tourism, recreation and leisure that depend on a particular state of marine ecosystems	Marine waters available for recreational activities Beaches available and safe to use Water quality Abundance and diversity of key species of recreational interest Area of biotopes of key interest to recreational users	Area (km^2) of sea of suitable water quality and accessible for recreational activities Number of patrolled beaches Contaminant concentrations, visual analysis, toxicity, enterococci orgs/100 mL Count data For example, extent of seagrass or kelp beds (km^2)
12 Aesthetic experience	Contribution that a marine ecosystem makes to the existence of a surface or subsurface landscape that generates a noticeable emotional response within the individual observer. This includes informal spiritual individual experiences but excludes that covered by service 16	Uniqueness of a site – national, state or regional significance Abundance of key species of individual interest Area of biotopes of key interest to individuals	Number of sites with similar features Count data For example, extent of seagrass or kelp beds (km^2)
13 Inspiration for culture, art and design	Contribution that a marine ecosystem makes to the existence of environmental features that inspire elements of culture, art, and/or design. This excludes that covered by services 2c, 12, and 15	Species, habitat or ecosystems that have or can potentially inspire any piece of artwork	Number of such species, habitats, ecosystems
14 Cultural heritage	Contribution of marine ecosystems to the maintenance of cultural heritage, and providing a `sense of place'	Species, habitat or ecosystems that have or can potentially form the core of contribute to a cultural custom, rite or way of life	Number of such species, habitats, ecosystems

Ecosystem service	Description	Potential indicator	Metric
15 Cultural diversity	Contribution of marine ecosystems to social and cultural values and adaptations that pertain to living at coasts and exploiting marine resources	Species, habitat or ecosystems that have or can potentially form the core of contribute to cultural diversity	Number of such species, habitats, ecosystems
16 Spiritual experience	Contribution that a marine ecosystem makes to formal and informal collective religious experiences. This excludes that covered by services 12 and 13	Species, habitats or ecosystems that is being or can potentially be worshipped or be of significance to a religious belief	Number of such species, habitats, ecosystems
17 Information for cognitive development	Contribution that a marine ecosystem makes to education, research, and individual and collective cognitive development	Species, habitats or ecosystems that are being or can potentially be studied to increase scientific knowledge	Number of such species, habitats, ecosystems
		Species, habitats or ecosystems that are being or can potentially be studied for educational purposes	Number of such species, habitats, ecosystems
Supporting services			
18 Migratory and nursery habitat	Contribution of a particular marine habitat to migratory and resident species' populations through the provision of critical habitat for feeding, or reproduction and juvenile maturation	Area of habitat or density of biogenic habitat creating species "used" or identified as important for nursery or reproduction	For example, extent of seagrass or kelp beds (km^2)
		Number and diversity of species using the area for nursery or reproduction	Abundance and species diversity
		Dependence of off-site (commercial) populations	Proximity to dependant populations or their migration routes; size (abundance) and health (viability) of off-site populations
19 Gene pool protection	Contribution of marine habitats to the maintenance of viable gene pools through natural selection/ evolutionary processes that enhances adaptability of species to environmental changes, and resilience of the ecosystem	Genetic diversity	Diversity of species and subspecies, phylogenetic distance, Biodiversity Intactness Index (BII)

1. B€ohnke-Henrichs, A., Baulcomb, C., Koss, R., Hussain, S.S. and de Groot, R. (2013) Typology and indicators of ecosystem services for marine spatial planning and management. *Environmental Management* 130: 135–145.
2. Hattam, C., Atkins, J.P., Beaumont, N., Borger, T., B€ohnke-Henrichs, A., Burdon, D., De Groot, R., Hoefnagel, E., Nunes, P., Piwowarczyk, J., Sergio, S., Austen, M. (2015) Marine ecosystem services: linking indicators to their classification. *Ecological Indicators* 49: 61-75.

VEAC
Victorian Environmental Assessment Council

WWW.VEAC.VIC.GOV.AU