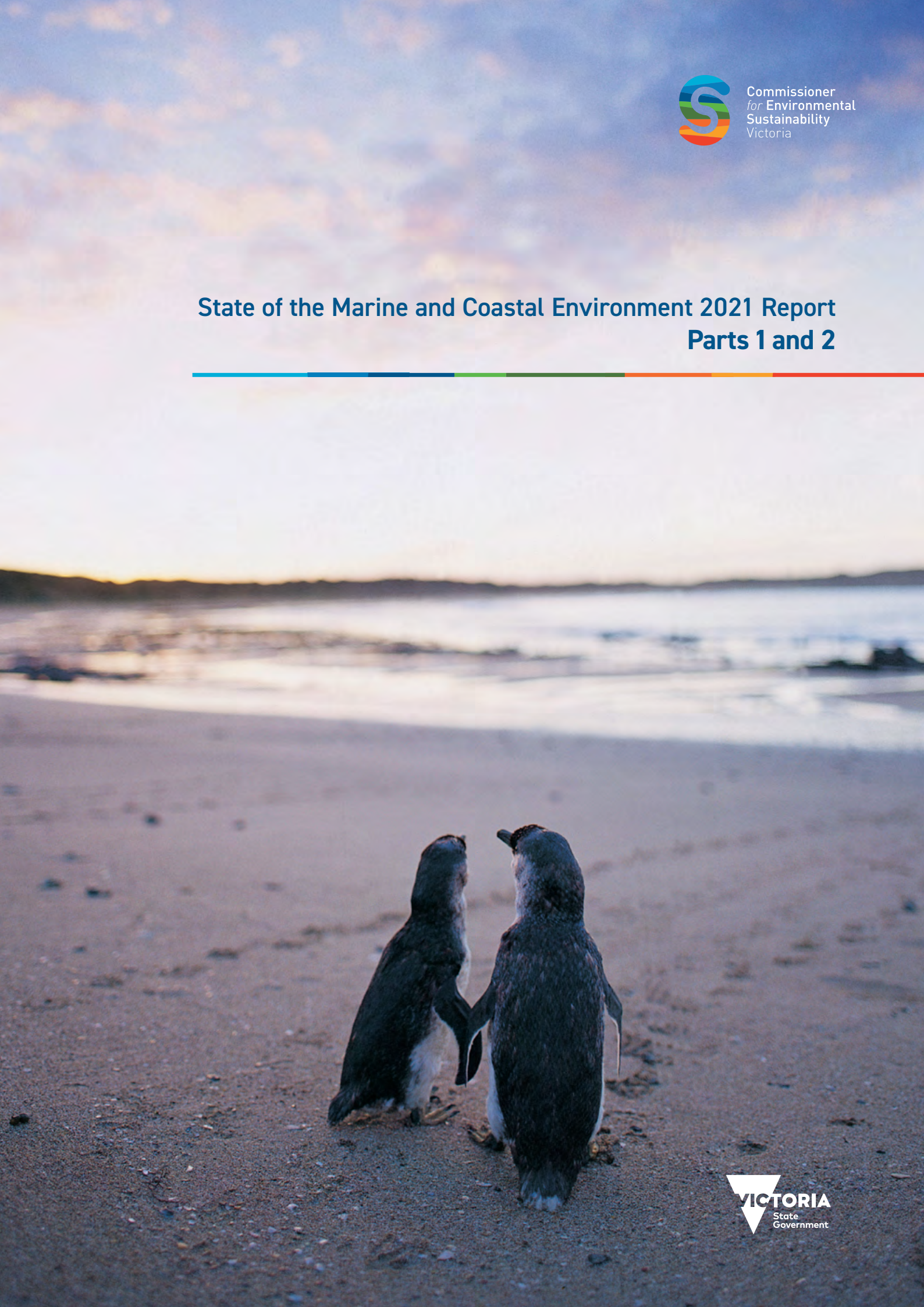
Commissioner *for* Environmental Sustainability Victoria

State of the Marine and Coastal Environment 2021 Report
Parts 1 and 2



VICTORIA State Government

Wedge-tailed eagle (*Aquila audax*)
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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Commissioner *for* Environmental Sustainability Victoria

Traditional Owners

The Commissioner for Environmental Sustainability proudly acknowledges Victoria's Aboriginal community and their rich culture and pays respect to their Elders past and present. We acknowledge Aboriginal people as Australia's First Peoples and as the Traditional Owners and custodians of the land and water on which we rely. We recognise and value the ongoing contribution of Aboriginal people and communities to Victorian life, and how this enriches us. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.

Little penguins (*Eudyptula minor*) on Phillip Island
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Commissioner's Foreword

Welcome to Victoria's first State of the Marine and Coastal Environment (SMCE) Report, an historic baseline study of the health of five important Victorian marine and coastal environments: Port Phillip Bay, Western Port, Corner Inlet and Nooramunga, the Gippsland Lakes, and Victoria's system of marine national parks and sanctuaries. This report assesses the overall health of these five regions, based on existing marine and coastal science. It builds on our State of the Bays 2016 Report, is a timely stocktake of current knowledge, and coincides with a period of great legislative and policy reform for marine and coastal management in Victoria – reform that recognises the environmental, social and economic values of Victoria's marine and coastal environments, and their importance to our health, happiness and prosperity.

This report is prepared according to the *Marine and Coastal Act 2018* (Vic), which requires the Commissioner for Environmental Sustainability (CES) to issue a five-yearly State of the Marine and Coastal Environment Report on:

- the condition of the marine and coastal environment
- the environmental, social and economic benefits of the marine and coastal environment
- threats to the marine and coastal environment.

The first full SMCE Report is not due until five years after the release of the Marine and Coastal Policy 2020. However, because five years have passed since the State of the Bays 2016 Report, it is timely to provide an independent update on the health of Victoria's marine and coastal environments for those regions where adequate science is currently available.

This SMCE Report expands on the two regions reported on in the State of the Bays 2016 Report (Port Phillip Bay and Western Port), to assess five regions. It compiles science and other information from many sources: Commonwealth and Victorian government agencies, local governments, catchment management authorities, universities, citizen scientists and non-government organisations.

Working closely with the Victorian Department of Environment, Land, Water and Planning (DELWP) and associated agencies, and expanding our science program to include non-government organisations, we have attempted in this inaugural SMCE Report to use a method that can be applied to the first full SMCE Report in 2024, which will assess Victoria's entire marine and coastal environment.

The Victorian Auditor General's audit Protecting Victoria's Biodiversity was tabled in Parliament after this report was finalised, however the findings of the audit, specifically concerns related to the availability of science and data, are consistent with those presented here.

This SMCE Report presents 215 assessments of 82 indicators of ecosystem health and social science. It includes some challenging findings and aims to highlight areas where our interventions and practical actions are improving environmental outcomes. For example, and consistent with the findings of the recently released Sixth Assessment Report of the United Nations Intergovernmental Panel on Climate Change,[1] none of the climate change impacts indicators in this report was assessed as good, with deteriorating trends observed for 21 of the 22 regional climate change indicators.

Nevertheless, this report does highlight some areas where our interventions and practical actions are improving the environment. For instance, we report promising statistics on the involvement of community members in coastal and marine volunteering, Coastcare, and citizen science activities. The Coastcare program supports hundreds of community groups and volunteers working to protect and improve Victoria's coastline. In 2019-20 a total of 13,444 people participated in Coastcare activities – a 28% increase on the previous financial year – and citizen scientists remained actively involved in marine and coastal programs.

1. Intergovernmental Panel on Climate Change (IPCC) 2021, 'Climate Change 2021: the physical science basis, contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, report prepared by V Masson-Delmotte, P Zhai, A Pirani, SL Connors, C Péan, S Berger, N Caud, Y Chen, L Goldfarb, MI Gomis, M Huang, K Leitzell, E Lonnoy, JBR Matthews, TK Maycock, T Waterfield, O Yelekçi, R Yu, and B Zhou (eds.), Cambridge University Press https://www.ipcc.ch/report/ar6/wg1/ Accessed 5 October 2021.

Even during the COVID-19 lockdowns, virtual projects enabled seal counts, for example (via webcam), and other activities to continue.

The report assesses 82 indicators covering nine themes of ecosystem health and social science:

- water quality and catchment inputs
- litter and pollution
- biodiversity
- seafloor integrity and health
- pests and invasive species
- climate and climate change impacts
- managing coastal hazard risks
- communities
- stewardship and collaborative management.

The report is in three parts. This Summary Report, which comprises Parts 1 and 2, provides a comprehensive overview of the science and strategic analysis of the complete report. Part 3 provides the comprehensive, peer-reviewed scientific assessments of specific issues and regions that form the evidence base for the indicator report card, summaries and main findings distilled in Part 1.

Part 1 includes the legislative and policy context for marine and coastal reporting, and summaries of all assessments by theme, region and indicator – including an indicator report card and a summary of the main findings. It also identifies gaps in knowledge and recommends future priorities. Importantly, it includes a section on cultural landscape health and management, and the critical role of Traditional Owners in managing and protecting sea Country and coastal environments.

Part 2 reviews the application of spatial information and international frameworks and proposes a method for applying the United Nations Sustainable Development Goals (SDGs) for future reporting on the state of the environment. A subset of 40 SDG targets were aligned with the 82 indicators in this report. Also included is a qualitative assessment of progress against six of these SDG targets, along with important work undertaken in collaboration with coastal managers and practitioners to identify local priorities for reporting.

The five future priorities proposed for marine and coastal management and reporting are:

1. Use spatial information and Earth observation to identify and protect Victoria's marine assets.
2. Update Victoria's Marine and Coastal Knowledge Framework to reflect the scientific assessments of this report.[2]
3. Develop thresholds to improve future reporting.
4. Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.
5. Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between the environment, community and economy of Victoria.

We need to apply a 'catchment-to-reefs' philosophy in Victoria. Many of the pressures on our coasts, bays, estuaries, lakes and ocean are caused by activities on land, so management and regulatory actions that link activities in our catchments to benefits for Victoria's marine and coastal environment are critical. So too is the need for strong action to mitigate, adapt and protect our marine and coastal environments and communities against the effects of climate change.

The challenge for all Victorians is to take full advantage of the potential of the recent reform of marine and coastal legislation and policy, and to continually strive for a whole-of-system approach to guide action. This will require the tools presented by the reform to be coherent and coordinated. They must be applied holistically: integrated water quality and pest management, adaptation to climate change, and conservation and protection priorities. This undertaking is twofold. It requires that commitments be kept, and that the policies established under this new legislative and policy framework lead to continuing improvement and protection of our marine and coastal environments.

2. Following the State of the Bays 2016 Report, Victoria put in place a Marine and Coastal Knowledge Framework to support planning for Victoria's marine and coastal areas. The framework is available at: https://www.marineandcoasts.vic.gov.au/coastal-programs/marine-and-coastal-knowledge-framework

Spatial information and Earth observation offer new paths to environmental understanding. These capabilities are growing in range and importance as enablers of better decision-making and more targeted environmental management. This report provides a comprehensive assessment of the contributions that spatial information can make to marine and coastal management and reporting – now and in the future.

It is an honour to be Victoria's Commissioner for Environmental Sustainability, and a privilege to have led the scientific and consultative endeavour that has resulted in this inaugural SMCE Report – a report that has been made possible only by a collaboration of many talented people. My team and I acknowledge and thank all of those who have generously contributed their time and effort to help prepare and review this report.

Also, we thank the dedicated members of the Commissioner's Reference Group, and colleagues from across DELWP and other agencies, without whom we cannot do our work. Finally, my sincere thanks to my team for their tireless efforts in preparing this report.

I am pleased to present the State of the Marine and Coastal Environment 2021 Report.

The report is also available in an interactive, simplified form and as visual web pages (www.ces.vic.gov.au/smce-2021), to encourage Victorians to care more, and know more, about our precious marine and coastal environment.

Dr Gillian Sparkes AM
Commissioner for Environmental Sustainability, Victoria

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Commissioner's Reference Group	
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Non-government Stakeholder Technical Advisory Group	
BirdLife Australia	Landcare Victoria Inc.
Conservation Volunteers Australia	Marine Mammal Foundation
Deakin University	Royal Society of Victoria
Dolphin Research Institute	University of Melbourne
Port Phillip EcoCentre	Victorian Farmers Federation
Environment Victoria	Victorian National Parks Association
Field Naturalists Club of Victoria	Werribee River Association
Greening Australia	Yarra Riverkeeper Association

Technical Advisory Group	
Better Boating Victoria (Department of Transport)	Local Jobs First
Bureau of Meteorology	Municipal Association of Victoria
City of Port Phillip	Melbourne Water
Conservation Volunteers Australia	Parks Victoria
Corangamite Catchment Management Authority	Phillip Island Nature Parks
Commonwealth Scientific and Industrial Research Organisation	Port Phillip and Westernport Catchment Management Authority
Deakin University (Blue Carbon Lab)	Ports Victoria
Department of Environment, Land, Water and Planning	Royal Botanic Gardens Victoria
Victorian Department of Health	Sustainability Victoria
Department of Jobs, Precincts and Regions	The Nature Conservancy
Department of Transport	Trust for Nature
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Environment Protection Authority Victoria	University of Wollongong
Fishcare Victoria	Victorian Environmental Assessment Council
Fishwell Consulting	Victorian Fisheries Authority
Glenelg Hopkins Catchment Management Authority	Victorian Marine and Coastal Council
Great Ocean Road Coast Committee	West Gippsland Catchment Management Authority
La Trobe University	Zoos Victoria

Abbreviations

ABS ..... Australian Bureau of Statistics
ARI ..... Arthur Rylah Institute for Environmental Research
AURIN ..... Australian Urban Research Infrastructure Network
BoM ..... Bureau of Meteorology
CES ..... Commissioner for Environmental Sustainability Victoria
CIN ..... Corner Inlet–Nooramunga
CMAs ..... Catchment Management Authorities
CPUE ..... catch per unit effort
CSIRO ..... Commonwealth Scientific and Industrial Research Organisation
DE ..... denitrification efficiency
DEA ..... Digital Earth Australia
DELWP ..... Victorian Department of Environment, Land, Water and Planning
EEA ..... environmental–economic accounting
EMP ..... Environmental Management Plan
EO ..... Earth observation
EPA ..... Environment Protection Authority Victoria
ERS ..... Environment Reference Standard
ESD ..... ecologically sustainable development
GDP ..... Gross Domestic Product
GIS ..... geographical information system
GL ..... Gippsland Lakes
GNSS ..... global navigation satellite system
GPS ..... global positioning system
IEC ..... Index of Estuary Condition
IMOS ..... Integrated Marine Observing System
IMU ..... inertial measurement unit
IoA ..... Internet of Animals
IoT ..... Internet of Things
IPA ..... Indigenous Peoples' Protected Area
LAC ..... limit of acceptable change
LiDAR ..... light detecting and ranging
MKF ..... Marine Knowledge Framework
ML ..... machine learning
MPA ..... marine protected area
NOAA ..... National Oceanic and Atmospheric Administration (USA)

NRM ..... National Resource Management

OMPA ..... other marine protected areas

PFAS ..... per and polyfluoroalkyl substances

PPB ..... Port Phillip Bay

RAP ..... Registered Aboriginal Party

RCS ..... Regional Catchment Strategies

RPV ..... remotely piloted vehicle

SAR ..... synthetic aperture radar

SDGs ..... United Nations Sustainable Development Goals

SEEA ..... United Nations System of Environmental–Economic Accounting

SMCE ..... State of the Marine and Coastal Environment

SoE ..... State of the Environment

SotB ..... State of the Bays

TOLMA ..... Traditional Owner Land Management Agreement

TOS ..... Traditional Owner Settlement Agreements

UN ..... United Nations

UNESCO ..... United Nations Educational, Scientific and Cultural Organisation

VEAC ..... Victorian Environmental Assessment Council

VFA ..... Victorian Fisheries Authority

VNPA ..... Victorian National Parks Association

WP ..... Western Port

WQIP ..... Water Quality Improvement Plan

Contents

Tables and figures

Tables

Figures

Commissioner *for* Environmental Sustainability Victoria

Part 1A
Key findings and future priorities

Report structure

Part 1A provides a summary of findings from the State of Marine and Coastal Environment 2021 Report and includes the legislative and policy context for marine and coastal reporting, summaries of assessments by theme, region and indicator and the report card (Table 1), summary pie charts and key findings. Part 1A concludes by proposing five future priorities, which are based on the evidence presented in the Scientific assessments (Part 3).

Part 1B includes information on the critical role of Traditional Owners in cultural landscape health and management, and more detailed information on the legislative and policy context for marine and coastal management. Part 1B concludes with indicator summaries for all 82 indicators assessed in Part 3, presenting metrics for each indicator, a comment arising from the assessment, summary of status, trend and confidence, the region to which the indicator applies, and identification of the data custodian.

Part 2 contains an environmental scan of current, emerging and future spatial information technologies and data coordination for state of environment reporting, the description of a proposed method for adopting the SDGs for environmental reporting in Victoria (including a process for identifying local priorities and an SDG synthesis and evaluation of specific targets) and an overview of environmental–economic accounts being developed by DELWP.

Appendix B in Part 2, at the end of this summary document, provides a useful analysis aligning 40 SDG targets (those assessed as relevant to marine and coastal reporting in Victoria) with the indicators in this report.

Part 3 contains the scientific assessments for each of the 82 indicators, presented across nine themes:

- Theme 1: water quality and catchment inputs
- Theme 2: litter and pollution
- Theme 3: biodiversity
- Theme 4: seafloor integrity and health
- Theme 5: pests and invasive species
- Theme 6: climate and climate change impacts
- Theme 7: managing coastal hazard risks
- Theme 8: communities
- Theme 9: stewardship and collaborative management.

Each theme commences with an overview and analysis of the key findings. The scientific assessments rely on publicly available scientific data, including reports, journal articles, submissions to parliamentary and government inquiries, citizen science projects, and interviews with experts in relevant fields. The data are subsequently assessed and synthesised by the science team supporting the CES.

The assessments have been conducted on a statewide and/or regional scale, based on the localisation of the impacts associated with each indicator and the spatial scale of the available evidence.

The scientific evidence and findings on Theme 8: Communities, and Theme 9: Stewardship and collaborative management, are presented on a statewide scale, unlike the regional structure of the biophysical science themes (Themes 1–7). However, where the data enable regional analysis, that disaggregation is provided.

Each indicator's scientific assessment includes:

- metrics used to measure the status and trend
- data confidence
- data custodian (the source of the data)
- region covered by the indicator (statewide or a particular region)
- reason for assessing the indicator
- indicator's performance
- thresholds for determining the status of each indicator (where available)
- a summary of the 2021 assessment
- an updated assessment and commentary where new data has become available since 2018.

The Science for Sustainable Development Framework approach to reporting embraces three levels of synthesis:

1. environmental condition reporting
2. assessing interlinkages across the SDG targets
3. tracking progress on selected SDG targets.

Part 2 delivers the second and third levels of synthesis and should aid further interpretation of the scientific assessments in Part 3. It proposes a Method, informed by the approach outlined in the Science for Sustainable Development Framework. This Method aims to provoke discussion with our partners and co-creators that will be tested throughout 2022 on a pathway to applying the SDGs as an operating framework for the Victorian State of the Environment 2023 Report.

Part 3 of this report delivers the evidence base and scientific assessments for the first level of synthesis.

The findings from the analyses in both Parts 2 and 3 contribute to the development of the five future priorities presented in Part 1 of this SMCE 2021 Report.

Dragonet (*Bovichtus angustifrons*), San Remo Channel, Western Port
© Julian Finn, Museums Victoria

Marine and coastal reporting

This State of the Marine and Coastal Environment 2021 Report is the first in Victoria's series of state of environment reports in the 2020–24 reporting cycle, and is a transitional report, updating the State of the Bays 2016 Report and widening the scope in preparation for the first full State of the Marine and Coastal Environment Report, due in 2024.

Figure 1 provides context for the reader, demonstrating how the Victorian Government's marine and coastal legislative and policy reform – particularly the objectives and guiding principles of the Marine and Coastal Policy – inform a broader adaptive cycle for marine and coastal management.

The emphasis here is on the crucial role of environmental reporting – not only in providing evidence and strengthening the frameworks for marine and coastal knowledge and marine spatial planning, but also in providing essential information for future iterations of the Marine and Coastal Policy and the Marine and Coastal Strategy.

In turn, the policy and strategy will guide the prioritisation and science focus of future SMCE Reports, identifying emerging policy and strategy interventions that require more robust evidence.

A more detailed description of the Marine and Coastal Policy and Marine and Coastal Strategy is provided in 'Public policy context – Victorian'.

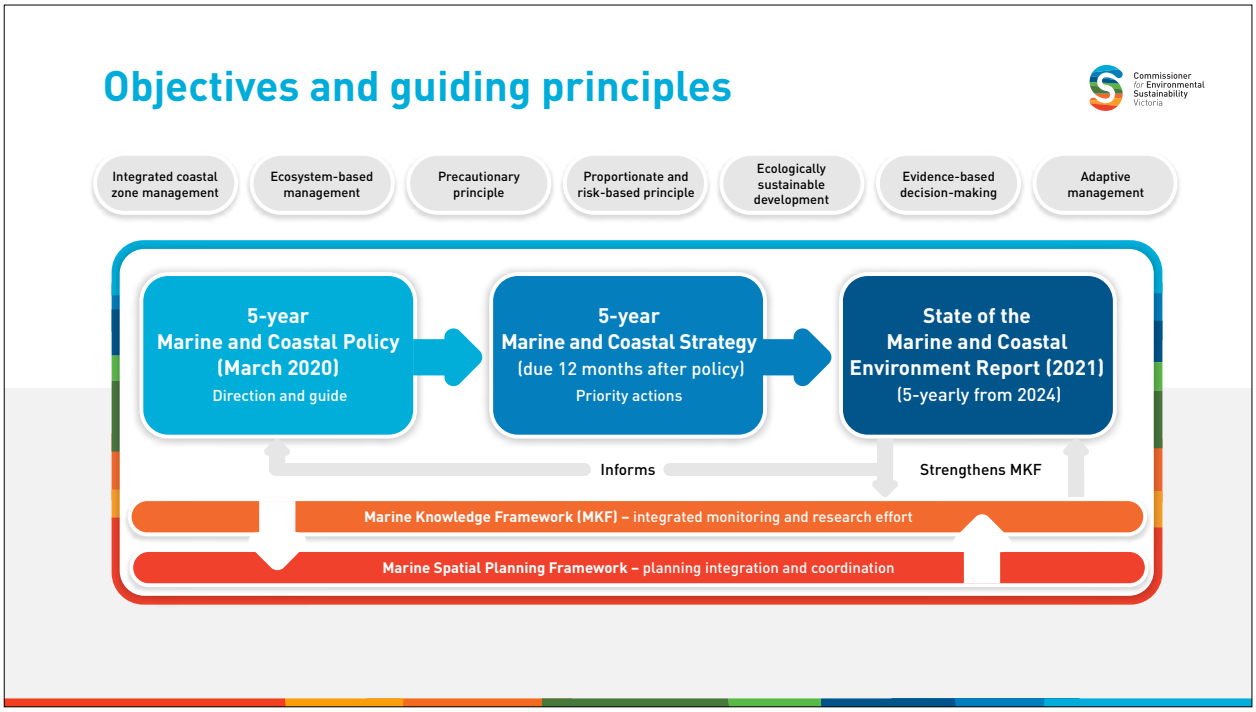


Figure 1: Marine and Coastal Act 2018 (Vic).

Figure 2 maps the Marine and Coastal Policy decision pathway against the structure of this report. This shows how the evidence is presented to support the policy priorities and to inform decision-makers of the science needed to make informed decisions at each point in the pathway. The themes, and accompanying indicators, of Part 3: Scientific assessments, are identified to the right of the complementary policy priorities.

This report has expanded the geographical scope of the State of the Bays 2016 Report, to include scientific assessments of Port Phillip Bay, Western Port, Gippsland Lakes, Corner Inlet and Nooramunga, Victoria's system of marine national parks and sanctuaries, and statewide analysis (where possible). The analysis of what constitutes 'marine and coastal' conforms with the definition in the Marine and Coastal Act 2018.

The marine and coastal environment includes all private and public land and waters between the outer limit of Victorian coastal water and 5km inland of the high-water mark of the sea, including:

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 sentence (a) above from time to time

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

The definition includes bays, inlets and estuaries, and the Gippsland Lakes.

This executive summary provides an overview of findings from Part 3: Scientific assessments. Each theme in Part 3 is introduced with a summary section as well. For a more detailed analysis of the issues presented below, see Part 3.

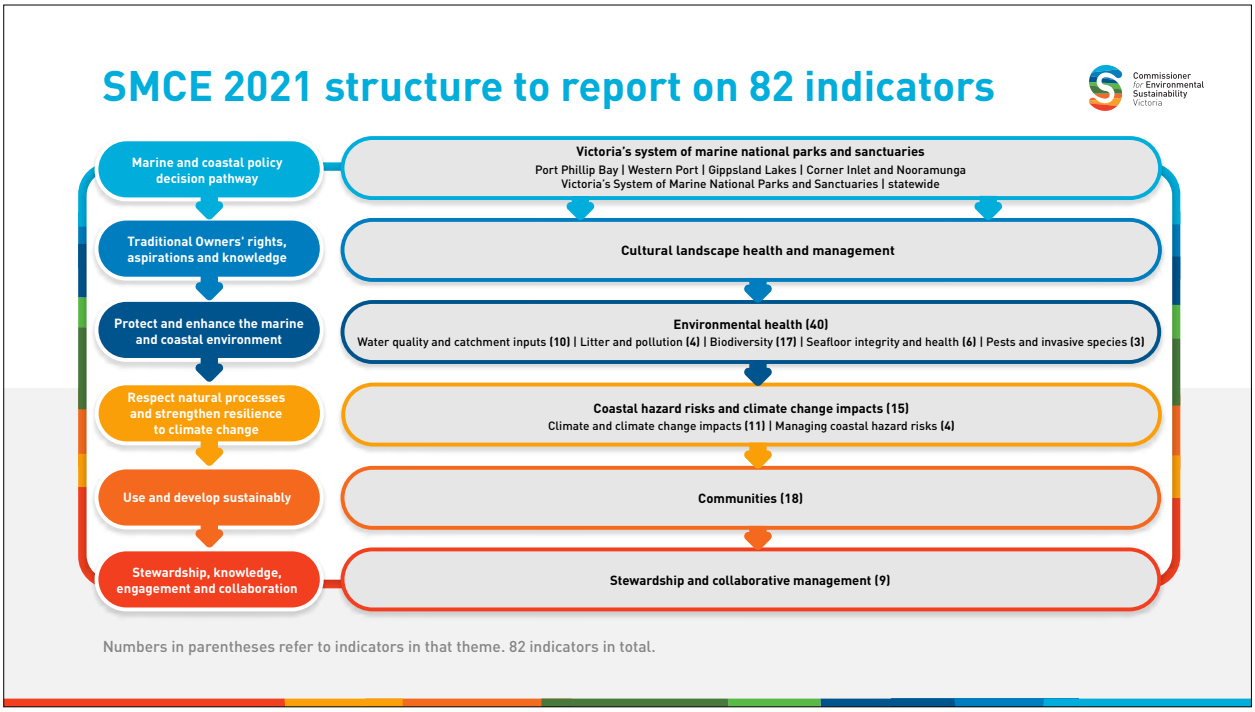


Figure 2: SMCE 2021 structure to report on indicators.

Summaries

Table 1 (on the next page) provides a summary of the Status, Trend and Data in the 82 indicator assessments for 2021. The colour keys for the assessments are as follows:

Key to status

Good

Fair

Poor

Unknown

Narrative but not assessed

Not assessed and no narrative

Key to trend

Improving

Stable

Deteriorating

Unclear

Key to data

High

Moderate

Low

Unknown

Not Applicable

Theme 1 indicator summaries: Water quality and catchment inputs

Indicator 01: Water quality (physicochemical)

Region		2021 status	2021 trend	2021 data
Port Phillip Bay				
Western Port				
Corner Inlet-Nooramunga				
Gippsland Lakes	Lake King			
	Lake Victoria			
	Lake Wellington			
Data source:		Environment Protection Authority Victoria (EPA), Melbourne Water, DELWP		

Indicator 02: Toxicants

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			Moderate (status), Low (trend)
Corner Inlet-Nooramunga			
Gippsland Lakes			Moderate (status), Low (trend)
Data source:	EPA, Melbourne Water, academic researchers		

Indicator 03: Water quality (estuaries)

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			High (status), Low (trend)
Western Port			High (status), Low (trend)
Corner Inlet-Nooramunga			High (status), Low (trend)
Gippsland Lakes			High (status), Low (trend)
Statewide			High (status), Low (trend)
Data source:	DELWP		

Table 1: SMCE 2021 report card.

Indicator 04: Plankton

Region		2021 status	2021 trend	2021 data
Port Phillip Bay				
Western Port				
Corner Inlet-Nooramunga				
Gippsland Lakes	Lake King			
	Lake Victoria			
	Lake Wellington			
Statewide				
Data source:		EPA, Integrated Marine Observing System (IMOS)		

Indicator 05: *Enterococci* bacteria

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Data source:	EPA		

Indicator 06: Regulated point source discharges to marine waters

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Corner Inlet-Nooramunga			
Data source:	EPA		

Indicator 07: Stormwater

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			Moderate (status), Low (trend)
Western Port			Moderate (status), Low (trend)
Corner Inlet-Nooramunga			
Gippsland Lakes			
Data source:	Melbourne Water		

Indicator 08: Total nutrient loads

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			Low (status), Moderate (trend)
Corner Inlet-Nooramunga			Moderate (status), Low (trend)
Gippsland Lakes			
Data source:	Melbourne Water, academic researchers		

Indicator 09: Total sediment loads

Region		2021 status	2021 trend	2021 data
Port Phillip Bay				
Western Port				
Corner Inlet-Nooramunga				
Gippsland Lakes	Lake King			
	Lake Victoria			
	Lake Wellington			
Data source:		Melbourne Water, academic researchers		

Indicator 10: Coastal acid sulfate soils

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Data source:	Department of Jobs, Precincts and Regions		

Theme 2 indicator summaries: Litter and pollution

Indicator 11: Litter and plastics

Region	2021 status	2021 trend	2021 data
Port Phillip Bay		↙	
Western Port		?	
Corner Inlet-Nooramunga		?	
Gippsland Lakes		?	
Data source:	Port Phillip EcoCentre, Tangaroa Blue Foundation, academic researchers		

Indicator 12: Light pollution

Region	2021 status	2021 trend	2021 data
Port Phillip Bay		?	
Western Port		?	
Corner Inlet-Nooramunga		?	
Gippsland Lakes		?	
Data source:	https://www.lightpollutionmap.info/, academic researchers		

Indicator 13: Coastal contaminated land

Region	2021 status	2021 trend	2021 data
Port Phillip Bay		?	
Western Port		?	
Corner Inlet-Nooramunga		?	
Gippsland Lakes		?	
Data source:	EPA		

Indicator 14: Coastal air quality

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	 (ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide)  (fine particle pollution)		 (near shipping terminals)  (elsewhere)
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes	 (fine particle pollution during bushfire periods)  (all other times)		 (during bushfires)  (all other times)
Data source:	EPA, academic researchers		

Theme 3 indicator summaries: Biodiversity

Indicator 15: Conservation of coastal ecosystems in protected areas

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Parks Victoria		

Indicator 16: Saltmarsh

Region		2021 trend	2021 data	2021 data
Port Phillip Bay				
Western Port				
Corner Inlet-Nooramunga	**Corner Inlet**			
	Nooramunga			
	Nooramunga islands			
Gippsland Lakes				
Data source:	Academic researchers, DELWP			

Indicator 17: Mangroves

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Data source:	Academic researchers, DELWP		

Indicator 18: Wetland and estuarine vegetation

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes	 (estuarine flora)  (wetland habitat extent)  (condition of paperbark-dominated wetlands)		 (estuarine flora)  (wetland habitat extent, condition of paperbark-dominated wetlands)
Statewide			
Data source:	Academic researchers, DELWP		

Indicator 19: Species of conservation concern

Region	2021 trend	2021 data	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Statewide			
Data source:	Victorian Biodiversity Atlas		

Indicator 20: Mobile invertebrates on intertidal reefs

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Other marine protected areas			
Data source:	Parks Victoria		

Indicator 21: Sessile invertebrates on intertidal reefs

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Other marine protected areas			
Data source:	Parks Victoria		

Indicator 22: Invertebrates on subtidal reefs

Region	2021 status	2021 trend	2021 data
Port Phillip Bay		 (north)  (south)	
Other marine protected areas			
Data source:	Parks Victoria, Reel Life Surveys		

Indicator 23: Commercially and recreationally important invertebrates

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	 (commercial scallop, short-spined sea urchin)	 (commercial scallop, short-spined sea urchin)	 (commercial scallop, short-spined sea urchin)
Statewide	 (southern calamari, Maori octopus)  (southern rock lobster)  (blacklip abalone)  (pipi, greenlip abalone)	 (southern calamari, Maori octopus, southern rock lobster)  (blacklip abalone)  (pipi, greenlip abalone)	 (southern calamari, southern rock lobster)  (Maori octopus, blacklip abalone)  (pipi, greenlip abalone)
Data source:	VFA		

Indicator 24: Commercially and recreationally important fish

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	 (snapper, King George whiting)  (southern sand flathead)	 (King George whiting)  (snapper, southern sand flathead)	 (snapper, King George whiting)  (southern sand flathead)
Western Port	 (snapper, King George whiting)	 (King George whiting)  (snapper)	 (snapper)  (King George whiting)
Corner Inlet-Nooramunga	 (King George whiting, rock flathead)	 (King George whiting)  (rock flathead)	 (King George whiting, rock flathead)
Gippsland Lakes	 (black bream, dusky flathead)	 (dusky flathead)  (black bream)	 (black bream, dusky flathead)
Statewide	 (bluethroat, purple wrasse)	 (bluethroat, purple wrasse)	 (bluethroat, purple wrasse)
Data source:	VFA, academic researchers		

Indicator 25: Subtidal reef fish

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	 (north)  (south)	 (north)  (south)	
Other marine protected areas			
Data source:	Parks Victoria, Reef Life Surveys, ReefWatch		

Indicator 26: Diadromous fish

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	N	N	N
Western Port	N	N	N
Gippsland Lakes	N	N	N
Statewide	●	?	●
Data source:	Academic researchers, DELWP, Melbourne Water		

Indicator 27: Marine and coastal waterbirds

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	●	→	●
Western Port	●	↙	●
Corner Inlet-Nooramunga	●	→	●
Gippsland Lakes	●	?	●
Data source:	BirdLife Australia, academic researchers, DELWP, Melbourne Water		

Indicator 28: Migratory shorebirds

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	●	↙	●
Western Port	●	↙	●
Corner Inlet-Nooramunga	●	↙	●
Gippsland Lakes	●	?	●
Data source:	BirdLife Australia, academic researchers, DELWP, Melbourne Water		

Indicator 29: Piscivorous (fish-eating) birds

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Data source:	BirdLife Australia, academic researchers, DELWP, Melbourne Water		

Indicator 30: Little penguins

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Data source:	Earthcare St Kilda, Phillip Island Nature Parks		

Indicator 31: Marine mammals

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	 (dolphins)	 (dolphins)	 (dolphins)
Western Port	 (dolphins and seals)	 (dolphins)  (seals)	 (seals)  (dolphins)
Gippsland Lakes	 (dolphins)	 (dolphins)	 (dolphins)
Data source:	Dolphin Research Institute, Marine Mammal Foundation, Phillip Island Nature Parks, academic researchers		

Theme 4 indicator summaries: Seafloor integrity and health

Indicator 32: Conservation of marine ecosystems in protected areas

Region	2021 status	2021 trend	2021 data
Other marine protected areas			
Data source:	Parks Victoria		

Indicator 33: Nitrogen cycle

Region		2021 trend	2021 data	2021 data
Port Phillip Bay				
Western Port				
Gippsland Lakes	Lake King			
	Lake Victoria			
	Lake Wellington			
Data source:	DELWP, Melbourne Water, academic researchers.			

Indicator 34: Seagrass

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Other marine protected areas			
Data source:	Academic researchers, Melbourne Water		

Indicator 35: Shellfish reefs

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Data source:	Academic researchers		

Indicator 36: Macroalgae on intertidal reefs

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Other marine protected areas			
Data source:	Parks Victoria		

Indicator 37: Macroalgae-dominated subtidal reefs

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	 (Port Phillip Heads Marine National Park)  (Ricketts Point Marine Sanctuary)  (Point Cooke and Jawbone marine sanctuaries)		
Other marine protected areas			
Data source:	Parks Victoria		

Theme 5 indicator summaries: Pests and invasive species

Indicator 38: Invasive marine species

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Other marine protected areas			
Data source:	Department of Jobs, Precincts and Regions		

Indicator 39: Coastal invasive plants

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	DELWP, Department of Jobs, Precincts and Regions, Parks Victoria		

Indicator 40: Coastal invasive animals

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Statewide		

Theme 6 indicator summaries: Climate and climate change impacts

Indicator 41: Rainfall

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Data source:	Bureau of Meteorology (BoM), Commonwealth Scientific and Industrial Research Organisation (CSIRO), DELWP		

Indicator 42: Air temperature

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Statewide			
Data source:	BoM, CSIRO, DELWP		

Indicator 43: Water temperature

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	BoM, CSIRO, DELWP		

Indicator 44: Ocean acidification

Region	2021 status	2021 trend	2021 data
Statewide			High (status) Low (trend)
Data source:	BoM, CSIRO, DELWP		

Indicator 45: Areas of coastal vulnerability

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	⚪	?	⚪
Western Port	⚪	?	⚪
Corner Inlet-Nooramunga	🟡	↙	🟡
Gippsland Lakes	🟡	↙	🟡
Statewide	N	N	N
Data source:	DELWP, academic researchers		

Indicator 46: Sea-level and coastal inundation

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	🟡	↙	🟢
Western Port	🟡	↙	🟢
Corner Inlet-Nooramunga	🟡	?	🟡
Gippsland Lakes	🟡	?	🟡
Statewide	🟡	↙	🟢
Data source:	BoM		

Indicator 47: Wave climate

Region	2021 status	2021 trend	2021 data
Port Phillip Bay	⚪	?	⚪
Statewide	⚪	?	⚪
Data source:	Academic researchers		

Indicator 48: Coastal erosion

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Corner Inlet-Nooramunga			
Gippsland Lakes			
Statewide			
Data source:	DELWP		

Indicator 49: Seawater intrusion into coastal aquifers

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Academic researchers		

Indicator 50: Frequency and impact of fire on marine and coastal ecosystems

Region	2021 status	2021 trend	2021 data
Gippsland Lakes			
Data source:	Academic researchers		

Indicator 51: Climate change impact on marine and coastal infrastructure

Region	2021 status	2021 trend	2021 data
Port Phillip Bay			
Western Port			
Gippsland Lakes			
Statewide			
Data source:	DELWP, AURIN (Australian Urban Research Infrastructure Network)		

Theme 7 indicator summaries: Managing coastal hazard risks

Indicator 52: Considering climate change risks in land-use planning

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	DELWP		

Indicator 53: Climate change adaptation plans

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Catchment management authorities (CMAs)		

Indicator 54: Nature-based adaptation

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	DELWP		

Indicator 55: Emergency planning and preparedness

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Emergency Management Victoria		

Theme 8 indicator summaries: Communities

Indicator 56: Population (resident)

Region	2021 status	2021 trend	2021 data
Statewide	N	N	
Data source:	Australian Bureau of Statistics (ABS), DELWP		

Indicator 57: Population (visitors)

Region	2021 status	2021 trend	2021 data
Statewide	N	N	
Data source:	DELWP Planning, Business Victoria 2020, Phillip Island Nature Parks		

Indicator 58: Significant landscapes

Region	2021 status	2021 trend	2021 data
Statewide		→	
Data source:	DELWP Planning		

Indicator 59: Coastal settlements

Region	2021 status	2021 trend	2021 data
Statewide	N	N	
Data source:	ABS, Agriculture Victoria, DELWP Planning		

Indicator 60: Cultural heritage

Region	2021 status	2021 trend	2021 data
Statewide		→	
Data source:	First Peoples – State Relations Group, Heritage Victoria		

Indicator 61: Use of marine and coastal areas

Region	2021 status	2021 trend	2021 data
Statewide		?	
Data source:	DELWP (Ipsos Social Research Institute), Parks Victoria		

Indicator 62: Tourism

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Business Victoria 2020, Parks Victoria, Tourism Victoria		

Indicator 63: Recreational boating and fishing contribution to the Victorian economy

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Better Boating Victoria, VFA		

Indicator 64: Recreational boating

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	VFA, Better Boating Victoria, academic researchers		

Indicator 65: Recreational fishing

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	VFA, academic researchers		

Indicator 66: Shipping and ports

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Bureau of Infrastructure and Transport Research Economics; Department of Infrastructure, Transport, Regional Development and Communications; Port of Melbourne, Gippsland Ports, Department of Agriculture, Water and the Environment		

Indicator 67: Commercial fishing

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	ABS, Fisheries Research and Development Corporation, VFA, academic researchers		

Indicator 68: Aquaculture

Region	2021 status	2021 trend	2021 data
Statewide			

Data source:	Fisheries Research and Development Corporation, Agriculture Victoria

Indicator 69: Resources and energy generation

Region	2021 status	2021 trend	2021 data
Statewide			

Data source:	Department of the Environment and Energy, DELWP, Department of Jobs, Precincts and Regions, academic researchers

Indicator 70: Agriculture

Region	2021 status	2021 trend	2021 data
Statewide			

Data source:	Agriculture Victoria, DELWP Planning, Melbourne Water

Indicator 71: Built and public benefit infrastructure

Region	2021 status	2021 trend	2021 data
Statewide			

Data source:	DELWP Coastal Programs, Victorian Auditor-General's Office

Indicator 72: Recreational boating infrastructure

Region	2021 status	2021 trend	2021 data
Statewide			

Data source:	Better Boating Victoria, DELWP, Victorian Environmental Assessment Council (VEAC)

Indicator 73: Illegal activities

Region	2021 status	2021 trend	2021 data
Statewide			

Data source:	EPA, Maritime Safety Victoria, VFA, DELWP, Office of the Conservation Regulator

Theme 9 indicator summaries: Stewardship and collaborative management

Indicator 74: Stewardship

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	DELWP		

Indicator 75: Community connection to the coast

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	Ipsos Marine and Coastal Community Attitudes and Behaviour Report, VFA creel surveys		

Indicator 76: Volunteering

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	ABS, DELWP, Parks Victoria		

Indicator 77: Citizen science

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	DELWP, Parks Victoria, VFA, Victorian National Parks Association (VNPA), Tangaroa Blue Foundation, EstuaryWatch, Redmap, Atlas of Living Australia		

Indicator 78: Planning and implementation

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	VEAC, Geoscience Australia, DELWP		

Indicator 79: Committees and councils

Region	2021 status	2021 trend	2021 data
Statewide			
Data source:	VEAC, Geoscience Australia, DELWP		

Indicator 80: Institutional knowledge and capacity

Region	2021 status	2021 trend	2021 data
Statewide		?	
Data source:	N/A		

Indicator 81: Engagement and inclusiveness

Region	2021 status	2021 trend	2021 data
Statewide	N	N	N
Data source:	Engage Victoria		

Indicator 82: Delivery and accountability

Region	2021 status	2021 trend	2021 data
Statewide		↗	
Data source:	Parks Victoria, Victorian Auditor-General's Office		

Summary of status assessments

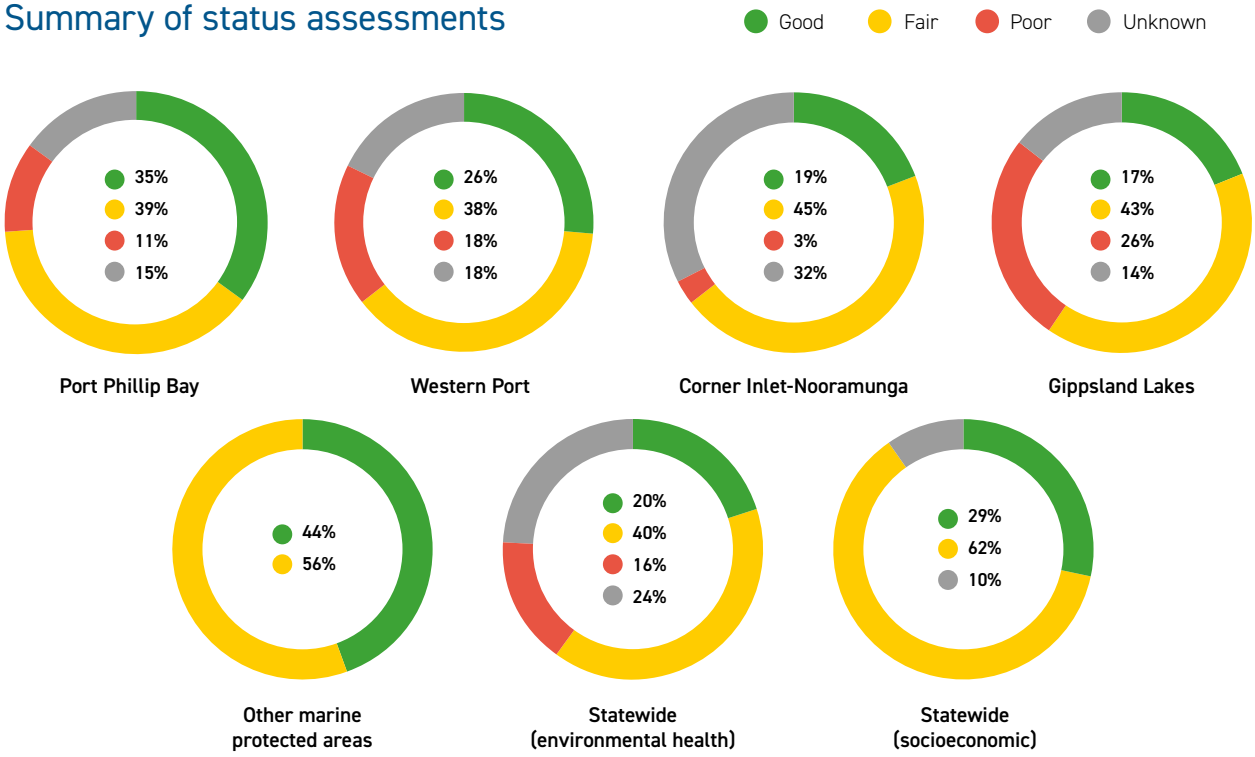


Figure 3: SMCE 2021 summary of regional indicator status assessments.

Statewide (environmental health) = statewide indicator assessments for Themes 1-7: Environmental health.

Statewide (socioeconomic) = statewide indicator assessments for Theme 8: Communities and Theme 9: Stewardship and collaborative management.

Summary of trend assessments

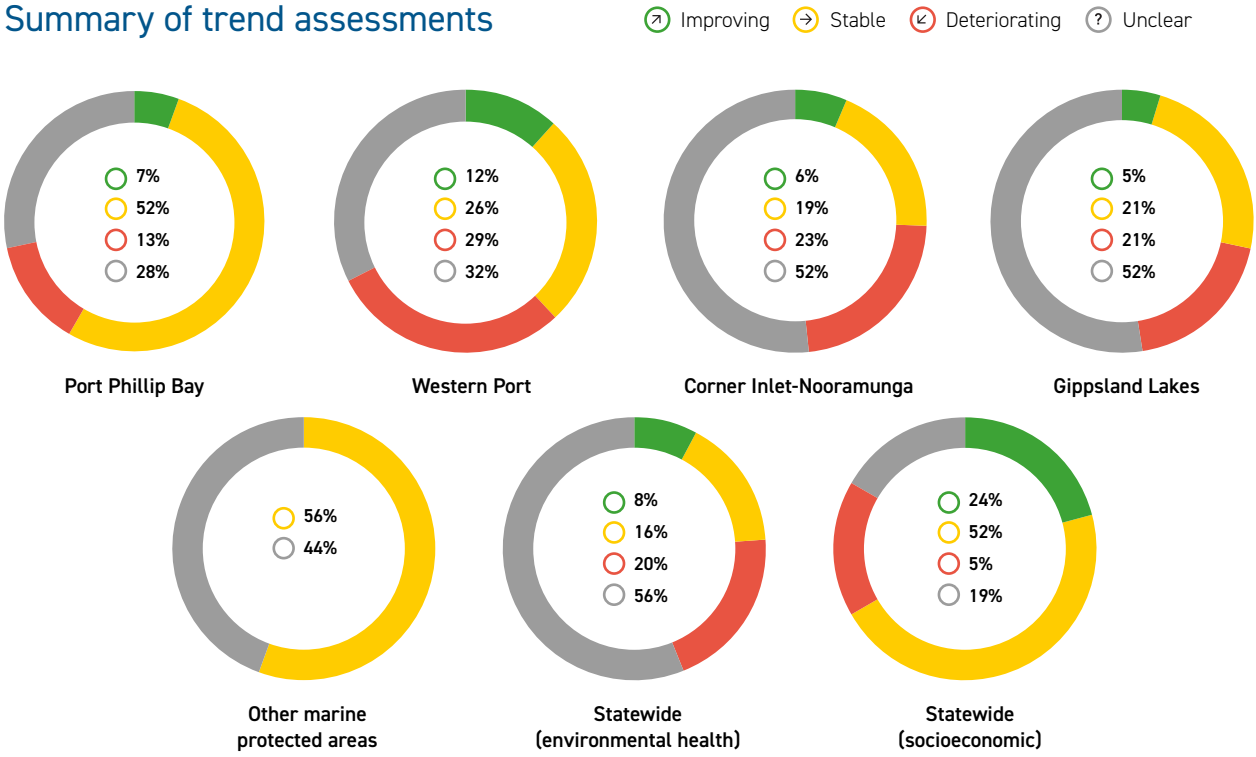


Figure 4: SMCE 2021 summary of regional indicator trend assessments.

Summary of data confidence assessments

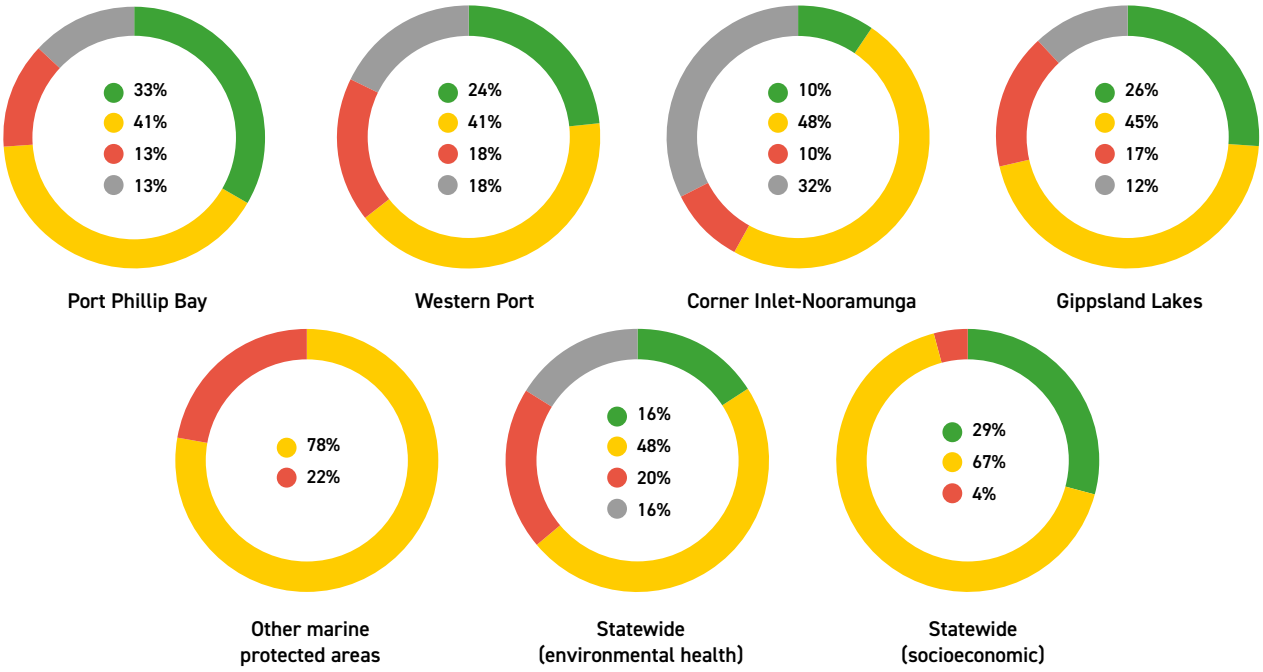


Figure 5: SMCE 2021 summary of regional indicator data confidence assessments.

Statewide (environmental health) = statewide indicator assessments for Themes 1-7: Environmental health.

Statewide (socioeconomic) = statewide indicator assessments for Theme 8: Communities and Theme 9: Stewardship and collaborative management.

Crested terns (*Thalasseus bergii*) at Mordialloc Pier, Port Phillip Bay
© Parks Victoria

Key findings

Environmental health indicators (Themes 1–7)

Theme 1: Water quality and catchment inputs

Poor water quality in marine environments harms marine ecosystems and discourages their use for human recreation. Water quality is monitored regularly in Port Phillip Bay, Western Port and the Gippsland Lakes.

- Water quality in Port Phillip Bay has been rated as fair or good each year since monitoring and reporting began in 2002.
- Water quality in Western Port has been good every year since monitoring and reporting began in 2000 except in 2017 (when it was rated as fair).
- Water quality in the eastern Gippsland Lakes (Lake King and Lake Victoria) has been good in six of the past seven years, while in Lake Wellington it has been poor for the past three years, and poor or very poor in seven of the past 10 years.

EPA provides daily forecasts on the suitability of more than 30 Port Phillip Bay beaches for swimming and other recreational uses during the warmer months, when there is greater recreational use of Port Phillip Bay. EPA's Beach Report program detects infrequent breaches of the short-term recreational water quality standards. All beaches have met long-term standards for secondary contact (for example, boating and canoeing) and most have met long-term standards for primary contact (for example, swimming) during dry weather. However, most beaches do not meet standards for all-weather primary contact. Stormwater pollution is often the main reason for beaches not meeting standards.

The consequences of poor water quality in Western Port are apparent in seagrass extent, which is strongly correlated with light availability. Thus, turbidity caused by sediment loads and variation in water depth plays a major role in seagrass decline or growth. Five of the nine estuaries flowing into Western Port and assessed for water quality in the 2021 Index of Estuary Condition received a rating of very poor, with elevated turbidity noted as a serious water quality problem for the estuaries that flow into Western Port.

Water quality in the Gippsland Lakes is generally characterised by divergent ratings. The eastern lakes (Lake King and Lake Victoria) are often rated as good, whereas Lake Wellington to the west has a higher frequency of poor water quality. Lake Wellington is a sink for sediments, nutrients and contaminants. Wind and waves in its shallow waters can re-suspend sediments and nutrients, with algal blooms often developing because of the high availability of nutrients. Catchment works have attempted to reduce the sediment and nutrient loads transported into Lake Wellington. These works have included riparian protection and revegetation, wetland restoration (sediment sinks), bed and bank stabilisation, and on-farm nutrient use and effluent loss reduction.

In the marine environment of the Corner Inlet and Nooramunga biounits, water quality is not currently routinely measured.

The effects of stormwater vary across Port Phillip Bay's catchments. In the Werribee catchment, stormwater has only minor effects on stream health, while in the Dandenong catchment stream health is being severely diminished. Importantly, urban development presents further risks to waterways, as catchment imperviousness expands.[3]

Stormwater condition for Western Port was rated as high (on a scale from very high to very low) in Melbourne Water's Healthy Waterways Strategy 2018.[4] This rating reflects an assessment that stormwater is having only minor effects on stream health. Much of Western Port's catchment is rural or forested, but urban areas of the growth corridor rate lower. For example, the Mornington Peninsula North-Eastern and Western Creeks sub-catchments both had low stormwater condition.[5]

As reported by Parks Victoria in 2005, about 30 stormwater and agricultural drains discharge into Corner Inlet,[6] but the consequences of urban stormwater drains are largely unknown because of the lack of information on water quality and quantity. Similarly, there are no available assessments of the contribution of stormwater to pollutant loads entering the Gippsland Lakes.

3. Melbourne Water 2018, 'Healthy waterways strategy 2018' https://www.melbournewater.com.au/media/6976/download Accessed 22 February 2021.
4. Ibid.
5. Melbourne Water 2018, 'Co-designed catchment program for the Werribee catchment region: working together for healthy waterways' https://healthywaterways.com.au/sites/default/files/2021-03/HWS-werribee-co-designed-catchment-program.pdf
6. Parks Victoria 2005, 'Corner Inlet marine national park management plan'., Melbourne, Victoria.

The Port Phillip Bay Environmental Management Plan 2017–2027[7] and the Corner Inlet and Nooramunga Water Quality Improvement Plan (WQIP) 2013[8] are examples of authorities developing targets to monitor water quality. However, no measurements of actual nutrient and sediment loads against the targets have been published.

The Annual Report and Delivery Plan Update 2019–20 (which contributes to regular reporting on the Port Phillip Bay Environmental Management Plan 2017–2027) did not include estimates of nutrient loads in relation to the specific strategy of 'ensuring nutrient and sediment loads do not exceed current levels and pollutant loads are reduced where practicable'.[9]

Similarly, although we are nearly halfway to the 2033 deadline for reaching the targets in the Corner Inlet [and Nooramunga] WQIP 2013, it is unclear whether any progress has been made towards meeting those targets. Only a limited number of the annual activities recommended in the WQIP 2013 have been reported, and this has hindered the tracking of progress.[10]

The Water Quality theme highlights the importance of the interconnected nature of our coastal communities and marine environment. The Port Phillip Bay Environmental Management Plan provides a strategic approach to managing water quality. Consideration should be given to the suitability of similar plans elsewhere in Victoria, to establish a catchment-to-reefs approach to water quality management.

Comparison with State of the Bays 2016 Report and State of the Environment 2018 Report

Generally, water quality in Port Phillip Bay and Western Port has remained consistently good since the State of the Bays (SotB) 2016 Report and SoE 2018 Report. Apart from algae and water clarity in Western Port, water quality in Port Phillip Bay and Western Port was assessed as good or fair in SotB 2016. These water quality parameters have been assessed as good in this report.

In SoE 2018, a single indicator encompassed water quality in both marine environments and catchments. The rating was poor for Western Port and fair for Port Phillip Bay. The present (2021) report separates assessment of water quality in marine environments from water quality in the catchments, enabling the generally good surface water quality in Port Phillip Bay and Western Port to be more clearly understood and reported, while drawing attention to the problem of catchment inputs.

The catchment inputs information provided in this report is disaggregated into discrete indicators (regulated point source discharges to marine waters, stormwater, total nutrient loads, and total sediment loads). Reporting on each of these separately represents a progression in our marine and coastal reporting, enabling water quality stressors and the scale of their effects to be individually understood. These focused catchment inputs indicator assessments can be used to prioritise resource allocation for research and management interventions. Regulated point source discharges to marine waters are still a knowledge gap in 2021, as in previous reports.

7. Department of Environment, Land, Water and Planning (DELWP) 2017, 'Port Phillip Bay Environmental Management Plan 2017–2027 supporting document', East Melbourne, Victoria, https://www.marineandcoasts.vic.gov.au/__data/assets/pdf_file/0034/88756/PPB-EMP-2017-Supporting-Doc.pdf Accessed 16 November 2021.
8. West Gippsland Catchment Management Authority (WGCMA) 2013, 'Corner Inlet water quality improvement plan 2013', Traralgon, Victoria, https://www.wgcma.vic.gov.au/wp-content/uploads/2019/08/WGCMA-Corner-Inlet-Water-Quality-Improvement-Plan-2013.pdf Accessed 16 November 2021.
9. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Port Phillip Bay Environmental Management Plan 2017–2027. 2019–2020 annual report and 2020 delivery plan update', East Melbourne, Victoria, https://www.marineandcoasts.vic.gov.au/__data/assets/pdf_file/0023/511844/PPB-EMP-2019-2020-Annual-Report-and-2020-Delivery-Plan-Update-1.pdf Accessed 16 November 2021.
10. West Gippsland Catchment Management Authority (WGCMA) 2013, 'Corner Inlet water quality improvement plan 2013', Traralgon, Victoria, https://www.wgcma.vic.gov.au/wp-content/uploads/2019/08/WGCMA-Corner-Inlet-Water-Quality-Improvement-Plan-2013.pdf Accessed 16 November 2021.

Theme 2: Litter and pollution

The number of litter items and microplastics flowing into Port Phillip Bay from the Yarra and Maribyrnong Rivers each year is estimated at more than 2.5 billion. About 85% are microplastics.[11] A deteriorating trend is confidently provided, based on the observed amount of litter increasing in both the Maribyrnong and the Yarra. Industrial precincts were responsible for a large majority of microplastics, with the Dandenong local government area the location with the most microplastics among the six local government areas studied.

No specific analyses of litter and plastics have occurred in Western Port, Corner Inlet and Nooramunga, or the Gippsland Lakes.

Like other places with a history of significant settlement and industrial activity, Victoria has a legacy of waste and pollution. Contaminated sites in coastal areas range from landfills and industrial facilities, to sites requiring active management to reduce the risk to human health and the environment. Various datasets published on Victoria Unearthed provide good information on the numbers of contaminated and potentially contaminated land locations within 5km of the coastline.[12]

Good air quality is essential for human health. The links between air quality, population exposure and health are an increasing focus for research and policy development. The coastal air quality indicator in this report is believed to be the first instance of focused coastal air quality reporting in Australia.

Coastal air quality surrounding the Port Phillip Bay is generally good. However, focused research on air quality near shipping terminals using lower-quality air monitoring sensors provides evidence of poor air quality, due to high concentrations of fine particle pollution near Station Pier (with a moderate confidence). This requires further investigation and research.

Large bushfires have occurred in coastal Victoria in recent years. Bushfire smoke has been measured at levels significantly higher than health-based standards. Quality of the air surrounding the Gippsland Lakes was closely monitored during the 2019–20 bushfire season, during which time the daily air quality standard for $PM_{2.5}$ was frequently breached.

Comparison with State of the Bays 2016 Report and State of the Environment 2018 Report

The present report significantly advances litter and pollution reporting by including dedicated pollution indicators with a coastal focus. It also contains a synthesis of the latest microplastics research in Victoria.

The SotB 2016 Report did not contain any litter or pollution indicator assessments, but a litter narrative was provided in the 'Threats to the bays' chapter. The SoE 2018 Report included indicators for light pollution, contaminated land and air quality, but these lacked the coastal focus of the present report. Litter and marine debris were included as a pressure in the 'Marine and coastal environments' chapter of the SoE 2018 Report and received a one-page commentary.

11. Charko F, Blake N, Seymore A, Johnstone C et al. 2020, 'Clean bay blueprint: microplastics in Melbourne', Port Phillip EcoCentre, Melbourne, https://ecocentre.com/sites/default/files/images/Documents/Programs/Baykeeper/EcoCentre_CleanBayBlueprint_FinalEdits%20(2).pdf
12. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victoria unearthed', East Melbourne, Victoria.

Theme 3: Biodiversity

The Biodiversity theme contains comprehensive indicator assessments on coastal vegetation, invertebrates on intertidal and subtidal reefs, fish, birds and marine mammals.

A few important stories emerged from the analysis of the information for commercially and recreationally important fish and invertebrates:

- Black bream (*Acanthopagrus butcheri*) and dusky flathead (*Platycephalus fuscus*) have both been rated as having a poor status in the Gippsland Lakes.
- The two fisheries management units with the largest catches of blacklip abalone (*Haliotis rubra*) in Victoria both have depleting stocks. Thus, the status of blacklip abalone has been assessed as poor, with a deteriorating trend.
- The recreational fishery for adult snapper (*Chrysophrys auratus*) in Port Phillip Bay is considered sustainable at its current level, but there is a declining trend in the recreational fishery for adult snapper in Western Port. However, recent strong recruitment[13] of snapper in Port Phillip Bay is expected to reverse any declining biomass trends and lead to a rebuilding of adult biomass and improved fishery performance in Western Port over the next five to 10 years.
- King George whiting (*Sillaginodes punctatus*) is expected to remain sustainable in Port Phillip Bay, Western Port and Corner Inlet.

The conservation status of coastal ecosystems in protected areas serves as a broad indicator for a range of coastal ecosystems and conservation efforts. The protection levels for coastal ecological vegetation classes vary. Parks Victoria manages around 70% of the Victorian coast, as national and state parks or coastal reserves. However, analysis reveals limited data on several coastal ecological vegetation classes in protected areas.

CES's collaboration with our co-creation partners to develop a Method for localising the SDGs (Part 2, Phase 3) has revealed a need for complementary top-down and bottom-up approaches to improve biodiversity at the local scale.

Greater collaboration is required among Victorian Government agencies to manage current threats to coastal fringe ecosystems at risk from climate change (salt marsh, mangroves, seagrasses). We also need collaborative strategies for working with local management authorities, non-government organisations and volunteers. Actions to conserve coastal ecosystems could include assessing threats to biodiversity and Ramsar areas, understanding conservation and protection needs, removing hard barriers to inland migration of marine species, and delivering programs coordinated between several agencies and community groups.

The status and trend assessments for the bird indicators are generally consistent with previous CES reports. The main declines noted in the marine and coastal waterbirds and migratory shorebirds indicators were among trans-equatorial migratory shorebirds. These declines are most likely to be due to habitat loss on their migratory flyways in east Asia, particularly over the Yellow Sea.

13. Recruitment is the process of very young, small fish surviving to become slightly older, larger fish. It is often measured as the number of new young fish that enter a population in a given year.

Little penguins (*Eudyptula minor*) continue to thrive on Phillip Island and around the St Kilda breakwater. Their numbers on Phillip Island are estimated at 32,000, and at St Kilda 1,400.[14]

There is a stable population of approximately 100 dolphins in Port Phillip Bay. Western Port has a small but stable resident population of 20 dolphins. There is also a population of between 60 and 100 dolphins living in the Gippsland Lakes, but there has been significant mortality recently, linked with severe bushfire effects in the region in 2019–20 and associated with skin infections observed on several dolphins.

The health of Australian fur seal (*Arctocephalus pusillus doriferus*) colonies, in terms of numbers, pup production and disease (including toxicants in the environment), can indicate trends in the general health of the marine environment. Fur seal colonies at Cape Bridgewater, Chinaman's Hat, Phillip Island and Wilsons Promontory have also become major tourist assets. There are an estimated 20,000 to 30,000 Australian fur seals in the Seal Rocks colony at the western entrance to Western Port.

Parks Victoria's study of macroinvertebrate species in Point Addis Marine National Park found consistent declines over the last 15 years of blacklip abalone and turban shell (*Lunella undulata*). The study also compares southern rock lobster populations (*Jasus edwardsii*) inside and outside the Point Addis Marine National Park protected waters. More than 3.5 times the abundance and 4.5 times the number of legal rock lobsters were captured inside the park than outside. Abundance and biomass of southern rock lobsters outside the park increased closer to the park boundary, suggesting that the Point Addis Marine National Park may be increasing the supply of lobsters to surrounding waters that are open to fishing.[15]

Comparison with State of the Bays 2016 Report and State of the Environment 2018 Report

Several indicators for this theme have an identical or similar scope to indicators in the 'Marine and coastal environment' chapter of the SoE 2018 Report, which means that clear comparisons can be made. In SoE 2018, reasonably good data was available for invertebrates in Port Phillip Bay and marine protected areas, and for birds. The information and assessments in the indicator assessments for these indicators are generally consistent with previous reporting by the CES.

This report contains more detail and new data on the fish indicators, to provide a significant update for this theme since previous CES reports. The fish assessments in the SotB 2016 Report were based on good data, while the data quality was rated as poor and assessments could not be made for the Impacts of fisheries production indicator in the SoE 2018 Report. For southern sand flathead in Port Phillip Bay, the indicator has been assessed as poor in this report, as it was in the SotB 2016 Report, but the more recent data show that the stock has now stabilised at a lower biomass under a lower recruitment regime, and recruitment has been sufficient to balance natural and fishing mortality at this lower level. This report also updates on the recreational fishery for adult snapper in Port Phillip Bay, with record snapper spawning in the region in 2018 likely to result in a snapper population boom in Port Phillip Bay in 2022 and 2023.

The inclusion of a marine mammals indicator in this report, which was not part of the SotB 2016 or SoE 2018 Reports, highlights the threat to the critically endangered dolphin population in the Gippsland Lakes from skin irritations.

14. Commissioner for Environmental Sustainability Victoria (CES) 2018, 'Victorian state of the environment 2018 report', Victoria State Government, Melbourne https://www.ces.vic.gov.au/reports/state-environment-2018 Accessed 23 September 2021.
15. Ierodiaconou D, Wines S, Carnell P, Tinkler P et al. 2020, 'An enhanced Signs of Healthy Parks monitoring program for Victoria's marine national parks and marine sanctuaries: Point Addis Marine National Park', Parks Victoria technical series no. 114, Melbourne, Victoria.

Theme 4: Seafloor integrity and health

The indicators in this theme contain assessments on the conservation of marine ecosystems in protected areas, and–more broadly across the assessed regions–seagrass, nitrogen cycling, macroalgae and shellfish reefs.

Seagrass meadows are critical habitat for many marine species, including fish targeted by commercial and recreational fishers. They also protect shorelines and store significant amounts of carbon. Changes in their condition can have environmental, social and economic consequences. Considerable losses in seagrass have been observed in Port Phillip Bay (in conjunction with the millennium drought from 1997 to 2009), in Western Port (in the mid-1970s and early 1980s) and in Corner Inlet (a slow decline from 1965 to 2013).

Macroalgae on intertidal and subtidal reefs has been monitored and reported on by Parks Victoria, with technical reports periodically published and generally focusing on individual marine protected areas. The condition and extent of macroalgae on subtidal reefs in Port Phillip Bay has been assessed as poor for Point Cooke and Jawbone marine sanctuaries, fair for Ricketts Point Marine Sanctuary, and good for Port Phillip Heads Marine National Park.

In 2020, a Parks Victoria study in Point Addis Marine National Park revealed an alarming decline in the previously dominant species, golden kelp (*Ecklonia radiata*), since 2012. While some other canopy-forming brown algae have increased since then (as shown in the 2018 survey), canopy-forming algae has now fallen below the lower control limit.[16] On the east coast of Port Phillip Bay (Cape Howe Marine National Park and Beware Reef Marine National Park), macroalgal beds have been under threat, and Parks Victoria advises that there has been a dramatic increase in urchin barrens.

Substantial losses of giant kelp (*Macrocystis pyrifera*) have been observed this century in marine areas off the coast of southeastern Australia, not restricted to Victoria's marine protected areas. Broad-scale temporal patterns in giant kelp canopy cover are correlated with El Niño–Southern Oscillation events, while regional patterns are related to rising sea-surface temperatures, raising concerns for the future of this species as a major habitat-forming kelp in Australia.[17]

Shellfish reef ecosystems support unique assemblages of associated fauna and valuable ecosystem services, including fish production, coastal protection, erosion mitigation and nutrient cycling. Historically, there were large reefs of native flat oyster (*Ostrea angasi*) in Port Phillip Bay, Western Port and Corner Inlet, and large reefs of blue mussel (*Mytilus edulis galloprovincialis*) in Port Phillip Bay. The extent of these shellfish reefs is now minimal, and the status of the shellfish reefs indicator has been rated as poor for these regions. Large mussel reefs can still be found in the entrance region of the Gippsland Lakes, which is why the status is fair in this region, despite the extent of shellfish reefs being noted to decline during the 20th century.

Comparison with State of the Bays 2016 Report and State of the Environment 2018 Report

Since the SotB 2016 Report and SoE 2018 Report, significant new research has been published and incorporated for this theme. Most notably, Parks Victoria technical reports, specifically for Point Addis Marine National Park, contain a comprehensive update to the macroalgae indicators. Additionally, there is a new indicator inclusion: shellfish reefs.

The Conservation of Marine Ecosystems in Protected Areas indicator includes fresh Parks Victoria data showing the condition of natural values as good or very good in 93% of marine parks. This indicator status assessment remains at fair, as it was in the SoE 2018 Report.

16. Ibid.
17. Butler CL, Lucieer VL, Wotherspoon SJ, Johnson CR 2020, 'Multi-decadal decline in cover of giant kelp *Macrocystis pyrifera* at the southern limit of its Australian range', *Marine Ecology Progress Series*, 653, pp. 1–18 https://doi.org/10.3354/meps13510

Theme 5: Pests and invasive species

The establishment and spread of invasive species are widely recognised as one of the greatest threats to global biodiversity. Monitoring is essential to knowing whether their range is expanding, with new incursions requiring rapid responses.

There are now more than 160 invasive marine species in Port Phillip Bay. The negative effects of some of these invasive species are significant, notably the northern Pacific seastar (*Asterias amurensis*), which causes changes in fish populations in Port Phillip Bay. New invasive species continue to arrive in Port Phillip Bay, most recently the Asian shore crab (*Hemigrapsus sanguineus*), which was first detected at Mount Martha in late 2020.

Western Port has several known invasive marine species, although the size and number of infestations is significantly less than in Port Phillip Bay.[18]

Corner Inlet has remained relatively free of invasive marine species. Japanese kelp (*Undaria pinnatifida*) has been detected at Port Welshpool, and the northern Pacific seastar has previously been detected at nearby Tidal River. The northern Pacific seastar was first detected in the Gippsland Lakes in 2015 and was observed again in 2019.[19] Both detections resulted in surveillance and removal efforts. The species is extremely difficult to eradicate and can rapidly establish large populations in new areas. To illustrate the risk posed to the Gippsland Lakes, the population of northern Pacific seastar in Port Phillip Bay had reached 165 million just five years after the species was first detected.[20]

The detection, monitoring and management of invasive plants are a complex and important process, essential for minimising harm. The State of the Parks 2018 reported on the effects of weeds and pest animals along the Victorian coastline. Those findings, along with analysis of datasets from DELWP and the Department of Jobs, Precincts and Regions, are presented in Part 3.

The coordination of marine pest management across agencies remains difficult, especially once a pest has become established in Victoria and is thus no longer a biosecurity threat managed by the Department of Jobs, Precincts and Regions. An end-to-end pest management plan is required, starting with prevention and preparedness and covering every stage through to on-ground asset-based management.

Comparison with State of the Bays 2016 Report and State of the Environment 2018 Report

New invasive species continue to arrive in Victoria's marine environments and spread to new areas. Thus, the trend of invasive marine species is rated as deteriorating for each geographic region in this report. The following species have recently been detected in new areas:

- The Asian shore crab (*Hemigrapsus sanguineus*) was first detected at Mount Martha in Port Phillip Bay in late 2020.
- *Undaria pinnatifida*, a seaweed also known as wakame, has been observed in Corner Inlet since 2018.
- The northern Pacific seastar was first recorded in the Gippsland Lakes in 2015 and has since been found in several locations in the Lakes.

The SotB 2016 Report did not contain any pests or invasive species indicator assessments, although a marine pests narrative was provided in the 'Threats to the bays' and 'Habitats and their dependent species' chapters. For the SoE 2018 Report, the status of the invasive marine species indicator was rated as poor for Port Phillip Bay, as it is in the present report.

18. Department of Environment, Land, Water and Planning (DELWP) 2017, 'Western Port Ramsar site management plan', East Melbourne, Victoria. https://www.water.vic.gov.au/__data/assets/pdf_file/0021/66270/Western-Port-Ramsar-Site-Management-Plan_revised.pdf
19. Australian Government Inspector-General of Biosecurity 2019, 'Pest and disease interceptions and incursions in Australia', p. 53, Mascot, NSW https://www.igb.gov.au/sites/default/files/documents/qid52819_igb_interceptions_and_incursions_report_-_final.docx Accessed 8 October 2021.
20. Parry G, Heislers S and Werner G 2004, 'Changes in distribution and abundance of *Asterias amurensis* in Port Phillip Bay 1999–2003', Department of Primary Industries technical report, Victoria, DOI:10.13140/2.1.4058.4484

Theme 6: Climate and climate change impacts

This theme assesses changes to Victoria's climate, and the consequences of those changes. None of the Climate and Climate Change Impacts indicators in this report were assessed as having a good status. Indeed, deteriorating trends were observed for 21 of the 22 regional indicators where the trend was assessed.

Tidal gauge measurements show that sea levels at Williamstown have been rising by approximately 1.8 cm per decade since 1981, and at Stony Point by 3.5 cm per decade since 1981. Future rises are projected with high confidence.[21] Research published in 2020 found significant change in shoreline position along 13% of the Victorian coast between 1986 and 2017.[22] The researchers estimated that erosion hotspots extend along 76.6 km of the coastline, equivalent to approximately 6.2% of the Victorian coast. Progradation hotspots (sediment deposits shifting the shoreline seaward) were estimated to extend along 72.7 km of coast, equivalent to approximately 5.9% of Victoria's coast. A 2017 assessment rated more than 100 km of the Gippsland coastline as highly vulnerable to coastal erosion.[23] This means that more than a quarter of the entire Victorian coastline most at risk to erosion is located along the Gippsland Lakes.

By the 2050s, average temperatures in Victoria are projected to be 1.4 to 2.4°C warmer under a high-emissions scenario (RCP 8.5) or 0.9 to 1.8°C warmer under a medium-emissions scenario (RCP 4.5), compared to 1986–2005. By the 2090s, average temperatures in Victoria are projected to be 2.8 to 4.3°C warmer under a high-emissions scenario (RCP 8.5) or 1.3 to 2.2°C warmer under a medium-emissions scenario (RCP 4.5), compared to 1986–2005 (high confidence). It is likely that Victoria's coastal regions have already warmed by more than 1°C, with areas of the Port Phillip Bay coastline now regularly experiencing years with temperatures approximately 1.5°C warmer than an indicative pre-industrial era baseline.

The increasing frequency of marine heatwaves around Australia in recent years has irreversibly changed marine ecosystem health, habitats and species. Effects include depleted kelp forests and seagrasses, a poleward shift in some marine species, and increased occurrence of disease. A 2019 international study found that the ocean off southeast Australia is particularly vulnerable to marine heatwaves.[24]

A fluctuating pressure is being exerted on the water resources and agricultural sectors by wetter years interspersing a predominantly drying climate. Rainfall reduction during the cool seasons is particularly important, given the consequent reductions in streamflows and the reduced reliability of water storage filling seasons. A reduction in annual rainfall of 7–12% has been observed along the Port Phillip Bay coastline during the 21st century, and a 13–20% reduction in cool-season rainfall. Notably, the biggest percentage rainfall reductions have occurred on the western side of Port Phillip Bay, which is also projected to have faster population growth in coming decades,[25] placing increasing pressure on water resources.

Comparison with State of the Bays 2016 Report and State of the Environment 2018 Report

The SotB 2016 Report did not contain any climate change indicator assessments, although a climate change narrative was provided in the 'Threats to the bays' chapter:

Climate change impacts are likely to include peak rainfall events that transport high loads of nutrients and pollutants to the bays in short time periods, and sea level rise that encroaches on important habitat. Water chemistry, water temperature, wind and storm patterns also contribute to a complex mix of potential impacts.

21. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victoria's climate science report 2019', East Melbourne, Victoria.
22. Konlechner TM, Kennedy DM, O'Grady JJ, Leach C et al. 2020, 'Mapping spatial variability in shoreline change hotspots from satellite data: a case study in southeast Australia', *Estuarine, Coastal and Shelf Science*, 246, 107018 https://dx.doi.org/10.1016/j.ecss.2020.107018.
23. Spatial Vision 2017, 'Victorian coastal hazard assessment 2017 technical report 1'. Melbourne, Victoria. https://www.marineandcoasts.vic.gov.au/__data/assets/pdf_file/0021/122709/VCHA2017_R1_Victorian_Coastal_Hazard_Assessment_2017_Final_R1.compressed.pdf
24. Smale DA, Wernberg T, Oliver ECJ, Thomsen M, et al. 2019, 'Marine heatwaves threaten global biodiversity and the provision of ecosystem services', *Nature Climate Change*, 9, pp. 306–312.
25. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victoria in future 2019: population projections 2016 to 2056', East Melbourne, Victoria, https://www.planning.vic.gov.au/__data/assets/pdf_file/0032/332996/Victoria_in_Future_2019.pdf.

The SoE 2018 Report assessed air temperature, rainfall, sea level, and sea-surface temperature, all rated as fair to poor, and the trends all rated as deteriorating.

Data available for the three most recent years generally show further deteriorations in the climatic indicators. Importantly, change in many climatic variables may be detectable only over longer periods than the five-yearly state of environment reporting cycle. Furthermore, even the smallest changes in climatic variables can have significant environmental consequences.

To complement the indicators previously reported, this report includes new climate change indicators on ocean acidification, wave climate, coastal erosion, seawater intrusion into coastal aquifers, and impact on built infrastructure.

Theme 7: Managing coastal hazard risks

DELWP has analysed the extent and quality of Victorian councils' consideration of climate change in land-use planning. A strong pattern emerged when comparing inland and coastal councils, with coastal councils three times more likely than inland councils to have an intermediate, high or advanced consideration of climate change in land-use planning. Nevertheless, 30% of coastal councils in 2018 had no or only basic integration of climate change in land-use planning.

Catchment management authorities are playing an important role in helping Victoria adapt to climate change. All 10 authorities in Victoria are implementing climate change adaptation plans or strategies. These are based on CSIRO's latest climate change projections and have been developed in collaboration with Australia's principal research organisations.

Protecting and restoring coastal blue carbon ecosystems such as mangroves, tidal marshes and seagrasses offers opportunities for carbon sequestration and avoidance of greenhouse gas emissions. Better management of blue carbon ecosystems can also improve fisheries and increase a coastline's resilience to rising sea levels and storm surges. Research published in 2019 found that allowing coastal wetlands in Victoria to naturally retreat with sea-level rise could sequester 1.6 million tonnes of carbon by 2050 with a value of $65 million.[26]

Comparison with State of the Bays 2016 Report and State of the Environment 2018 Report

The only indicator for this theme that was previously reported on by the CES is 'Considering climate change risks in land-use planning'. This was included in the SoE 2018 Report, which found consensus across local councils, particularly coastal councils, that land-use planning should be informed by up-to-date climate science. No further quantitative analysis has been undertaken for this indicator since that report. The only additional commentary for that indicator in the present report is on updated planning guidance materials developed in recent years.

Climate change adaptation plans, nature-based adaptation, and emergency planning and preparedness indicators are all new indicators in this report. Nature-based adaptation is a particularly important addition, as it reveals missed opportunities to capture carbon via saltmarshes, mangroves and seagrasses.

26. Carnell PE, Reeves SE, Nicholson E, Macreadie P et al. 2019, 'Mapping ocean wealth Australia: the value of coastal wetlands to people and nature', The Nature Conservancy, Melbourne, DOI:10.13140/RG.2.2.15789.84969.

Socioeconomic indicators (Themes 8 and 9)

Theme 8: Communities

Socioeconomic assessments

The Marine and Coastal Act 2018 introduced a socioeconomic objective into state of the environment reporting. While a healthy environment is fundamental to meeting our socioeconomic needs, a healthy environment relies upon communities having social wellbeing and the economic resources to contribute to good environmental outcomes.

The inclusion of a socioeconomic objective in environmental reporting in the Marine and Coastal Act 2018 offers an opportunity to incorporate the social sciences and economics into DELWP's Marine and Coastal Knowledge Framework (MACKF) and to integrate the measures and thresholds for future reporting on communities' indicators with the biophysical science priorities.

The application of the SDGs to environmental reporting can achieve this. In the Method described in Part 2, Phase 3 (Localisation of SDG reporting) and Phase 4 (Reporting on SDG targets) provide an approach to both identify priority issues of importance to coastal communities and, through the synthesis of socioeconomic and biophysical data, assess our progress against targets, identifying opportunities for co-benefits and recognising where trade-offs will need to be managed. This process has also identified knowledge gaps that the MACKF, expanding its scope to include the three science objectives of the Marine and Coastal Act 2018, could fill in the future.

Coastal communities

The Communities theme focuses on activities undertaken by, and the liveability of, coastal communities.

The development of **coastal settlements** represents a significant change in land use, potentially reducing natural habitat and introducing impervious surfaces. It is often assumed that population in coastal areas is increasing faster than in non-coastal areas. In Victoria this is not the case.

Recent rates of coastal population growth (1.6%) have been lower than for non-coastal areas (2.2%). In 2019, the coastal population of Victoria formed a slightly smaller proportion of the Victorian population than it had a decade earlier.[27] Population growth in coastal suburbs of Melbourne has been rapid, with increasing density of development, while coastal locations near Melbourne and Geelong, particularly on the Bellarine Peninsula and around Torquay, have also experienced rapid population growth. Work is currently underway to protect significant landscapes in several coastal areas that are under development pressure. On balance, planning controls are being strengthened to protect important landscapes, but we have no monitoring systems in place to determine whether these are actually protecting the qualities of these significant landscapes.

Legislative protection is given to a range of **cultural heritage** for both Aboriginal and non-Aboriginal Victorians, on land and in marine environments. Data on the number of registered sites having cultural significance are available, subject to certain restrictions in the case of Aboriginal cultural heritage. While cultural heritage can be assessed quantitatively — in March 2021 there were 38,827 registered Aboriginal places on the Victorian Aboriginal Heritage Register and 1,143 cultural heritage management plans — it is important to monitor the qualitative status of sites and the degree to which investment is supporting their preservation and protection.

Tourism and recreation (especially boating and fishing) are supported through Victorian Government policy and are seen as valuable sources of jobs and revenue for Victorian coastal communities. A recent study estimated that recreational fishing and boating in Victoria in 2018/19 generated:

- $14 billion combined direct and indirect output, including $6.14 billion direct output
- $5.83 billion combined direct and indirect value added, including $2.12 billion direct added
- 55,780 combined direct and indirect full-time equivalent jobs, including 25,058 direct jobs.[28]

27. Data based on coastal Statistical Areas Level 2 (SA2) average annual population growth between 2009 and 2019. Australian Bureau of Statistics (ABS), 'Regional population growth', cat. 3218.0.

28. Ernst & Young, for Better Boating Victoria and Victorian Fisheries Authority 2020, 'The economic value of recreational fishing and boating in Victoria': Final report, p.7 https://vfa.vic.gov.au/__data/assets/pdf_file/0003/629256/The-economic-value-of-recreational-boating-in-Victoria-2020-Ernst-and-Young-Report.pdf.

At present there appear to be limited links between tourism growth policies and visitor management or environmental management strategies. While data are available, it tends to be geographically broad and survey-based, which makes detailed assessment of tourist impact very difficult. Environmental certification schemes do not yet enable comprehensive assessment of tourism operators' environmental credentials.

Recreational fishing is a popular activity, contributing to people's wellbeing. But increases in recreational fishing may lead to increased pressures on fisheries and the broader ecosystem. Management strategies and education are required to prevent this. While some data on recreational fishing are available, there are gaps in our understanding of its scale and consequences. Increasingly, programs aim to foster responsible fisher behaviour, which improves environmental outcomes.

While Victoria's systems for managing **commercial fisheries** are generally effective, some threats are still evident: overfishing, illegal and unreported fishing, introduction of pests, bycatch, and entanglements. State and Commonwealth commercial fisheries provided $101 million of gross production value to the Victorian economy and added value of $223 million.[29] More than 2,000 full-time equivalent jobs were provided in the industry, which translated into $129 million in household income.

Aquaculture is an increasingly important source of seafood in Victoria, for both the domestic and export markets. The main species farmed in Victorian coastal waters are abalone and blue mussels. Regulations are in place to prevent the spread of invasive marine species in the aquaculture industry. However, disease outbreaks remain a threat to the industry – in 2021 an outbreak of abalone viral ganglioneuritis led to a local marine area closure near Portland. Coastal aquaculture contributed an estimated $35 million of added value and 427 full-time equivalent jobs to the Victorian economy in 2016–17.[30]

Victoria uses both renewable and non-renewable resources from marine and coastal environments to generate electricity. **Resources and energy generation** are undergoing major change at present due to the decarbonisation of Victoria's energy sources. Development of wind and solar energy has been increasing in recent years and more projects are planned. There are nine operational wind farms along Victoria's coastline, including Victoria's first wind farm built in 2001 at Codrington, east of Portland.[31] This wind farm alone generates enough electricity each year to supply 10,000 Victorian homes, avoiding the emission of 49,000 tonnes of greenhouse gas emissions annually.[32] Global initiatives towards decarbonisation are likely to place pressure on Victoria's fossil fuel use in the coming decade, requiring a more rapid transition to renewable energy sources.

Agriculture is a major use of land in Victoria. It provides economic benefits and food for the wider community. Agriculture can be done in a sustainable way: farmers can be stewards of their land by maintaining or improving soils, vegetation and other environmental features. However, some environmental risks from agriculture require management. Water runoff from farming land may have high nutrient loads from fertiliser or contain toxins from agricultural chemicals like pesticides.

Melbourne Water and CSIRO have undertaken studies to estimate fine sediment loads in runoff from the Western Port catchment. This catchment has been subject to increasing urbanisation, particularly in the urban growth areas of Casey and Cardinia Shires, although much of the catchment still comprises agricultural land use with some significant areas of remnant vegetation. Although the largest proportion of fine sediment load in catchment runoff comes from grazing and cropping (21%), this reflects the fact that grazing and cropping comprise a high proportion of catchment land use (31%). By contrast, roads, which represent only 3.4% of land use in the catchment, account for 24% of fine sediment load running into Western Port. Low-density residential use also causes significant runoff (12%) despite being a small proportion of overall land use (2%).[33]

Coastal infrastructure is under threat from climate change, due to rising sea levels and increasingly frequent severe weather events. The condition of coastal assets and infrastructure is currently undergoing review. It is therefore difficult to fully assess their status.

29. Abernethy K, Barclay K, McIlgorm A, Gilmour P et al. 2020, 'Victoria's fisheries and aquaculture: economic and social contributions', Fisheries Research and Development Corporation and University of Technology Sydney.
30. Ibid.
31. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Wind energy projects. As at 08/10/20' https://www.planning.vic.gov.au/permits-and-applications/specific-permit-topics/wind-energy-facilities/wind-energy-projects-planning?_ga=2.189197033.318809511.1602653626-245237306.1598233448 Accessed 14 October 2020.
32. Pacific Hydro 2020, 'Codrington wind farm' https://www.pacifichydro.com.au/projects/operations/codrington-wind-farm/ Accessed 14 October 2020.
33. Melbourne Water and CSIRO 2021, 'Westernport catchment planning tool' https://www.flowmatters.com.au/viz/#/mw-cpt?_page=0 Accessed 20 July 2021.

Theme 9: Stewardship and collaborative management

The Stewardship and Collaborative Management theme ranges from participation in stewardship activities at the local level through to Victorian Government legislation and policy. By working in partnership, agencies and communities can create policy that leads to strong stewardship of Victoria's marine and coastal environments.

While it is relatively easy to measure the number of participants involved in a program, it is more difficult to measure institutional characteristics or the effectiveness of policies and processes. For this reason, some of the indicators for this theme of Part 3 of the SMCE provide a narrative exploration and assessment rather than specific or precise measurements. We anticipate that this approach will raise issues and lead to new ways of measuring these aspects of stewardship and collaborative management in future reports.

There is a growing recognition of the importance of people being connected to nature. **Stewardship** activities involve many participants. At the community level are farmers and other land managers, fishers and others who rely on marine industries, Traditional Owners caring for Country, and various volunteer groups involved in environmental protection and improvement. A wide range of government departments and agencies are also involved in stewardship activities, through funding processes, policy making, and management of programs. Although stewardship is difficult to define or measure, DELWP has made progress recently by developing a Marine and Coastal Stewardship Index. While it is too early to measure trends using this index, benchmark data are starting to be collected for Port Phillip Bay programs, and this should provide a model for future data collection and indicator assessment.

Volunteering is one activity for which data are available. This data show that, although many committed volunteer groups contribute to protecting, conserving and improving marine and coastal environments, fewer than 6% of Australians who volunteer are involved in environmental activities.

A survey of community attitudes undertaken in 2018 by market research company Ipsos examined community participation in relation to Victoria's coast, and potential financial contributions to the preservation of the Victorian coast and marine environments.[34] Forty-two percent of respondents indicated an interest in joining a coastal volunteer group, while 39% indicated their willingness to contribute financially to improve coastal management.

Coastcare Victoria is a community-based program that supports community stewardship of Victoria's marine and coastal environments. Volunteering is central to Coastcare's activities, and the program aims to foster community appreciation of marine and coastal areas. Coastcare supports hundreds of community groups and volunteers working to protect and improve Victoria's coastline. Activities include revegetating coastal areas, building boardwalks and tracks, fencing, monitoring native shorebirds and animals, presenting educational and awareness-raising sessions, planting, landscaping and protecting cultural sites.[35] A total of 13,444 people participated in Coastcare activities in 2019–20,[36] an increase from 10,500 in the previous financial year.[37]

Citizen scientists have been involved in marine and coastal programs, even during COVID-19 lockdowns, when virtual projects enabled seal counts (via webcam) and other activities to continue. These broad-ranging programs can provide important data for scientific analysis, as long as appropriate levels of rigour are applied to data collection and analytical methods. It is important for the DELWP MACKF to identify the role of, and constraints on, volunteers and citizen scientists in contributing to the evidence base of critical marine and coastal scientific knowledge. The current development of a citizen science framework for Victoria is a promising development that can help address some of these requirements and challenges to expand citizen science activities.

34. Ipsos 2018, 'Wave 5 Marine and Coastal Community Attitudes and Behaviours Report', prepared for the Victorian Marine and Coastal Council (VMaCC), Parks Victoria and Department of Environment, Land, Water and Planning (DELWP), East Melbourne, Victoria, https://www.marineandcoasts.vic.gov.au/__data/assets/pdf_file/0029/438329/Final-Report-Wave-5-Victorian-Marine-and-Coastal-Attitudes-Research.pdf
35. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Coastcare Victoria strategy 2020–2025: Have your say on our draft Coastcare Victoria Strategy', Victorian Government, Melbourne https://engage.vic.gov.au/coastcare-victoria-strategy-2020-2025 Accessed 24 February 2021.
36. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Annual report 2020', Victorian Government, Melbourne, p. 52 https://www.delwp.vic.gov.au/__data/assets/pdf_file/0025/494134/Annual-Report-2019-20-3.pdf
37. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Annual report 2019', Victorian Government, Melbourne, p. 42 https://www.delwp.vic.gov.au/__data/assets/pdf_file/0032/438188/DELWP-Annual-Report-2018-19-web.pdf

Future priorities

This report's assessment of the Victorian Government's role in stewardship activities takes a narrative form, exploring Victoria's marine and coastal planning regimes and implementation strategies. In the past, Victoria's marine and coastal planning and policy arrangements have been criticised for being overly complex and multi-layered, thus limiting policy coherence. The introduction of the *Marine and Coastal Act 2018* and the subsequent Marine and Coastal Policy 2020 have helped to streamline and clarify aspects of coastal policy.

Institutional knowledge and capacity are critical for effective environmental policy. At the aggregate level, a meaningful assessment of institutional knowledge and capacity is unrealistic, because of the large number, variety and complexity of institutions that have responsibilities for marine and coastal management. Following the State of the Bays 2016 Report, Victoria has put in place a MACKF to support the knowledge needs of planning for Victoria's marine and coastal areas. One outcome has been CoastKit – an online system for marine and coastal spatial data. While the development of data systems for marine and coastal management is welcome, analysis of what the data tell us and the degree to which it is being used in decision-making is still unclear and unable to be fully assessed yet. It is important that the MACKF considers the supply of analysis and interpretation to complement datasets, to provide clarity for future state of the environment reporting.

38. Victorian Government 2020, 'Victorian Government response to the State of the Environment 2018 Report', https://www.environment.vic.gov.au/reports/state-of-the-environment-report-response Accessed 26 August 2021.

Part 2 Spatial analysis and applying international frameworks

This is the first report to be produced using the approach described in the Science for Sustainable Development Framework, which was tabled in the Parliament of Victoria in June 2020. Part 2 of this report focuses on the application of three of the framework's strategic enablers, to improve state of the environment reporting and enable better decision-making by strengthening the evidence base and its application. This analysis also contributes to the implementation of relevant recommendations (18, 19 and 20) from the Victorian State of the Environment 2018 Report, which were supported in principle or in part by the Victorian Government in 2020.[38]
The three strategic enablers are:

- spatial information, the technologies that deliver it, and spatial data coordination for state of the environment reporting
- the United Nations (UN) Sustainable Development Goals (SDGs)
- the UN System of Environmental–Economic Accounting (SEEA).

Spatial analysis

Harnessing the scientific and technological developments and availability of Earth observation and spatial information for monitoring and protecting Victoria's marine assets is a major opportunity to support and protect Victoria's marine and coastal environments and communities. An analysis of the current, emerging and future opportunities in this area is provided in Part 2, with further detail included as Appendix A.

The opportunity for future SMCE Reports to include data sourced via spatial technologies is evident. The importance of Earth observation and spatial technologies for coastal and marine protection and management is increasing–and will continue to increase. Exploiting these opportunities and developing a process for continuous improvement in Victoria's investment, adoption and use of Earth observation and spatial technologies for marine and coastal monitoring and management will also enable continuous improvement in our science and reporting programs.

Applying international frameworks: the United Nations Sustainable Development Goals

The Science for Sustainable Development Framework assumes that using the SDGs can help Victoria achieve the four objectives of the *Commissioner for Environmental Sustainability (CES) Act* (the Act) in a way that was not possible for state of the environment (SoE) reporting before 2015. Hence the framework extends the aims of the SoE 2023 report beyond the limitations of previous cycles to meet objectives (s. 7) of the Act.

The first four phases of a formative Method for achieving this are presented in Part 2:

Phase 1 Selection of relevant SDG targets – proposes a list of SDG targets that are relevant to marine and coastal reporting in the SMCE 2021 Report. This section describes the process for selecting a subset (40) of the 169 SDG targets relevant to marine and coastal reporting in Victoria.

Phase 2 Evaluating comprehensiveness of indicators – assigns indicators from the SMCE Report's scientific assessments (Part 3) to the 40 SDG targets identified in Phase 1 of the Method. The assigned indicators were also weighted, as not all indicators mapped to a specific target are equally important in assessing the target; critical indicators were given a heavier weighting.

The comprehensiveness assessment is included in Part 2, Appendix B.

Phase 3 Localisation of the Sustainable Development Goals – working with local coastal and land managers and practitioners to understand local priorities.

Phase 4 Reporting on SDG target assessments – applies the Method to specific SDG targets that were identified in Phase 1 (as relevant to marine and coastal reporting in Victoria) and assessed in Phase 2 (evaluated for comprehensiveness of indicators to report progress in a meaningful way). Qualitative reporting on the SDG targets in Phase 4 draws on the information and evidence base in Part 3, but with a focus on the system and the telling of interconnected stories (narratives) to inform holistic policy interventions and management.

The narrative approach adopted in this report is one of a range of methods for assessing interlinkages but is limited to a qualitative assessment. Semiquantitative (matrix/network analysis), quantitative (statistical correlation), and dynamic quantitative (modelling) methods will require a targeted research project and an analysis of the applications across all themes to measure Victoria's progress on the SDGs: identifying areas in which we are lagging; exploring how economic, social and environmental targets interlink; and modelling how recommendations from SoE reporting can improve progress on ecological sustainable development.

Applying international frameworks: the United Nations System for Environmental–Economic Accounting

DELWP is developing accounting applications based on the United Nations System of Environmental–Economic Accounting to provide better-integrated and more consistent information on, and analysis of, our environmental assets in Victoria: information on which assets have been depleted or lost, which are declining in condition, and how the health of these assets affects our wellbeing as a society.

This will support the Victorian Government's policy, planning and investment decisions that affect the environment. It will also strengthen the ability of local government, business, not-for-profit and community stakeholders to recognise the benefits of protecting and investing in the environment.

DELWP's initial ecosystem accounting work (in the early 2010s) aimed to demonstrate concepts using available information. The more recent program of work (since 2020) responds to an identified policy need and to the recommendations of the SoE 2018 Report. The existing Victorian ecosystem accounts are a snapshot of ecosystem status and productivity at a point in time and have been developed for much of Victoria's land and water area.

Future priorities

The CES proposes five future priorities, which recognise that research outcomes will benefit from better integration and coordination of effort and from the adoption of new technologies and methods. These will enable more frequent and extensive monitoring and will ultimately improve our understanding of the marine and coastal environment.

1. Use spatial information and Earth observation to help identify and protect Victoria's marine assets.
2. Update Victoria's Marine and Coastal Knowledge Framework to reflect the scientific assessments of this report.[39]
3. Develop thresholds to improve future reporting.
4. Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.
5. Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

Together, these five priorities enable a shift from issues-based marine and coastal management to an integrated, systems approach that recognises the interlinkages of the SDGs and is built on a catchments-to-reefs philosophy. The first four priorities would benefit from the SDG modelling proposed in the fifth priority.

The SDG modelling will improve our understanding of interlinkages and enable predictive analysis (i.e., which interventions will maximise benefits and limit trade-offs). It would provide the frame, logic and rationale for the system presented in Figure 6. The data for the decision-making system described can be applied to any policy domain, but in Figure 6 it is applied to marine and coastal policy.

The spatial information and Earth observation data would contribute significantly to the evidence base for decision making. The perspectives and values of Traditional Owners, local management authorities, community groups and volunteers would provide the operational intelligence–identifying the local priorities for specific regions of Victoria's coasts and marine assets. The MACKF, environmental–economic accounts and the independent reporting and assessments of the State of the Marine and Coastal Environment, would address the knowledge

Figure 6: Data for decision making applied to the SMCE 2021 Report.

39. This priority supports the proposed activity of the Marine and Coastal Strategy to underpin evidence-based marine planning and management by updating Victoria's Marine and Coastal Knowledge Framework (including CoastKit).

gaps (identified in the SMCE Report; addressed by the MACKF) informed by local priorities. Finally, the Marine Spatial Planning Framework provides the integration–ensuring planning and management decisions consider all sectors and the application of sectoral decisions across all Victoria's marine and coastal regions–and that these decisions are reflected in future iterations of strategy and policy.

Future priority 1: Use spatial information and Earth observation to help identify and protect Victoria's marine assets.

An analysis of the current, emerging, and future opportunities to harness spatial information and Earth observation technologies to improve marine and coastal management is provided in Part 2, and a detailed summary at Appendix A. The opportunity for future SMCE reporting to adopt more spatial technologies is evident. Part 3 of this SMCE Report relies on a plethora of diverse mapped and measured data to assess an indicator at a point in time.

We found that emerging technologies will improve both the spatial resolution and temporal resolution of data. Consequently, data volumes will increase. Over time, synthesising this data into insights may become more technically complex, but the opportunity to create information that better represents change over time, at more local scales, is an exciting one. Many of these data collection types and technologies discussed should not be used in isolation as they will be more valuable in combination. The analysis presented in Part 2 should inform and contribute to Victoria's first Marine Spatial Planning Framework, which is currently being developed under the Marine and Coastal Policy 2020. This Framework is intended to provide overarching guidance and a process for achieving integrated and coordinated planning and management of the marine environment.

Future priority 2: Update Victoria's Marine and Coastal Knowledge Framework (MACKF) to reflect the scientific assessments of this report.

The State of the Bays 2016 Report proposed a Marine Knowledge Framework to guide an ecosystem-wide understanding of the bays and enable forward-looking and well-considered policy making. Policies should account for economic and social benefits, as well as environmental ones. They can inform robust urban planning decisions, and positively and pre-emptively deal with the effects of climate change.

In 2017, the Victorian Government funded the Marine Knowledge Framework. When the SoE 2018 Report recommended a broadening of the scope of the Framework, DELWP responded by including coastal issues – thereby expanding the research program and monitoring beyond Port Phillip Bay and Western Port. The resulting MACKF has made an important contribution to this report, through DELWP and other agencies that support the science investment and research undertaken.

The marine science component of the MACKF would be further improved by stronger ties to national efforts (e.g., the Integrated Marine Observing System (IMOS)).

Future priority 3: Develop thresholds to improve future reporting.

The indicator assessments presented in Part 3 are based on the best available science, and contributions by technical experts in all areas of Victorian marine and coastal science. Where possible, thresholds are used for transparency of reporting, to ensure consistent standards are adopted across reporting cycles, and to raise awareness of the environmental conditions required for an indicator to improve (e.g., from fair to good) or deteriorate (e.g., from fair to poor).

These thresholds are adopted from pre-existing reporting regimes (for example, EPA's Environment Reference Standards (ERS) or Ramsar's limits of acceptable change). However, for many critical indicators – from microplastics to contaminated land, from light pollution to coastal acid sulfate soils – thresholds have not been developed. For efficiency, it will be important that current initiatives, such as the Marine Biodiversity Index, the Port Phillip Bay EMP Monitoring Evaluation Reporting and Improvement strategy, and the Victorian Coastal Monitoring Program, develop these thresholds for future reporting.

Future priority 4: Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.

Since the publication of the State of the Bays 2016 Report, the Victorian Government has significantly reformed marine and coastal legislation, policy and planning. The Marine and Coastal Act 2018 and Policy are central to this reform – with the Strategy out for consultation as well. Planning documents such as Biodiversity 2037, Water for Victoria, and the Port Phillip Bay EMP have also helped shaped policy and management over the past five years.

These initiatives create a very robust legislative and policy framework for managing Victoria's marine and coastal environments. The challenge for all Victorians is to maximise the potential of this reform and to take a whole-of-system approach to guide our actions. This will require that the tools presented by the legislation, policy, strategy and plans are coherent and coordinated and applied with a catchment-to-reefs philosophy that integrates water quality and pest management, adaptation to climate change, and conservation and protection priorities.

This undertaking is twofold. Firstly, actions must be delivered, and commitments kept. Secondly, the policy levers of the new legislative and policy framework must be applied to bring real change and environmental benefits.

Future priority 5: Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

In this report we have broadened the scope of the SMCE analysis required under the legislation, to include both environmental and socioeconomic indicators, and we have explored their interlinkages. Further research is required to fully realise the vision of the Science for Sustainable Development Framework, to:

1. show how the environment and natural capital underpin Victoria's social and economic wellbeing
2. identify trade-offs and areas of tension, and potential co-benefits
3. highlight potential opportunities for collaboration between management sectors in the SDG network (e.g., environment, health and infrastructure)
4. enable predictive analysis to assess the causal interlinkages of specific interventions and inform future recommendations.

The narrative approach adopted in this report is one of a range of methods to be trialled for assessing interlinkages but is limited to qualitative assessment. Semiquantitative (matrix/network analysis), quantitative (statistical correlation), and dynamic quantitative (modelling) approaches will require a targeted research project and an analysis of the applications across all SoE reporting themes.

In this way, the SoE 2023 can be both retrospective (extending the scientific baseline another five years) and prospective. It will measure Victoria's progress on the SDGs, identifying areas in which Victoria is lagging; exploring how economic, social and environmental targets interlink; and showing how recommendations help progress the ecologically sustainable development of Victoria.

Part 1B
Policy context

Cultural landscape health and management

Introduction

Victoria's cultural landscapes are unique. They are host to one of the oldest continuing cultures in the world, and home to a vast array of flora, fauna and sites that have both symbolic and practical value to Aboriginal Victorians – and to all other Victorians. Today's cultural landscapes reflect Aboriginal people's interactions with their world and experience of their surroundings. They are the product of generations of economic activity, material culture and settlement patterns. Although colonisation resulted in the landscape being broken up into different land tenures, and brought in different management regimes, Aboriginal people remain connected to Country, and cultural landscapes span such artificial boundaries.[40]

Country is both a place of belonging and way of believing and living. It relates to all aspects of an Aboriginal person's existence, including culture, spirituality, language, law, family and identity.[41]

The Draft Marine and Coastal Strategy highlights the role of Traditional Owners in marine and coastal management.

The full integration of Traditional Owner values, uses and practices in the rehabilitation and management of Country will foster continuity of Traditional Owner cultures, knowledge, and practices to heal our coastal and marine environment for current and future generations.[42] The Strategy proposes that Traditional Owners be involved in research, planning, management and monitoring of land and sea Country.

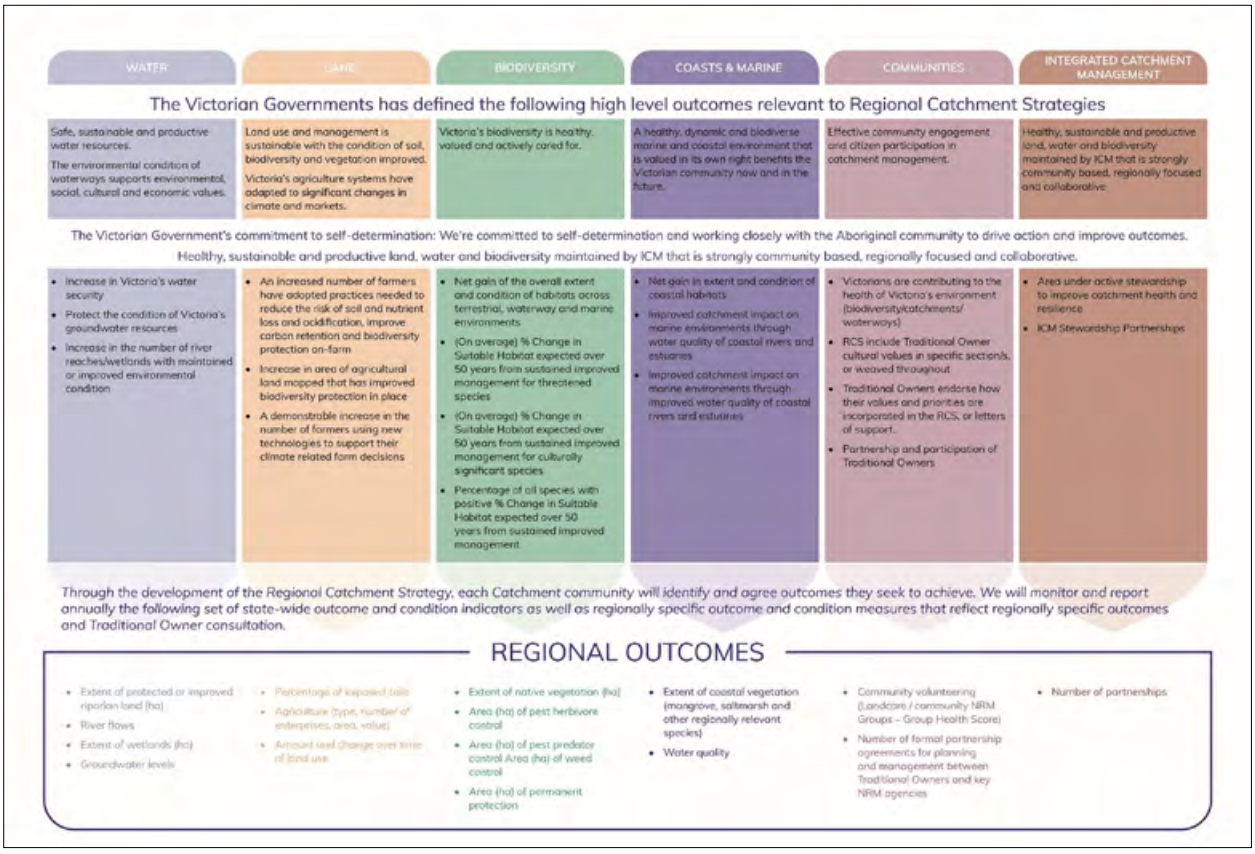


Figure 7: Regional catchment strategies outcomes framework.[43]

40. Parks Victoria 2020, 'Managing Country together' https://www.parks.vic.gov.au/managing-country-together Accessed 16 April 2020.
41. Aboriginal Victoria 2020, 'Victorian Government Aboriginal Affairs report 2019: Culture and Country' https://www.aboriginalvictoria.vic.gov.au/victorian-government-aboriginal-affairs-report-2019/culture-country Accessed 23 April 2020.
42. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Draft marine and coastal strategy', Victoria State Government, p. 8 https://engage.vic.gov.au/draft-marine-and-coastal-strategy Accessed 24 September 2021.
43. North East Catchment Management Authority 2021, 'Monitoring and reporting' https://northcentral.rcs.vic.gov.au/this-strategy/monitoring-and-reporting/ Accessed 7 October 2021.

Traditional Owners are also being recognised through Regional Catchment Strategies with a common statewide reporting indicator being developed for partnership with, and participation by, Traditional Owners. The indicator is in the Statewide Communities Outcome (Figure 7) and focuses on partnerships between NRM agencies and Traditional Owners. Such partnerships represent collaborative work to improve natural resource management and to realise Traditional Owners' aspirations and plans for their Country. This indicator is in the section on the localisation of SDG indicators in the SDG synthesis and evaluation in this Summary Report. Future reporting on this indicator by Traditional Owners and CMAs will be incorporated into SoE reporting. The indicator is also aligned with SDG 17: Partnerships for the Goals, specifically Target 17.17: Encourage and promote effective public, public–private and civil society partnerships, building on the experience and resourcing strategies of partnerships.

State of environment reporting

The SoE 2018 Report made a transition from a singular focus (reporting on Aboriginal cultural heritage only), to assessment of cultural landscape health and management. This new reporting approach includes indicators aligned to four themes:

- connection to Country
- building capacity
- land justice, self-determination, governance and mechanisms for sustainability
- funding and pathways to other organisations.

These four themes aim to incorporate the social, economic, spiritual, cultural, environmental and health and wellbeing values of Victorian Traditional Owners, Registered Aboriginal Parties and Aboriginal Victorians. The intention is to respect and support Aboriginal Victorian advancement for Treaty, self-determination and empowerment, as defined in the *Advancing the Treaty Process with Aboriginal Victorians Act 2018* and as advocated by Australia's Human Rights Commission.[44]

Aboriginal Victoria language families

Aboriginal people have lived in Australian coastal areas for the past 65,000 years,[45] and are often termed 'saltwater people'.[46] Under Aboriginal interpretations, saltwater people are Australian Aboriginal peoples from coastal areas across the nation who are the Traditional Owners, guardians and custodians of the lands and waters characterised by saltwater environments.[47] There are more than 250 known Australian Aboriginal languages across the nation.[48] Each saltwater Aboriginal culture group has a Country-specific relationship to its own particular lands and waters. Language and traditional knowledge are integral parts of this relationship.[49] Thus, a generic language or set of traditions does not exist.

At the time of British colonisation, there were approximately 38 languages and 11 language families across Victoria (Note: Languages are shown in lower case text; language families in upper case text. (Figure 7).[50]

Many of the 38 languages were further divided according to family groups and their traditional lands, while the 11 language families were grouped according to shared words, grammar and sounds.[51] During British colonisation, there were approximately eight known Aboriginal language families across coastal Victoria.[52,53] Listed geographically from west to east they are: Buandig, Dhauwurd Wurrung, Keerray Woorroong, Gadubanud, Wadawurrung, Boon Wurrung, Gunai Kurnai and Bidwell.

44. Australian Human Rights Commission 2019, 'Right to self-determination' https://www.humanrights.gov.au/our-work/rights-and-freedoms/right-self-determination Accessed 28 May 2019.
45. Clarkson C, Jacobs Z, Marwick B, Fullagar R et al. 2017, 'Human occupation of northern Australia by 65,000 years ago', *Nature*, 547, pp. 306–310.
46. Thurstan R, Brittain Z, Jones D, Cameron E et al. 2018, 'Aboriginal uses of seaweeds in temperate Australia: an archival assessment', *Journal of Applied Phycology*, 30, pp. 1821–1832, https://doi.org/10.1007/s10811-017-1384-z.
47. Ibid.
48. Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) 2020. 'Mabo v Queensland' (No. 2) [1992] HCA 23; (1992) 175 CLR 1 https://jade.io/article/67683 Accessed 6 October 2021.
49. Thurstan R, Brittain Z, Jones D, Cameron E et al. 2018, 'Aboriginal uses of seaweeds in temperate Australia: an archival assessment', *Journal of Applied Phycology*, 30, pp. 1821–1832, https://doi.org/10.1007/s10811-017-1384-z.
50. Victorian Aboriginal Corporation for Languages (VACL) 2020, Map: 'Aboriginal languages of Victoria' https://vacl.org.au/home Accessed 16 April 2020.
51. ANTaR Victoria 2020, 'Local Nations: language groups' https://antarvictoria.org.au/local-nations Accessed 16 April 2020.
52. Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) 2020. 'Mabo v Queensland' (No. 2) [1992] HCA 23; (1992) 175 CLR 1 https://jade.io/article/67683 Accessed 6 October 2021.
53. Victorian Aboriginal Corporation for Languages (VACL) 2020, Map: 'Aboriginal languages of Victoria' https://vacl.org.au/home Accessed 16 April 2020.

Figure 8: Aboriginal languages and language families across Victoria at the time of British colonisation.[54]

Since British colonisation, many languages in the larger language families have dissipated or disappeared, due to the displacement or dispossession of family groups from their Country, and to laws enforced during colonisation that forbade communities from speaking their own language or practising their culture. The importance of language in a Country-specific relationship to lands and waters, coupled with the diversity of languages and language families along Victoria's coastline and marine waters, highlights the need to support Traditional Owners and Aboriginal Victorians in practising and using their languages and language families.

Victorian Aboriginal rights to access, care and manage Country

In Victoria, Aboriginal Victorians can use several federal and state mechanisms to exercise their rights to access, use and manage lands and water on Country, as a basis for self-determination and economic independence.[55] These mechanisms include:

- *Native Title Act 1993* (Cth) – native title determination covering 14,899 km^2 in Victoria[56]
- *Aboriginal Heritage Act 2006* (Vic) – A Traditional Owner community can be formally recognised in Victoria as a Registered Aboriginal Party (RAP) and hold decision-making responsibilities for protecting Aboriginal cultural heritage in a specific geographical area. As at July 2020, there were 11 RAPs, covering 74% of Victoria[57]
- *Traditional Owner Settlement Act 2010* (Vic) – A Traditional Owner community can achieve legally enforceable recognition by the Crown of its rights to Country, through Traditional Owner Settlement Agreements (TOS). As at June 2020, TOS covered 50,976 km^2 of Victoria.[58]

54. Ibid.
55. Petrie A 2018, 'Land and water rights of Traditional Owners in Victoria', Research paper no. 3, Research and Inquiries Unit, Parliamentary Library and Information Service, Department of Parliamentary Services, Parliament of Victoria https://www.parliament.vic.gov.au/publications/research-papers/send/36-research-papers/13877-land-and-water-rights-of-traditional-owners-in-victoria Accessed 16 April 2020.
56. Aboriginal Victoria 2020, *Victorian Government Aboriginal Affairs report 2020*, Victorian Government, Melbourne, p. 96 https://www.firstpeoplesrelations.vic.gov.au/victorian-government-aboriginal-affairs-report-2020 Accessed 6 October 2021.
57. Victorian Aboriginal Heritage Council (VAHC) 2020, 'Victoria's current Registered Aboriginal Parties' https://www.aboriginalheritagecouncil.vic.gov.au/victorias-current-registered-aboriginal-parties Accessed 23 July 2021.
58. Aboriginal Victoria 2020, *Victorian Government Aboriginal Affairs report 2020*, Victorian Government, Melbourne, p. 96 https://www.firstpeoplesrelations.vic.gov.au/victorian-government-aboriginal-affairs-report-2020 Accessed 6 October 2021.

The lack of an overarching legislative mechanism is a significant barrier to developing a comprehensive and broadly accepted system of recognition for Aboriginal Victorian rights to land and water. This creates complexity for individual Aboriginal Victorians, their communities, governments, private bodies and the broader public as they try to navigate the different mechanisms.[59] Additional complexities arise from the different concepts of land ownership and use held by Aboriginal Victorians and legislators.[60]

It should also be noted that there are many other mechanisms to support self-determination and economic prosperity for all Aboriginal Victorians. These include the *Victorian Charter of Human Rights and Responsibilities Act 2006* (Vic), *Corporations (Aboriginal and Torres Strait Islander) Act 2006* (Cth) and *Advancing the Treaty Process with Aboriginal Victorians Act 2018* (Vic).

Native title

Mabo v Queensland (No. 2) [1992] HCA 23 (commonly known as Mabo) was a landmark decision of Australia's High Court that recognised native title in Australia for the first time. The High Court rejected the doctrine of *terra nullius* in favour of the Common Law doctrine of native title. This saw the passing of the Native Title Act 1993 (Cth), enabling Indigenous people throughout Australia to claim traditional rights to unalienated land.[61] Native title is a set of rights and interests over land or waters where Aboriginal and Torres Strait Islander groups have practised traditional laws and customs since before the time of European occupation and continue to do so. Native title determinations of relevance to the geographic scope of this SMCE 2021 Report include:

- Gunditj Mirring Traditional Owners Aboriginal Corporation Native Title Determination 2007, covering almost 140,000 hectares across south-west Victoria. Consent determination area is bounded on the west by the Glenelg River and to the north by the Wannon River.[62]
- Gunditj Mirring Traditional Owners Aboriginal Corporation and Eastern Maar Aboriginal Corporation Native Title Determination 2011, for the land and waters between the Shaw and Eumeralla Rivers from Deen Maar (Lady Julia Percy Island), including Yambuk, to Lake Linlithgow.
- Gunaikurnai Native Title Determination 2010.

A native title proceeding still underway, and relevant to the scope of this report, is the Eastern Marr Aboriginal Corporation's native title claim in the Federal Court, lodged in 2012.

Traditional Owner Settlement Agreements

The Traditional Owner Settlement Act (TOS Act) provides a framework for the Victorian Government to recognise Traditional Owners and their rights to Country. At the time of publication, three Victorian Traditional Owner Corporations had negotiated such an agreement, of which one is within the scope of the SMCE 2021 Report:

- Gunaikurnai Land and Waters Aboriginal Corporation
- Dja Dja Wurrung Clans Aboriginal Corporation
- Taungurung Clans Aboriginal Corporation.

New Traditional Owner Settlement Agreements continue to be negotiated alongside native title determinations, and include:

- Eastern Maar
- First Peoples of the Millewa Mallee
- Barengi Gadjin Land Council (represents Traditional Owners from the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagulk communities who already hold native title rights).

Registered Aboriginal Parties

In Victoria, there are currently 11 Registered Aboriginal Parties (RAPs), covering approximately 75% of the state. Five of these have Country along the Victorian coastline and which extends out into marine waters:

- Bunurong Land Council Aboriginal Corporation
- Eastern Maar Aboriginal Corporation
- Gunaikurnai Land and Waters Aboriginal Corporation

59. Petrie A 2018, 'Land and water rights of Traditional Owners in Victoria', Research paper no. 3, Research and Inquiries Unit, Parliamentary Library and Information Service, Department of Parliamentary Services, Parliament of Victoria https://www.parliament.vic.gov.au/publications/research-papers/send/36-research-papers/13877-land-and-water-rights-of-traditional-owners-in-victoria Accessed 16 April 2020.
60. Ibid.
61. Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) 2020. 'Mabo v Queensland' (No. 2) [1992] HCA 23; (1992) 175 CLR 1 https://jade.io/article/67683 Accessed 6 October 2021.
62. Gunditj Mirring Traditional Owners Aboriginal Corporation 2020, 'Native title across Gunditjmara Country' https://www.gunditjmirring.com/nativetitle Accessed 23 April 2020.

- Gunditj Mirring Traditional Owners Aboriginal Corporation
- Wadawurrung Traditional Owners Aboriginal Corporation.[63]

RAPs are Traditional Owner groups legally recognised under the *Aboriginal Heritage Act*. As the primary guardians, RAPs are responsible for managing and protecting the Aboriginal cultural heritage of a particular area. RAPs are the primary source of advice and knowledge on matters relating to Aboriginal places or objects in their region. Their functions include:

- evaluating cultural heritage management plans
- assessing cultural heritage permit applications
- making decisions about cultural heritage agreements
- providing advice on applications for interim or ongoing protection declarations
- entering into Aboriginal Cultural Heritage Land Management Agreements with public land managers
- nominating Aboriginal intangible heritage to the Victorian Aboriginal Heritage Register and managing intangible heritage agreements.[64]

Under the Aboriginal Heritage Act, intangible heritage is defined 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 environmental and ecological knowledge, but does not include anything that is widely known to the public. It also includes any intellectual creation or innovation.

RAPs are Traditional Owner organisations with established administrative and management functions that hold decision-making powers under the Act for the protection and management of Aboriginal cultural heritage in a specified geographic area. RAPs are appointed by the Victorian Aboriginal Heritage Council, an independent statutory body. The Council consists of up to 11 Traditional Owners, who are appointed by the Minister for Aboriginal Affairs. All members are resident in Victoria and have extensive knowledge and relevant experience of Aboriginal cultural heritage in Victoria. The Office of the Victorian Aboriginal Heritage Council provides support to the Victorian Aboriginal Heritage Council. Victoria's RAPs are shown in Figure 9.

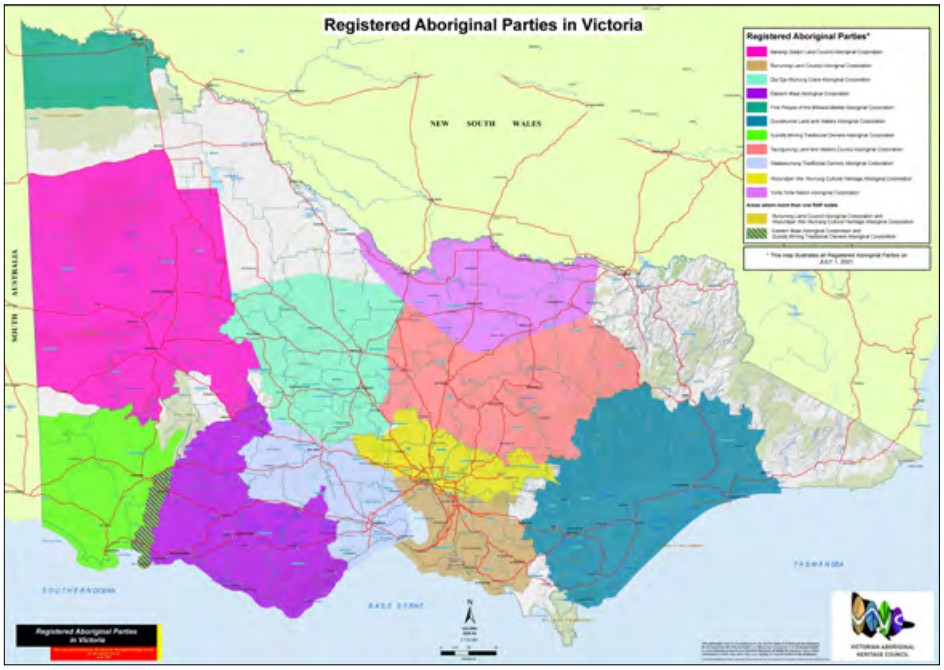


Figure 9: Registered Aboriginal Parties (RAPs) in Victoria as at 1 July 2021.[65]

63. Victorian Aboriginal Heritage Council (VAHC) 2020, 'Victoria's current Registered Aboriginal Parties' https://www.aboriginalheritagecouncil.vic.gov.au/victorias-current-registered-aboriginal-parties Accessed 23 July 2021.
64. Victorian Aboriginal Heritage Council (VAHC) 2021, 'About Registered Aboriginal Parties' https://www.aboriginalheritagecouncil.vic.gov.au/victorias-registered-aboriginal-parties Accessed 23 July 2021.
65. Victorian Aboriginal Heritage Council (VAHC) 2020, 'Victoria's current Registered Aboriginal Parties' https://www.aboriginalheritagecouncil.vic.gov.au/victorias-current-registered-aboriginal-parties Accessed 23 July 2021.

To reiterate, Traditional Owners are formally recognised by the Victorian Government in three ways: through the Native Title Act 1993 (Cth); by way of a recognition and settlement agreement under the Traditional Owner Settlement Act 2010 (Vic); and through appointment as a Registered Aboriginal Party (RAP) under the Aboriginal Heritage Act 2006 (Vic).

Victorian Aboriginal cultural heritage

Aboriginal cultural heritage in Victoria is protected under the Aboriginal Heritage Act 2006 (the Act) and Aboriginal Heritage Regulations 2018. Aboriginal cultural heritage is the knowledge and lore, practices and people, objects and places that are valued, culturally meaningful and connected to identity and Country and that has been passed on from ancestors to future generations.[66] The Act establishes a framework of mechanisms for the management and protection of Aboriginal cultural heritage, including cultural heritage management plans, cultural heritage permits, protection declarations, and Aboriginal Cultural Heritage Land Management Agreements. Aboriginal cultural heritage can be tangible or intangible, and can include secret or sacred objects, ancestral remains, Aboriginal places, knowledge, lore and practices.

Caring for Country

Under the terms and objectives of these legislative mechanisms for ensuring Aboriginal Victorian rights to access, manage and care for Country, several formal approaches support Treaty, self-determination, land justice and economic prosperity. Some of these are discussed below, but this is not a complete list. There are many formal and informal agreements and partnerships between Aboriginal Victorian communities and local government, government statutory bodies and the wider community that are not listed here.

Joint management plans

Joint management refers to a formal partnership between Traditional Owner communities and the Victorian Government that promotes the sharing of knowledge on the management of Crown land, such as national parks or other public parks.[67,68] Joint management is established under the terms of the *Conservation, Forests and Lands Act 1987* (Vic) and the Traditional Owners Settlement Act 2010 (Vic) via a Recognition and Settlement Agreement.

Joint management is formalised via a Traditional Owner Land Management Agreement (TOLMA) by Traditional Owner communities under a form of land title called Aboriginal Title. The TOLMA can include a provision for national parks and other public parks to be returned to Aboriginal ownership while continuing to be managed as a national park or a public park. The TOLMA establishes a process for developing joint management plans on Aboriginal Title lands and involves Traditional Owners working with Parks Victoria and DELWP staff in sharing knowledge to manage these lands.

Joint management plans are endorsed by the Secretary of DELWP and the Victorian Minister for Environment. Endorsed plans also allow for the establishment of Traditional Owner Land Management Boards, to recognise the knowledge and culture of Traditional Owner communities in the joint management of Aboriginal Title lands. Traditional Owner Land Management Board members are appointed by the Minister for Environment, where membership composition is at least 50% Traditional Owner representation, DELWP Secretary's nominee and general members. Membership can range between 7 and 11 people. Joint management also aims to economically benefit the whole Traditional Owner community through the creation of jobs, such as joint manager rangers, and potential commercial partnerships, while supporting reconciliation, land justice and community healing.[69]

Parks Victoria and DELWP will continue to manage the lands on a day-to-day basis and will permanently keep some core management functions.[70] This includes fire management and catchment management including designated water supply catchment areas under the *National Parks Act 1975* (Vic).[71] Traditional Owner Land Management Boards will also play a role in monitoring and supporting compliance with Joint Management Plans.

66. Victorian Aboriginal Heritage Council (VAHC) 2020, 'Aboriginal cultural heritage' https://www.aboriginalheritagecouncil.vic.gov.au/aboriginal-heritage Accessed 16 April 2020.
67. Parks Victoria 2020, 'Managing Country together' https://www.parks.vic.gov.au/managing-country-together Accessed 16 April 2020.
68. Petrie A 2018, 'Land and water rights of Traditional Owners in Victoria', Research paper no. 3, Research and Inquiries Unit, Parliamentary Library and Information Service, Department of Parliamentary Services, Parliament of Victoria https://www.parliament.vic.gov.au/publications/research-papers/send/36-research-papers/13877-land-and-water-rights-of-traditional-owners-in-victoria Accessed 16 April 2020.
69. Parks Victoria 2020, 'Managing Country together' https://www.parks.vic.gov.au/managing-country-together Accessed 16 April 2020.
70. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Land management: joint management' https://www.forestsandreserves.vic.gov.au/land-management/joint-management Accessed 16 April 2020.
71. Ibid.

At the time of writing this report, Victoria had formal agreements with five Traditional Owner communities for joint management of traditional lands under either the Native Title Act 1993 (Cth), Traditional Owner Settlement Act 2010 (Vic) and/or the Aboriginal Heritage Act 2006 (Vic).[72] Formal agreements relevant to the geographic scope of this SMCE 2021 Report include:

- Gunaikurnai Settlement Agreement: established in 2010 – the first agreement under the Traditional Owner Settlement Act.
- Gunditjmara Settlement Agreement: established in 2007 following a consent determination from the High Court of Australia.[73]

Aboriginal Cultural Heritage Land Management Agreements

An Aboriginal Cultural Heritage Land Management Agreement is a voluntary agreement between a RAP and a public land manager[74] It facilitates a proactive, holistic approach to managing and protecting Aboriginal cultural heritage and landscape during ongoing, routine land management activities in a RAP area.[75] These agreements document the approach taken to manage Aboriginal cultural heritage by setting out the results of a cultural heritage assessment and mutually agreed measures on how Aboriginal cultural heritage will be protected and managed during land management activities over a specified time frame.[76] As at June 2021, three RAPs have entered into an Aboriginal Cultural Heritage Land Management Agreement.[77]

Whole of Country Plans

Several Victorian Traditional Owner organisations, including RAPs, are working in partnership with government and non-government organisations to develop Whole of Country Plans, strategies and assessment frameworks that will integrate cultural heritage and spiritual values, self-determination and governance, health and wellbeing, and economic capacity to improve, care and manage the cultural landscape health of Country. Whole of Country Plans are overarching, long-term visions that set out clear goals and priorities, principles of engagement, and measures of success in caring for Country.[78] At the time of this report's publication, there were nine Whole of Country Plans.

Those relevant to the geographic scope of this SMCE 2021 Report include:

- Gunaikurnai Whole-of-Country Plan – Gunaikurnai Land and Waters Aboriginal Corporation
- Budj Bim Master Plan (including UNESCO World Heritage Landscape listing and Indigenous Protected Areas) – Gunditj Mirring Traditional Owners Aboriginal Corporation
- Meerreengeeye ngakeepoorryeeyt Country Plan – Eastern Maar Aboriginal Corporation.

Indigenous Peoples' Protected Areas

Indigenous Peoples' Protected Areas (IPA), also known as Indigenous Peoples' and Community Conserved Territories and Areas, are defined as:

clearly defined geographical spaces, within the lands and waters under traditional occupation and use by a given Indigenous people, nation or community, that are voluntarily dedicated and managed, through legal or other effective means including their customary law and institutions, to achieve the long-term conservation of nature with associated ecosystem services, as well as the protection of the inhabiting communities and their culture, livelihoods and cultural creations.[79]

72. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Agreements with Traditional Owners' https://www.forestsandreserves.vic.gov.au/land-management/what-we-do/agreements-with-traditional-owners Accessed 16 April 2020.
73. Native Title Tribunal 2007, 'The Gunditjmara People's native title determinations 30 March 2007 south-west Victoria' http://www.nntt.gov.au/Information%20Publications/Determination%20brochure%20Gunditjmara%20March%202007.pdf
74. Aboriginal Victoria 2020, 'Cultural heritage management plans, permits, agreements and tests: processes under the Aboriginal Heritage Act 2006 for managing and protecting Aboriginal cultural heritage' https://www.aboriginalvictoria.vic.gov.au/cultural-heritage-management-plans-permits-agreements-and-tests Accessed 16 April 2020.
75. Ibid.
76. Aboriginal Victoria 2020, 'Aboriginal Cultural Heritage Land Management Agreements' https://www.aboriginalvictoria.vic.gov.au/aboriginal-cultural-heritage-land-management-agreements Accessed 23 April 2020.
77. Personal communication: Department of Premier and Cabinet 2021, First Peoples – State Relations Group, Victorian Government, Melbourne.
78. Aboriginal Victoria 2020, 'Victorian Government Aboriginal Affairs report 2019: Culture and Country' https://www.aboriginalvictoria.vic.gov.au/victorian-government-aboriginal-affairs-report-2019/culture-country Accessed 23 April 2020.
79. Stolton S, Shadie P, and Dudley N 2013, 'IUCN WCPA best practice guidance on recognising protected areas and assigning management categories and governance types', Best practice protected area guidelines series no. 21, International Union for Conservation of Nature, Gland, Switzerland https://www.iucn.org/theme/protected-areas/resources/iucn-wcpa-best-practice-guidelines-protected-area-managers-series Accessed 24 September 2021.

IPA rules generally intertwine with cultural and spiritual values. Although some of the protected areas governed by Indigenous peoples and local communities have been in existence for hundreds or even thousands of years, their recognition by national governments and their inclusion in national protected area systems is a much more recent phenomenon.[80] The main distinguishing features of IPAs have to do with the socio-political arrangements that are established between Indigenous peoples and government of lands and resources in Indigenous peoples' lands:

- IPAs are based on the collective rights of the respective Indigenous people, nation or community to lands, territories and resources, under national contexts.
- IPAs are established as protected areas in application of the right of self-determination, exercised mainly through:
    - self-declaration of the protected area by the Indigenous people or nation with collective territorial rights on the area
    - free, prior and informed consent of the people, nation or community with territorial rights on the area, in cases where the designation proposal is originated in government agencies, conservation organisations or other actors.
- IPAs are based on ancestral or traditional occupation.
    - Occupation, use and management are connected to and dependent upon the broader socio-cultural and political structure of a people or nation, which includes their customary law and institutions.
- IPAs are self-governed by Indigenous institutions within their territories and the protected areas contained therein, in application of arrangements established with system-level protected area authorities[81]

In Australia, IPAs have been created at the request or initiative of Indigenous owners, or through joint arrangements with governments and agencies. In such cases, Indigenous land and resource rights, as well as Indigenous government of the land, are important features. In Victoria, RAPs and Traditional Owners are primary guardians responsible for IPAs.

Within the geographic scope of the SMCE 2021 Report, the Gunditj Mirring Traditional Owners Aboriginal Corporation is the guardian for the IPA in the Budj Bim UNESCO World Heritage Landscape.

Marine and coastal public policy context

Victorian, as well as international and national, public policies are of direct relevance to this State of the Marine and Coastal Environment 2021 Report.

Prominent policies are briefly described below, with more detail on the policies and their direct links to environmental condition and management of the marine and coastal environment provided in the indicator assessment narratives in Part 3.

International

When the parties to the UN Convention on Biological Diversity met in 2010 at Aichi, Japan, they committed to the Strategic Plan for Biodiversity 2011–2020. This set five strategic goals and 20 targets for countries to slow and reverse biodiversity loss during the UN Decade on Biodiversity.

The 2030 Agenda for Sustainable Development was adopted by the UN in 2015 and comprises 17 goals with 169 targets.[82] Victoria's progress towards many of the Sustainable Development Goals (SDGs) – notably 'SDG 13 – Climate action', 'SDG 15 – Life below water' and 'SDG 17 – Partnerships for the goals' – are reviewed in Part 2 of the present report.

Indicator 32, Conservation of marine ecosystems in protected areas, contains an analysis of Victoria's extent of marine protected areas against international benchmarks for levels of protection, such as the Aichi targets and the SDGs. Both Aichi Target 11 and SDG Target 14.5 aim for at least 10% of coastal and marine areas to be conserved.

The Ramsar Convention[83] aims to halt the loss of wetlands and conserve those that remain. Victoria has 12 wetland sites on the List of Wetlands of

80. Ibid.
81. Ibid.
82. United Nations Department of Economic and Social Affairs, n.d. 'Sustainable development: The 17 goals' https://sdgs.un.org/goals Accessed 23 September 2021.
83. Ramsar Convention 2014, 'Wetlands of international importance' https://www.ramsar.org/sites-countries/wetlands-of-international-importance Accessed 23 September 2021.

As a signatory to the Ramsar Convention, Australia has committed to wetlands conservation, reserves and education. The first of a series of national action plans was released in 2016, and forms part of Australia's implementation of the four goals and 19 strategies of the Ramsar Strategic Plan 2016–24. Seven thematic sub-chapters in Part 3 of the present report include a focus on the Gippsland Lakes.

National

Several national policies, strategies, plans and laws are relevant to the scope of the present report.

The Commonwealth Department of Agriculture, Water and Environment is responsible for protecting and strengthening Australia's agriculture, water resources, environment and heritage. The relevant ministers administer various national laws, including the *Environment Protection and Biodiversity Conservation Act 1999* .[84] This is Australia's most important piece of environmental legislation and covers environment and heritage protection and biodiversity conservation. Actions that will lead to changes in land use or land management in any state or territory may be subject to its provisions.

The Environment Protection and Biodiversity Conservation Act protects nine 'matters of national environmental significance', including:

- listed threatened species and communities
- listed migratory species
- Ramsar wetlands of international importance
- world heritage properties
- national heritage places.

The National Climate Resilience and Adaptation Strategy 2015[85] follows on from the National Climate Change Adaptation Framework agreed to by the Commonwealth, state and territory governments in 2007. The strategy has as its vision: 'We act together to support prosperity and wellbeing in Australia and beyond by building the resilience of communities, the economy and the environment to a variable and changing climate'.[86] Its four priorities for national engagement are 'Understand and communicate', 'Plan and act', 'Check and reassess' and 'Collaborate and learn'.

Various standards, guidelines and strategies have been developed to mitigate risks associated with shipping and ports. The International Convention for the Control and Management of Ships' Ballast Water and Sediment places obligations on vessels to manage ballast water to reduce the translocation of invasive marine species.[87] Australian commercial shipping standards assist in maintaining vessel safety, thus minimising the risk of potential accidents, such as oil spills.[88] The *Biosecurity Act 2015* (Cth) deals with ballast water and marine pests.[89] The Australian Ballast Water Management Requirements set out the obligations on vessel operators for the management of ballast water and ballast tank sediment when operating in Australian seas.[90]

National guidelines deal with problems such as biofouling (Anti-Fouling and In-water Cleaning Guidelines 2015).[91] To minimise the risks associated with marine pests, the Commonwealth Government, in conjunction with state and territory governments, industry, research organisations and non-government organisations, has released *MarinePestPlan 2018–2023*.[92] 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
- engage stakeholders to better manage marine pest biosecurity.

84. Commonwealth of Australia, *Environment Protection and Biodiversity Conservation Act 1999*, https://www.legislation.gov.au/Series/C2004A00485 Accessed 23 September 2021.
85. Commonwealth of Australia 2015, 'National climate resilience and adaptation strategy', https://www.environment.gov.au/climate-change/adaptation/strategy Accessed 23 September 2021.
86. Ibid.
87. International Maritime Organisation 2004, 'International convention for the control and management of ships' ballast water and sediments. Adoption: 13 February 2004; Entry into force: 8 September 2017' https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Control-and-Management-of-Ships%27-Ballast-Water-and-Sediments-(BWM).aspx Accessed 6 July 2021.
88. Australian Maritime Safety Authority 2021, 'National standard for commercial vessels (NSCV)', Australian Government, Canberra https://www.amsa.gov.au/about/regulations-and-standards/national-standard-commercial-vessels-nscv Accessed 1 July 2021.
89. Commonwealth of Australia 2020, *Biosecurity Act 2015*, no. 61, compilation no. 8 incorporating amendments up to 25 March 2020 https://www.legislation.gov.au/Details/C2020C00127 Accessed 6 July 2021.
90. Department of Agriculture, Water and the Environment 2020, 'Australian ballast water management requirements: Version 8', Australian Government, Canberra.
91. Department of Agriculture, Department of Environment 2015, 'Anti-fouling and in-water cleaning guidelines', Australian Government, Canberra. https://www.agriculture.gov.au/sites/default/files/documents/australian-ballast-water-management-requirements.pdf.
92. Department of Agriculture and Water Resources 2018, 'MarinePestPlan 2018–2023: The national strategic plan for marine pest biosecurity', Australian Government, Canberra, https://www.marinepests.gov.au/what-we-do/publications/marine-pest-plan Accessed 18 November 2021.

National Light Pollution Guidelines for Wildlife were published by the Commonwealth Government in January 2020.[93] In the introduction to these guidelines, natural darkness was described as providing a conservation value in the same way that clean water, air and soil have intrinsic value.

Victorian

Several Victorian Government agencies and organisations are part of the collaborative governance arrangements that influence biodiversity conservation and bushfire management and recovery. They interact with a diverse and complex set of policies, laws, regulations, strategies, plans and monitoring frameworks.

On 1 August 2018 the Marine and Coastal Act 2018 (the Act) came into effect, with the aim of protecting Victoria's marine and coastal environment now and into the future. The Act outlines the following objectives for the planning and management of the marine and coastal environment in Victoria:

- to protect and enhance the marine and coastal environment
- to promote the resilience of marine and coastal ecosystems, communities and assets to climate change
- to respect natural processes in planning for and managing current and future risks to people and assets from coastal hazards and climate change
- to acknowledge Traditional Owner groups' knowledge, rights and aspirations for land and sea Country
- to promote a diversity of experience in the marine and coastal environment
- to promote the ecologically sustainable use and development of the marine and coastal environment and its resources in appropriate areas
- to improve community, user group and industry stewardship and understanding of the marine and coastal environment
- to engage with specified Aboriginal parties, the community, user groups and industry in marine and coastal planning, management and protection
- to build scientific understanding of the marine and coastal environment.

The Act is complemented by Victoria's Marine and Coastal Reforms Final Transition Plan, which lists 45 actions to be taken between 2018 and 2022. Making a statewide marine and coastal policy, which includes a marine spatial planning framework, and also making a statewide marine and coastal strategy, are some of the Transition Plan's most important actions.

The Act requires the Minister to make a marine and coastal policy that:

- sets out policies for planning and managing the marine and coastal environment
- provides guidance to decision-makers in delivering the objectives of the Act
- includes a Marine Spatial Planning Framework to set out steps for achieving integrated and coordinated planning and management of Victoria's marine environment.

The Victorian Government, with guidance from the Victorian Marine and Coastal Council, developed a statewide Marine and Coastal Policy, which was released in March 2020.[94] An important focus of the policy is to manage the health of the marine and coastal environment so that ecosystems, communities and built assets are as resilient as they can be in the face of future change. Change could be from natural hazards, climate change, population growth or, most likely, a combination of these factors. The policy states that a healthy marine and coastal environment will promote resilience for industries and communities that rely on its resources from a liveability and economic perspective.

The Act requires the relevant Victorian Government minister to make a marine and coastal strategy within 12 months of formulating the marine and coastal policy. A draft strategy was released in July 2021, containing six actions:

- Traditional Owners determine how their rights and obligations are embedded into planning and management of the marine and coastal environment.

93. Australian Government Department of the Environment and Energy, and Western Australian Department of Biodiversity, Conservation and Attractions 2020, 'National light pollution guidelines for wildlife: Including marine turtles, seabirds and migratory shorebirds', Commonwealth of Australia. https://www.environment.gov.au/system/files/resources/2eb379de-931b-4547-8bcc-f96c73065f54/files/national-light-pollution-guidelines-wildlife.pdf.
94. Department of Environment, Land Water and Planning (DELWP) 2020, 'Marine and coastal policy', East Melbourne, Victoria. https://www.marineandcoasts.vic.gov.au/__data/assets/pdf_file/0027/456534/Marine-and-Coastal-Policy_Full.pdf

- Improve the condition and connectivity of habitats and respect and care for our marine and coastal areas.
- Support sustainable use and development of the marine and coastal environment.
- Adapt to impacts of climate change.
- Implement integrated planning of the marine environment.
- Identifying resource needs and funding for sustainable marine and coastal management.[95]

The Marine and Coastal Act 2018 (the Act) requires the development of a statewide marine and coastal policy that must include a Marine Spatial Planning Framework which 'establishes a process for achieving integrated and coordinated planning and management of the marine environment'. The Marine Spatial Planning Framework provides an overarching guide for planning, management and decision-making by marine sectors.

A Marine and Coastal Council (effective 1 August 2018) has been tasked with providing independent advice to the government on a range of matters including:

- the development and implementation of statewide policy and strategy (and other plans developed under the Act)
- significant decisions relating to the marine and coastal environment
- matters requiring scientific research.

Environmental Management Plans (EMPs) can be developed under the Marine and Coastal 2018 Act at the discretion of the Minister. Currently there is only one EMP implemented in Victoria. The Act requires an EMP for Port Phillip Bay and five-yearly evaluation. This plan, and any developed in the future for other marine and coastal ecosystems, will align government, industry and community groups on actions to manage future challenges resulting from population growth, urbanisation, and climate change. The monitoring, evaluation, reporting and improvement mechanisms associated with developing and implementing EMPs will be used to inform future State of the Marine and Coastal Environment Reports.

In July 2021, the Environment Protection Act 2017 (Vic) came into effect. It incorporated findings from the Victorian 2016 Inquiry into the EPA.[96] This Act's subordinate legislation includes Environment Protection Regulations and the ERS.[97] The ERS is a new tool which identifies environmental values that Victorians want to achieve and maintain, and enables assessment of those values across Victoria.[98]

Victoria's Climate Change Strategy, released in 2021, is a roadmap to net-zero greenhouse gas emissions and a climate-resilient Victoria by 2050. The initiatives in the Climate Change Strategy will support communities and businesses as they make the changes needed to reduce the effects of climate change and continue to support our economy to grow.[99]

The Invasive Plants and Animals Policy Framework presents the overarching Victorian Government approach to the management of existing and potential invasive species. It incorporates a biosecurity approach and ensures that Victoria maintains a comprehensive planning framework to guide future policy, planning and community activity specific to invasive species. The document sets out a vision for what invasive species management can achieve for Victoria, and a framework for working towards that vision. Response to invasive pests is also part of the State Emergency Management Plan Biosecurity Sub-plan. This describes the integrated approach and shared responsibility between state and Commonwealth governments, agencies, business and the community in responding to biosecurity emergencies, which may be new incursions of invasive plants or animals, or rapid population increases in established pests.[100] Cooperation and coordination between agencies can improve emergency preparedness, including the development and regular review of agreed emergency response arrangements, and ensuring adequate training and capacity.

95. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Draft marine and coastal strategy', Victoria State Government, p. 3 https://engage.vic.gov.au/draft-marine-and-coastal-strategy Accessed 24 September 2021.
96. Environmental Protection Authority Victoria 2021, 'New laws to better protect the environment' https://www.epa.vic.gov.au/about-epa/laws/new-laws Accessed 2 August 2021.
97. Environmental Protection Authority Victoria 2021, 'Subordinate legislation tools to support the new Act' https://www.epa.vic.gov.au/about-epa/laws/new-laws/subordinate-legislation Accessed 2 August 2021.
98. Environmental Protection Authority Victoria 2021, 'The Environment Reference Standard: About the Environment Reference Standard' https://www.epa.vic.gov.au/about-epa/laws/epa-tools-and-powers/environment-reference-standard Accessed 2 August 2021.
99. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victoria's climate change strategy' https://www.climatechange.vic.gov.au/victorias-climate-change-strategy Accessed 26 May 2021.
100. Emergency Management Victoria 2018, 'State Emergency Response Plan. Biosecurity Sub-Plan', Edition 1.1, p. 11. Note that the State Emergency Response Plan (SERP) has been superseded by the State Emergency Management Plan (SEMP), which incorporates existing sub-plans from the SERP.

Table 2: Victorian legislation and policies relevant to the SMCE 2021 Report.

Theme	Legislation and policies
Water quality and catchment inputs	Environmental Protection Act 2017 Water Act 1989 Melbourne Water 2018, Healthy Waterways Strategy 2018–2028 Port Phillip Bay Environmental Management Plan 2017–2027 Coastcare Victoria Strategy 2020–2025 State Environment Protection Policy (Waters) 2018 State Environment Protection Policy (Waters) Environmental Reference Standards 2021
Litter and pollution	Environmental Protection Act 2017 Environment Protection Regulations 2021 Melbourne Water 2018, Healthy Waterways Strategy 2018–2028 Coastcare Victoria Strategy 2020–2025
Biodiversity	Fisheries Act 1995 Victorian Fisheries Regulations 2009 Environmental Protection Act 2017 Environmental Reference Standards Flora and Fauna Guarantee Act 1988 Port Phillip Bay Environmental Management Plan 2017–2027 Biodiversity 2037 Coastcare Victoria Strategy 2020–2025 Parks Victoria Act 2018, Marine National Parks and Marine Sanctuaries, Marine and Coastal Parks, Marine Parks, Marine Reserves and Managing Country Together
Seafloor integrity and health	Land Act 1958 Biodiversity 2037
Pests and invasive species	Catchment and Land Protection Act 1994 Flora and Fauna Guarantee Act 1988 National Parks Act 1975 Fisheries Act 1995 Sustainable Forests (Timber) Act 2004 State Emergency Management Plan Biosecurity Sub-plan Invasive Plants and Animals Policy Framework

Table 2: Victorian legislation and policies relevant to the SMCE 2021 Report.

Theme	Legislation and policies
Climate and climate change impact	Climate Change Act 2017 Victoria's Climate Change Strategy 2021 Victoria's Draft 30-Year Infrastructure Strategy 2020 Siting and Design Guidelines for Structures on the Victorian Coast, May 2020
Managing coastal hazards and risks	Climate Change Act 2017 Victoria's Climate Change Strategy 2021 Emergency Management Act 2013
Communities	Marine and Coastal Act 2018 Marine and Coastal Policy 2020 Draft Marine and Coastal Strategy 2021 Victoria's Climate Change Strategy 2021 Great Ocean Road and Environs Protection Act 2020 Victorian Planning and Environment Act 1987 Victorian Planning Provisions Planning and Environment Amendment (Distinctive Areas and Landscapes) Act 2018 Aboriginal Heritage Act 2006 Heritage Act 2017 Heritage (Underwater Cultural Heritage) Regulations 2017 Port Management Act 1995 State Emergency Management Plan Biosecurity Sub-plan Fisheries Act 1995 Environmental Protection Act 2017 Siting and Design Guidelines for Structures on the Victorian Coast May 2020
Stewardship and collaborative management	Environmental Protection Act 2017 Catchment and Land Protection Act 1994 Crown Land Reserves Act 1978 Coastal Waters (State Title) Act 1980 Marine and Coastal Act 2018 Marine and Coastal Policy 2020 Draft Marine and Coastal Strategy 2021 Coastcare Victoria Strategy 2020–2025

Part 2A
Spatial analysis

Commissioner *for* Environmental Sustainability Victoria

Spatial analysis

This section[101] focuses on spatial information technology and data coordination for state of the environment reporting. Spatial technologies are divided into eight categories for this analysis, with five categories representing data collection types and three defined as data technologies (Table 3). The opportunities and potential for spatial information technologies are supported by the analysis in Appendix A. This analysis considers in detail each technology's potential to improve marine and coastal reporting now, in the immediate future and in the longer term.

Table 3: Spatial technology and data maturity assessment.

		Current	Emerging	Future
DATA COLLECTIONN TYPES	**Earth observation (EO) and remote sensing**	Satellite passive and active sensors Aerial imagery Airborne light detection and ranging (LiDAR) Mobile LiDAR Ship sonar Video	SmallSats (small spacecraft) and CubeSats (a class of nanosatellite) High-altitude pseudo satellites (HAPS) Analysis-ready data (ARD) Configurable payloads Satellite-as-a-service e.g., Exodus Orbitals Ground-station-as-a-service e.g., Amazon GroundStation or Azure Orbital	Real-time EO Persistent EO HD video from space Sensor miniaturisation and integration New sensors e.g. ultraspectral Space-based edge computing Satellite on board processing
	Smart sensors and the Internet of Things (IoT)	QR Codes, barcodes and radio frequency identification devices Smartphones Telemetry systems Sensor meters and probes Data loggers Smart meters DNA sensors	Real-time 5G mobile IoT Edge computing Explosion of IoT devices Intelligent sensor networks IoT analytics Digital twins Smart cities Mobile phone LiDAR Low Earth orbit communication e.g. SpaceX's Starlink	Smart cars Smart houses Intelligent mobility The Internet of Animals (IoA)
	Remotely piloted vehicle systems	Fixed-wing, single-rotor and multi-rotor Blimps, balloons and kites Boats, submersibles and underwater gliders Optical camera and video payloads Thermal camera payloads Multispectral or hyperspectral camera payloads	Hybrid platforms LiDAR payloads Specialised payloads Obstacle detection and collision avoidance Open real-time kinematic and satellite-based augmentation systems for aviation Automated RPV for sonar seafloor capture	Solar RPV Self-driving autonomous RPV Smart RPV (capture, analyse and act) Smart sensor payloads Onboard optimisation of big data processing
	Global positioning system (GPS) and tracking	Data loggers and passive tracking Data pushers and active tracking Data pullers and transponders Free, open centimetre-level accurate positioning	Integrating IoT connectivity Geofencing Device miniaturisation Precise indoor positioning Release timers Satellite-based augmentation systems and real-time kinematic accurate Global navigation satellite systems (GNSS) and inertial measurement unit (GNSS+IMU) sensor fusion Dead-reckoning techniques	Improved battery life for multi-year lifespan tracking The Internet of (tracked) Animals Precise smartphone GNSS Ubiquitous, low-cost, high-accuracy devices
	Citizen science	Traditional citizen science projects Citizen Science platforms Crowdsourcing Real-time data streams for planning and mapping e.g., Google traffic	New technologies for data collection Citizen science in policymaking Gamification Virtual peers (bots) Machine Learning for citizen science data	Citizen sensing
DATA TECHNOLOGY	**Artificial intelligence (AI) and machine learning**	Predictive analysis Decision support systems Optimisation ML	Artificial Intelligence AI Deep learning Automated feature extraction Real-time predictions Imagery+synthetic aperture radar (Imagery+SAR) ML super sampling	Natural language processing Generative adversarial networks AI robotics & and Artificial Intelligence of Things Event detection from ML (+SAR) Space-based ML and AI
	Big data and analytics including a geographic information system (GIS) mapping	Local storage and computing Distributed processing Data mining Predictive analysis Visualisation GIS analysis for experts Scripting and visual modelling	Cloud storage and computing Hybrid storage (local and cloud) Multi-cloud environments such as BigQuery Open Data Cube Cloud-based supercomputer capability	Space-based edge computing Quantum computing Fast data Actionable data Intelligent modelling (eGIS for non-experts) Self-organising big data optimisation
	Simulation and modelling	Environmental modelling Species predictive modelling (ARI) Atmospheric modelling	Thematic digital twin Environmental modelling + simulation and warning Simulated populations	Ocean avatar Real-time monitoring Understanding blue carbon fluxes

101. The content in this section (and Appendix A) has been adapted from analysis provided by FrontierSI 2021.

There is overlap between categories for two primary reasons: (i) data collection types must be paired with a data technology to process and analyse acquired data, and (ii) the rise of integrated technologies. For example, citizen scientists may use remotely piloted vehicles to capture earth observation data which are then processed by machine learning algorithms to extract useful information.

The following analysis describes the opportunity to apply these technologies to future SMCE reports.

Earth observation and remote sensing

Earth observation (EO) involves acquiring information about the Earth's surface using remote sensing. This began with capturing aerial photographs from a balloon in the 1850s, only two decades after photography was invented. Today there are many types of sensors categorised as passive or active. Passive sensors do not emit radiation, but typically use the sun as the energy source, including multispectral, hyperspectral and microwave radiometry sensors. Active sensors provide their own energy source and include light detection and ranging (LiDAR), synthetic aperture radar (SAR) and radar altimetry sensors. There are also different platforms for these sensors including remotely piloted aircraft (drones), aeroplanes, satellites and ships.

In recent years, satellites have become smaller, promoting reduced build and launch costs, and resulting in the emergence of SmallSats and CubeSats and an exponential increase in space satellites. A focus on improving spatial resolution and obtaining better coverage and faster revisit time aims to provide near real-time, persistent EO monitoring accessible to everyone. With an abundance of satellites in orbit, the collaborative economy is being applied to this industry with satellite-as-a-service, for shared access to single-host, multi-tenant platforms through pay-as-you-go services. EO providers are likely to evolve from data to intelligent information provision. The future of EO will include new sensor types such as greenhouse gas emissions detection, sensor miniaturisation and integration, space-based computing to produce analysis-ready data in space, and real-time persistent monitoring.

See Appendix A for an analysis of EO and remote sensing applications for marine and coastal science.

Smart sensors and the Internet of Things

The Internet of Things (IoT) is a network of interconnected physical objects or things embedded with sensors and software that can collect and transfer data over the internet. Physical objects can be anything from computing devices (e.g. phones), machines (e.g. vehicles), infrastructure (e.g. light poles) to animals or people. IoT helps people live and work smarter by offering smart devices to automate processes and access information from anywhere. Common types of sensors used in IoT include temperature, humidity, pressure, water level, proximity, infrared and optical sensors. Communications technologies for transmitting the data collected by sensors have matured into commercially available solutions over the last few years, including globally standardised low-power wide-area networks such as LoRaWAN and narrowband IoT (NB-IoT).

Although low-power wide-area networks are on the rise, often they do not support remote areas and this is where emerging low Earth orbit communication satellite networks such as SpaceX's Starlink come into play. Other emerging technologies in this area are 5G mobile, which enables real-time IoT, and edge computing, which performs analysis at or close to the location at which data are captured, to improve response times and save bandwidth. The future of IoT will see the development of smart industries and areas such as smart healthcare, smart cities, and the Internet of Animals.

See Appendix A for an analysis of smart sensors and the Internet of Things applications for marine and coastal science.

Remotely piloted vehicle systems

Remotely piloted vehicles (RPVs) were originally used in the military for combat and surveillance, with aerial systems becoming popular as recreational products from 2013. Subsequently, as systems advanced, the commercial use of drones began. The Civil Aviation Safety Authority has regulations for flying aerial RPVs. Consumers can use off-the-shelf RPVs (under 25 kg) for sport and recreation if they follow the safety rules. Two specific regulations limiting enterprise adoption in Australia are that pilots must always keep their RPV in visual line of sight and that operator accreditation or a remote pilot licence is required, depending on the RPV's size.

RPVs are commonly regarded as autonomous aerial vehicles, but there are also water-based RPVs such as boats and submersibles which operate without a human occupant. Different types of RPV platforms are available, including fixed-wing, single-rotor, multi-rotor and hybrid systems. Apart from typical RPV platforms, blimps, balloons and kites are increasingly used for continuous monitoring applications.

Payload refers to an RPV's carrying capacity and the equipment it conveys. Sensor payloads include:

- optical cameras which capture visible light
- thermal cameras to detect heat
- multispectral or hyperspectral cameras which capture visible light, heat and ultraviolet light (hyperspectral cameras able to do so with many more bands of data)
- other specialised instruments such as particle sensors and magnetometers.

Payloads can also be deliveries or collections such as water or soil samples. LiDAR and specialised sensor payloads are starting to emerge as they become small and light enough for an RPV to carry. Depth-sensing cameras that help drones identify objects and avoid collisions have also been a recent development focus. In the future, RPVs will become solar powered, self-driving (rather than remotely piloted) and smart, as they will capture data, perform onboard processing and then act based on the data analysis.

See Appendix A for an analysis of RPV systems applications for marine and coastal science.

Global positioning system and tracking

Global positioning system (GPS) tracking monitors an object's (e.g. car, person, animal or equipment) exact location using GPS or broader global navigation satellite system (GNSS) satellites and tracking devices. There are three main types of GPS trackers:

1. Data loggers or passive trackers simply log the position of the device at regular intervals to their internal memory, which is then downloaded.
2. Data pushers or active trackers are the most common type and push or send their location at regular intervals to a server.
3. Data pullers or transponders are always on and can be queried to acquire the location data as often as required.

Emerging technology in this area includes device miniaturisation, the integration of IoT connectivity, improvements in positioning techniques such as satellite-based augmentation systems and real-time kinematic accuracy, GNSS and IMU sensor fusion and dead-reckoning techniques (calculating position when the GNSS signal is lost). The future of GPS and tracking will see ubiquitous, low-cost, high-accuracy devices with improved battery life to enable multi-year lifespan tracking and contribution to the IoT and IoA.

See Appendix A for an analysis of GPS and tracking applications for marine and coastal science.

Citizen science

Citizen science is scientific research conducted, in whole or in part, by amateur or non-professional scientists which aims to increase scientific knowledge. There are many types of citizen science projects, including bird counts, frog watches and post-bushfire animal monitoring schemes, for marine and terrestrial plants and animals. While citizen science is not new, it has become popular globally over recent decades and is increasingly common and technology enabled. This is due to extended human life spans resulting in more retirees applying their scientific skills and knowledge; scientists and governments recognising the benefits of volunteer engagement; and technological advancement including the proliferation of smartphones which has expedited data collection by citizen scientists. There are now many citizen science platforms available for the community to source projects and activities and contribute data (e.g. the Atlas of Living Australia and iNaturalistAU). Emerging technologies in this field include more accurate positioning for smartphones, contribution to policymaking, and machine learning (ML) for citizen science data. The future of citizen science will be citizen sensing, which will see people using low-cost or self-built sensors to collect data on issues they care about to empower themselves.

See Appendix A for an analysis of citizen science applications for marine and coastal science.

Artificial intelligence and machine learning

Artificial intelligence (AI) is a technique which enable machines, via computer programs, to mimic human behaviour. Machine learning (ML) is a subset of AI which uses statistical methods (or algorithms) in computer programs, allowing machines to improve through iteration and data use. ML facilitates spatial dataset creation via automated feature extraction, that often cannot be created any other way and uses datasets that cannot be leveraged with traditional methods. Although most of an ML process (70–80%) can be automated, considerable upfront investment is needed to produce training data, train an algorithm, review the outputs and perform any manual corrections required.

AI and ML are new and emerging fields along with deep learning, a specific ML approach that makes the computation of multi-layer neural networks feasible. These concepts extend the existing approaches of predictive analysis, decision support and optimisation. The future of AI and ML will see improvements in natural language processing, such as digitising archived documents and generative adversarial networks. These are ML models that allow two neural networks to compete to become more predictively accurate, by creating new data instances resembling existing training data. There will also be AI robotics, Artificial Intelligence of Things, AI and ML on board satellite platforms.

See Appendix A for an analysis of artificial intelligence and machine learning applications for marine and coastal science.

Big data and analytics (including a geographic information system)

As big data comprises EO, remote sensing and IoT data, and analytics includes AI and ML, there is significant overlap between this category and earlier categories. Big data are defined by the three Vs of volume, velocity and variety. So big data are larger (measured in terabytes to zettabytes), faster (real-time or near real-time) and more complex, deriving from many different sources (structured, semi-structured (e.g. digital photo or email) and unstructured (e.g. Twitter stream or video)). Traditional data types are structured and fit in relational databases which can be processed and visualised with desktop GIS and stored locally.

Big data analytics uses advanced technology systems and mathematics on big data to uncover hidden patterns, correlations and other insights. There are four types of big data analytics: descriptive, diagnostic, predictive and prescriptive. The development of open-source frameworks, allowing a network of computers to solve problems, contributed to big data's growth by making it easier and cheaper to work with. The volume of big data is growing exponentially with the rise of IoT and ML and will increasingly be stored and processed in the cloud. Hybrid storage across local and cloud environments and multi-cloud storage environments are emerging, along with cloud-based supercomputer capability.

The future of big data and analytics will see space-based edge computing, quantum computing, fast data processed in real-time streams and actionable data analysed to provide value.

See Appendix A for an analysis of big data and analytics applications for marine and coastal science.

Simulation and modelling

Spatial modelling is a process of spatial analysis that uses mathematical rules and procedures to analyse and visualise spatial data. While modelling is the act of building a model, simulation is the process of using the model to study the behaviour of a system. The objective of spatial modelling and simulation is to study objects or phenomena that occur in the real world, for problem-solving and planning. For example, a flood model could be filled to different flood levels for risk assessment, or a species predictive model could be used to predict the distribution of a species over time for species management.

Models and simulations are an important way to study inaccessible systems, and to complement conventional scientific experiment and observation approaches. Emerging concepts in this area include thematic digital twins (e.g. building information models) and environmental modelling systems combined with simulation and advanced warning (e.g. to predict natural disasters). The future of simulation and modelling may include an ocean avatar (an entire ocean digital twin) and real-time monitoring feeds in simulated environments.

See Appendix A for an analysis of simulation and modelling applications for marine and coastal science.

Future opportunities

The opportunity for future SMCE reporting to adopt more spatial technologies is evident, and these opportunities will continue to increase. Prioritising them and developing an ongoing improvement process will establish Victoria as an authority on SMCE reporting and provide a reporting template that is efficient, effective and informative.

Part 3 of this SMCE 2021 Report relies on a plethora of diverse mapped and measured data to assess an indicator at a point in time. This complex and important activity builds on crucial data created by many different government departments and agencies and demonstrates the potential of data to be 'created once and used many times' adding significant value. This reliance on data from many stakeholders will only increase over time, as will the number of data sources. For SMCE reporting to be repeatable, CES needs assurance that the data will be maintained, interpreted, findable, accessible and interoperable into the future. Collaboration with data owners is essential to support the ongoing maintenance (and potential improvement) of data required for this process.

This report's analysis also finds that with emerging technologies, both the spatial resolution and temporal resolution of data will improve, and data volumes will increase. Over time, the role of SMCE reporting to synthesise these data into insights may become more technically complex, but the opportunity to create information that is better able to represent change over time, at more local levels is an exciting one. Many of the data collection types and technologies discussed above should not be used in isolation as they will be of more value through integrated approaches.

Part 2B
Applying international frameworks

Commissioner *for* Environmental Sustainability Victoria

Science for Sustainable Development (SDG) Framework

The Science for Sustainable Development (SDG) Framework embraces three levels of synthesis:

1. environmental condition reporting
2. assessing interlinkages across the SDG targets
3. tracking progress on selected SDG targets.

Part 3 of this report delivers the evidence base and scientific assessments for the environmental condition report. The following section is a formative method towards achieving our goal of assessing interlinkages and tracking progress against SDG targets in future reports.

Method objectives

Figure 10 is repeated from Part 1A (Figure 6). It represents the program logic (data for decision making) of the proposed Method. The data for the decision-making system described can be applied to any policy domain, but in Figure 10 it is applied to marine and coastal policy.

The logic is designed to deliver the Method's following objectives:

- Deliver a reporting regime that 'operationalises' the SDG framework by anticipating the whole system – representing all 17 goals – in its findings and recommendations.
- Improve our understanding of how elements of the system affect the whole – and how the system affects discrete elements.
- Assess policy coherence – acknowledging strengths and challenging incoherence.
- Provide data for decision-making in a clear and targeted way that anticipates management and policy options that improve coherence.

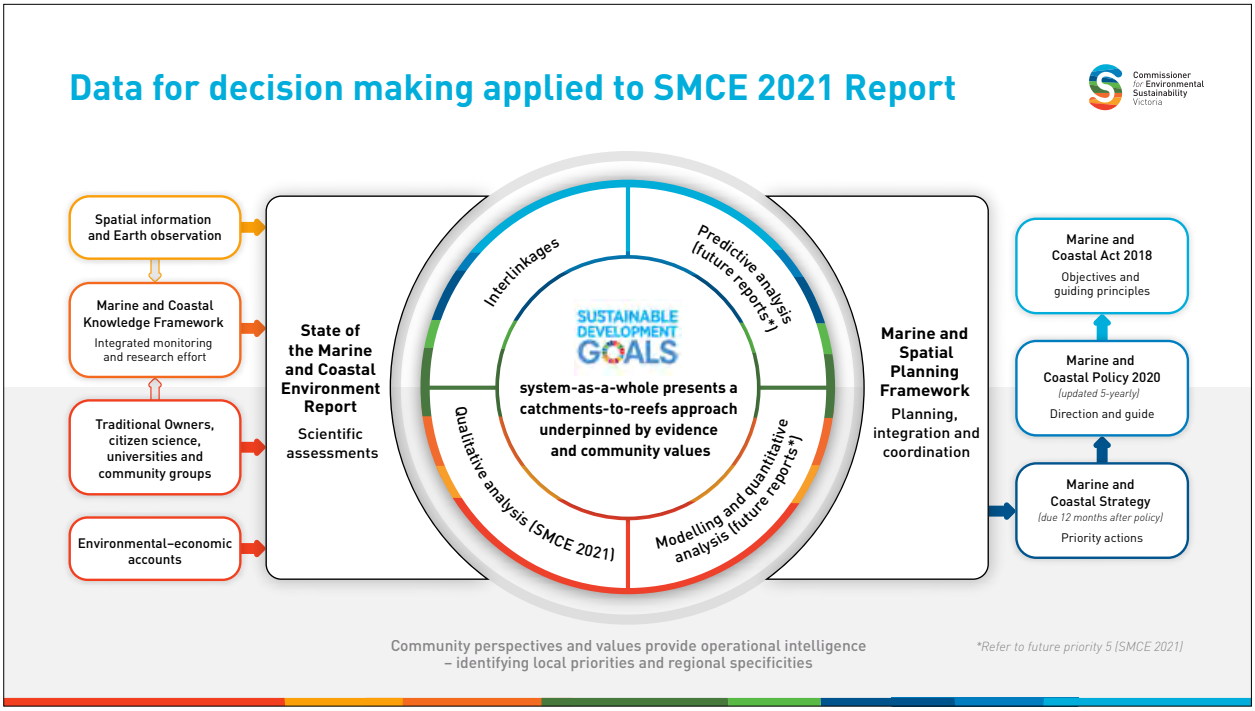


Figure 10: Data for decision making: applied to the SMCE 2021 Report.

The Method's first four phases will be considered in the following sections. A summary of each is provided below.

Summary of the Method's first four phases to operationalise the SDGs for state of the environment reporting:

Phase 1 Selection of relevant SDG targets proposes a list of SDG targets that are relevant to marine and coastal reporting in the SMCE 2021 Report. This section describes the selection process for a provisional subset of the 169 SDG targets relevant to SoE reporting in Victoria; from that list a marine and coastal subset of 40 is selected.

Phase 2 Evaluating comprehensiveness of indicators assigns indicators from the scientific assessments (Part 3) in the SMCE 2021 Report to the 40 SDG targets identified in Phase 1 of the Method. The assigned indicators were weighted because not all of the indicators that were mapped to a specific target were equally important in assessing that target; critical indicators were given a heavier weighting.

Phase 3 Localisation of the SDGs describes the steps undertaken to understand local priorities through an engagement process with local coastal and land managers and practitioners.

Phase 4 Reporting on SDG target assessments applies the Method to specific SDG targets that were identified in Phase 1 (i.e. those targets selected as being relevant to marine and coastal reporting in Victoria) and assessed in Phase 2 (i.e. those targets evaluated for comprehensiveness of indicators to report progress in a meaningful way). Reporting on the SDG targets in Phase 4 draws on the information and evidence base in Part 3 but with a focus on the system and the telling of interconnected stories to inform holistic policy interventions and management.

Phase 1 Selection of relevant SDG targets

To enable the application of the SDGs as an organising framework for the SoE 2023 report, a method to report on the connectivity and interlinkages of the SDG targets will be required. This method will also identify a subset of the 169 targets to be reported on in the SoE 2023.

Science for Sustainable Development Framework

Phase 1 proposes a list of 40 SDG targets that are relevant to marine and coastal reporting in the SMCE 2021 Report. Central to a method for adopting the SDGs as an operating framework for SoE reporting in Victoria is the selection of targets that are appropriate and relevant to track ecological sustainable development in Victoria.

Considering the need to 'ensure impartiality, openness, transparency and accountability'[102] in the Commissioner's work, it is critical that clear, authorised criteria are established to guide the determination of SDG target relevancy for Victoria. This is important across all scales – national, state (sub-national, in this section), to local (see Phase 3 Localisation of SDGs).

The legislative framework for selecting SDG targets

The Method adopted here animates the approach described by the Science for Sustainable Development Framework and grounds the criteria for SDG target selection in the CES Act, specifically the objectives for ecologically sustainable development (ESD) defined in the CES Act. The strength of anchoring the selection criteria in the ESD definition in the CES Act is that it provides a robust approach to the Method that will embed longevity and consistency to the Method as this work evolves for future reports.

Ecologically sustainable development objectives:

4.2(a) to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations

4.2(b) to provide for equity within and between generations

4.2(c) to protect biological diversity and maintain essential ecological processes and life support systems.[103]

102. Victorian Government, *Commissioner for Environmental Sustainability Act 2003*, s 10,1 (d) https://www.ces.vic.gov.au/sites/default/files/publication-documents/CES%20Act%202003.pdf
103. Ibid., p. 4.

Through this process, an SDG target was 'selected' as aligned with state of environment reporting in Victoria if assessed as being aligned with all three ESD objectives.

Alignment with the SMCE 2021 Report

Further analysis then took place on the selected SDG targets to assess their relevance to marine and coastal reporting in Victoria.

This analysis aligned the SMCE 2021 Report's three objectives, as defined in the Marine and Coastal Act 2018 (Vic), with the subset of targets identified as aligned with SoE reporting.

These legislative objectives are the:

- condition of the marine and coastal environment
- environmental, social and economic benefits of the marine and coastal environment
- threats to the marine and coastal environment.[104]

Through this alignment exercise, 40 targets from the subset of 98 were found to be aligned with at least one marine and coastal objective (Appendix A).

This list of 40 selected targets for SMCE reporting will be the focus of future phases of the methodology: evaluating comprehensiveness (Phase 2 Evaluating comprehensiveness of indicators) and progress reporting on SDG target assessments (Phase 4 Reporting on SDG target assessments) below.

Phase 2 Evaluating comprehensiveness of indicators

Phase 2 assigned indicators from the scientific assessments (Part 3) in the SMCE 2021 Report to each of the 40 SDG targets identified in the marine and coastal subset.

However, assigning or mapping indicators is not sufficient; for even if extensive alignment is demonstrated, it does not necessarily prove that reporting on a specific target is comprehensive. It only identifies that there are many relevant SoE indicators for that specific target.

To address this, Phase 2 weighted the assigned indicators (i.e. critical indicators were given a heavier weighting).

Informed by the suite of marine and coastal indicators that comprise the scientific assessments (Part 3) in this report, a set of criteria were developed to assign indicators to the 40 selected SDG targets. The criteria were:

- Logical validity: the indicators are related to the main intention, focus or scope of the target.
- Statistical adequacy: the indicators selected represent valid and reliable measures.
- Policy relevance: all selected indicators assist decision-makers in formulating policy options.

Significantly, these criteria help select the indicators and evaluate the relative importance of each one in assessing the target, informing the 'weighting' of each indicator for undertaking the assessment (Appendix B).

Assessing comprehensiveness

This process, when conducted on all 40 SDG targets in the marine and coastal subset, also revealed potential gaps in the indicators, and corresponding data, to comprehensively assess that selected target.

Most notable is the need to ensure Traditional Owners' priorities are reflected in the synthesis and evaluation (refer to the Cultural Landscape Health and Management section in Part B).

The 40 selected SDG targets were aligned with the indicators that have been developed for the SMCE 2021 Report (Part 3). On only two occassions were SoE 2018 indicators (targets 2.5 and 15.6) considered to be more appropriate indicators.

A final point of caution is to note that while it is one thing to align indicators with the targets, and assess them for their comprehensiveness, this does not necessarily mean that the data quality and confidence for making assessments based on those indicators is good. In fact, it will often be quite varied. This issue is explored further in progress reporting on SDG target assessments (Phase 4).

104. Marine and Coastal Act 2018 (Vic) https://content.legislation.vic.gov.au/sites/default/files/2020-04/18-26aa003%20authorised.pdf.

Phase 3 Localisation of the SDGs

An ambition of the Science for Sustainable Development Framework is to track Victoria's progress against the selected SDG targets by prototyping and testing the veracity of using localised indicators that are meaningful at a state, regional, precinct or ecosystem scale.[105]

There are two parts to this work – understanding local priorities and determining the scalability of data. Understanding local priorities has been conducted through an engagement process with local coastal and land managers. In May 2021, the Commissioner for Environmental Sustainability (CES), in partnership with the Royal Society of Victoria, joined a workshop with local coastal and land managers from local government authorities, the Department of Environment, Land, Water and Planning (DELWP), catchment management authorities and other agencies, community groups and volunteers. The workshop brought together more than 70 participants to prioritise a subset of indicators from this report. The aim was to agree on a subset of indicators to which all stakeholders could contribute, and which could reasonably enable the participation and collection of data on priority issues, statewide, to help monitor and manage Victoria's coast.

Workshop participants prioritised SMCE indicators on the following criteria:

- indicators that represent issues of significant local importance
- indicators where local authorities, committees of management, and volunteers can make a difference to improve the result
- indicators requiring a response from more than one local agency, management authority, volunteer group or community group to make a difference and improve the result.

Formal partnerships between Traditional Owners and local authorities were included as a pre-prioritised indicator (see Cultural Landscape Health and Management in Part B). This was justified as an indicator because it was produced by the extensive catchment management authority engagement already done to develop the regional catchment strategies across Victoria. The workshop resulted in the addition of two biodiversity indicators: species of conservation concern (SMCE Indicator 19) and coastal invasive plants (SMCE Indicator 39).

105. Commissioner for Environmental Sustainability (CES) 2020, 'Framework for the Victorian State of the Environment (SoE) 2023 Report', p. 14, Melbourne, Victoria https://www.ces.vic.gov.au/sites/default/files/CESV_Framework%20Report%202023_FINAL_WEB_OCT.pdf

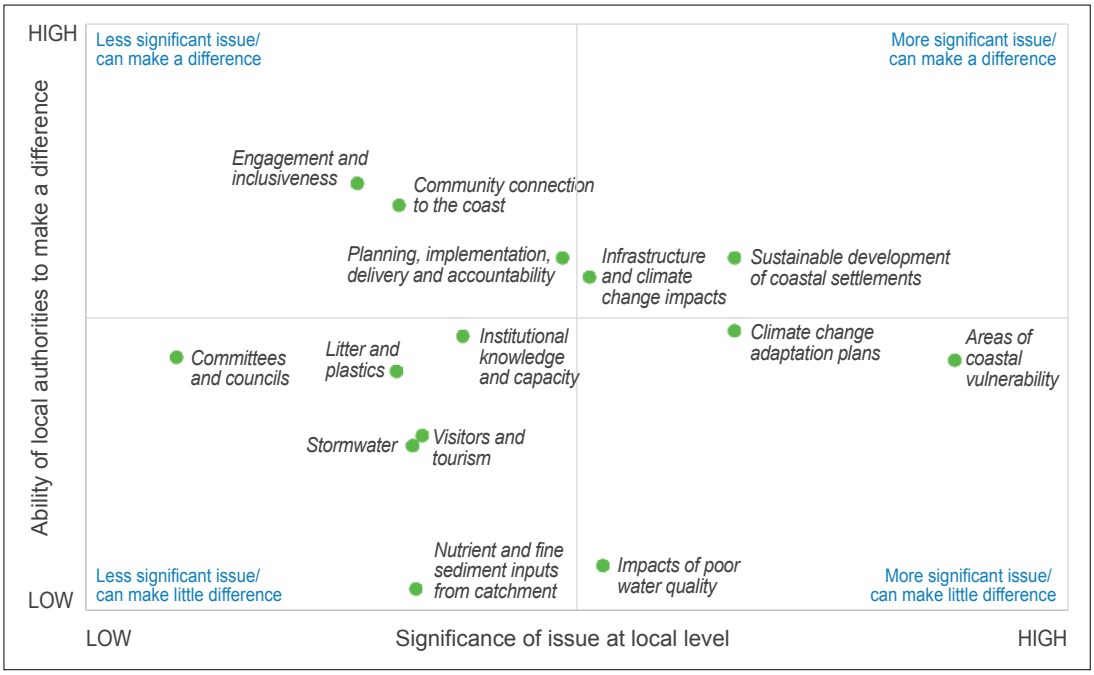


Figure 11: Feedback from stakeholder workshop on relative significance of indicators and ability to influence outcomes at the local level.

The ranking of the remaining indicators by workshop participants was based largely on criteria one and two (above): the significance of the issue represented by the indicator and the degree to which a difference can be made at the local level. While the results are subject to specific interpretation (qualitative responses were collected alongside numerical scoring), it is useful to consider some of the indicators in terms of a quadrant – between the local significance of the issue and the degree of difference that can be made at the local level (Figure 11).

Overall, areas of coastal vulnerability/climate change impacts (SMCE Indicators 45–51) proved to be the most important for those dealing with coastal areas. The consequences of sea-level rise and more frequent storm events are significant for the local coastal environment. Concerns raised by local land and coastal managers include loss of natural habitat and loss of physical infrastructure.

Several indicators relate to pollution, such as the effects of poor water quality, litter and plastics, nutrient and fine sediment inputs from a catchment, and stormwater. The disaggregated way in which these pollution indicators were presented made ranking difficult for some participants and it is likely that this diluted the results.

Participants raised pollution as an issue of concern, so a combined pollution and water quality indicator has been included: inputs from catchment impacting ecosystem health.

Climate change is seen as a significant issue for local authorities and practitioners and one for which they have a moderate ability to make a difference. This assessment of having some, but not a high level of influence in addressing the issue highlights the importance of partnerships between local authorities and other agencies or organisations and communities to improve the ability to address problems in a practical way at the local level.

It is important to note that data and information acquired by local authorities, Traditional Owners, citizen scientists and volunteers will be important, but a greater focus on local reporting must avoid placing a greater burden on these already under-resourced groups. Data from national organisations (ABS, CSIRO, BoM, Geoscience Australia) and state government (DELWP, Parks Victoria and EPA) will continue to be the primary information source. However, these official statistics, while robust, can often be limited in terms of disaggregation at the local scale. The role of local authorities and citizens to address data scalability is an area to be explored.

Eight uniform local indicators were determined as an outcome of a coastal and marine stakeholder workshop:

- formal partnerships between Traditional Owners and local authorities
- species of conservation concern
- invasive coastal plants
- areas of coastal vulnerability
- climate change adaptation plans
- sustainable development of coastal settlements
- climate change impacts on infrastructure
- inputs from catchment impacting ecosystem health.

Phase 4 Reporting on SDG target assessments

In this section, the Method is applied to specific SDG targets that were identified in Phase 1 (i.e. selected as relevant to marine and coastal reporting in Victoria) and assessed in Phase 2 (i.e. evaluated for comprehensiveness of indicators in Part 3 to report progress in a meaningful way).

The work presented in Phase 3 (localisation of the SDGs) is also important in Phase 4 as the prioritisation of issues by local coastal managers influenced the choice of SDG targets (issues) that the Method was applied to in this section (see criteria below).

The narratives for each of the six selected targets in this phase provide additional context for the future priorities proposed, often including practical examples and benefits to marine and coastal management and outcomes for specific priorities.

Future priority 1: Use spatial information and Earth observation to help identify and protect Victoria's marine assets.

Future priority 2: Update Victoria's Marine and Coastal Knowledge Framework to reflect the scientific assessments of this report.[106]

Future priority 3: Develop thresholds to improve future reporting.

Future priority 4: Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.

Future priority 5: Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

These future priorities support a catchments-to-reefs approach.

Qualitative assessment of SDG Target interlinkages

A systems analysis to the assessments presented in Part 3 has been applied below for six selected SDG targets to help demonstrate the application of the SDGs to frame and contextualise future priorities:

SDG Target 12.4 – By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimise their adverse impacts on human health and the environment

SDG Target 13.2 – Integrate climate change measures into national policies, strategies and planning

SDG Target 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

SDG Target 15.8 – By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems, and control or eradicate priority species

SDG Target 16.6 – Develop effective, accountable and transparent institutions at all levels

SDG Target 17.14 – Enhance policy coherence for sustainable development.

106. This priority supports the proposed activity of the Marine and Coastal Strategy to support evidence-based marine planning and management by updating Victoria's Marine and Coastal Knowledge Framework (including CoastKit).

The six SDG targets assessed in this section were selected from the 40 SDG targets (Appendix B) aligned with the objectives in the Marine and Coastal Act 2018 (Vic) in Phase 1, based on the following criteria:

- opportunity for storytelling
- data availability (based on comprehensiveness assessment in Phase 2)
- crossover between environmental and social sciences
- alignment with the uniform local indicators (identified in Phase 3)
- ensuring a diversity of SDG goals are represented.

SDG Target 12.4: Achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.

Weighted SMCE indicators:

02. Toxicants (25%)

05. *Enterococci* bacteria (25%)

08. Total nutrient loads (25%)

09. Total fine sediment loads (25%)

Narrative outline:

- Chemical pollutants and other waste represent a significant threat to marine and coastal ecosystems.
- Management responses in Victoria aim to prevent chemicals and other waste from entering waterways and marine and coastal areas.
- Monitoring provides regular assessment of marine pollutants, although it mostly focuses on Port Phillip Bay and Western Port.
- There is an absence of public reporting available to determine how the nutrient and sediment loads (in Port Phillip Bay) are tracking in relation to the Victorian Government's load targets. Where information is available, the pollutant loads are not categorised by source.
- In Corner Inlet and Nooramunga, it is unclear whether any progress has been made to meeting Water Quality Improvement Plan (WQIP) 2013 targets. Only a limited number of the recommended annual activities in the WQIP 2013 have been reported, which has hindered the tracking of progress on target achievement.
- Although water quality is good at most locations monitored in the Gippsland Lakes catchment, the lower reaches of major rivers, as well as Lake Wellington and Lake Victoria, have only fair or poor water quality.

Link to future priorities

The analysis of this target supports the following future priorities:

Future priority 4: Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.

Future priority 5: Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

The Port Phillip Bay Environmental Management Plan 2017–2027 and the Corner Inlet [and Nooramunga] Water Quality Improvement Plan (WQIP) 2013 are examples of environmental management authorities developing targets to monitor water quality results. However, no public reporting is available to determine how the nutrient and sediment loads are tracking in relation to the government's load targets.

Interim results from catchment modelling of nutrient and sediment loads from the Port Phillip Bay catchment supplied to the CES for this report suggest a stable trend in annual loads of nutrients and sediments over the period 2016–2019. This is included as part of a broader discussion in the total nutrient loads and total sediment loads indicators in Part 3.

The Port Phillip Bay Environmental Management Plan 2017–2027 includes a priority target that nutrient loads do not exceed current levels. The aim to keep nutrient loads at existing levels recognises that progress has already been made and must be maintained. The first environmental management plan for the bay was released in 2001 and included an objective to reduce the annual nitrogen load to the bay by 1,000 tonnes. The nitrogen load reduction of 1,000 tonnes was achieved through upgrades to the Western Treatment Plant and improved stormwater management in the catchments.

The 2019–20 Annual Report and 2020 Delivery Plan Update (which contributes to regular reporting on the Port Phillip Bay Environmental Management Plan 2017–2027) did not provide estimates of nutrient loads in relation to the specific strategy of 'ensuring nutrient and sediment loads do not exceed current levels and pollutant loads are reduced where practicable'.

Nearly halfway to the 2033 timeline for achieving the targets in the Corner Inlet (and Nooramunga) WQIP 2013, it is unclear if any progress has been made towards meeting those targets. As only a limited number of the recommended annual activities in the WQIP 2013 have been reported, this has hindered the tracking of progress on target achievements. Public reporting is required to aid management responses, engage stakeholders and help them to make a practical contribution. Pollutant loads need to be categorised by source to enable assessment and to track intervention efficacy.

SDG Target 13.2: Integrate climate change measures into national policies, strategies and planning

Weighted SMCE indicators:

45. Areas of coastal vulnerability (20%)
52. Considering climate change risks in land-use planning (20%)
53. Climate change adaptation plans (20%)
54. Nature-based adaptation (20%)
55. Emergency planning and preparedness (10%)
80. Institutional knowledge and capacity (10%)

Narrative outline:

- Addressing climate change requires institutions to have the appropriate skills and knowledge so that innovative solutions can be found for evolving problems.
- Preventative as well as responsive approaches will be necessary in dealing with climate change, highlighting the importance of both strategic planning and operational responsiveness and efficiency.
- There is a critical gap in available knowledge to inform climate change adaptation planning. The combination of the Port Phillip Bay Coastal Hazard Assessment and the proposed statewide hazard maps are expected to aid rigorous and robust reporting of coastal areas' vulnerability in future SMCE reports. It is essential that these resources are delivered on schedule.
- Protecting and restoring coastal blue carbon ecosystems, such as mangroves, tidal marshes and seagrasses, offers opportunities for carbon sequestration and mitigation of greenhouse gas emissions.
- Engagement with the community is a critical component of climate change preparedness which can involve engagement on scientific data and proposed planning responses as well as community involvement to monitor change through citizen science.
- While plans and strategies have been developed at state, regional and local levels, the degree of success in adapting to climate change is unclear and requires the development of effective assessment metrics.

Link to future priorities

The analysis of this target supports all five future priorities.

Protecting and restoring coastal blue carbon ecosystems, such as mangroves, tidal marshes and seagrasses, offers opportunities for carbon sequestration and mitigation of greenhouse gas emissions. A 2019 Australian study analysed the effects of land management practices on blue carbon stocks and greenhouse gas fluxes in coastal ecosystems.[107] Upgraded management of blue carbon ecosystems can also improve fisheries and increase coastal resilience to rising sea levels and storm surges. Further research published in 2019 found that saltmarshes, mangroves and seagrasses in Victoria capture approximately 2% of the carbon that it would be possible to capture by 2050 if coastal wetlands can naturally retreat. According to this research, removing levees now and allowing natural tidal exchange to occur would provide an additional 1.65 million tonnes of carbon sequestration, valued at $67 million using average carbon prices paid via the Australian Emission Reduction Fund when the research was completed in 2019.[108]

Research published in 2019 found that allowing coastal wetlands in Victoria to naturally retreat with sea-level rise could sequester 1.6 million tonnes of carbon by 2050 with a value of $65 million.

There are additional natural climate regulation opportunities, for example kelps can absorb an estimated 20 times more carbon dioxide per hectare than forests on land, supporting diverse marine plants and animals and helping to stabilise coasts by absorbing wave energy and dissipation through wrack (debris) on beaches. The benefits of intertidal marshes building coastal resilience to inundation and erosion can also be significant.

To support a future nature-based adaptation strategy, and maximise the opportunities of blue carbon ecosystems, a greater understanding of the threats to both those ecosystems and adjacent communities is required. This research emphasis should be incorporated into current planning for Victoria's Marine and Coastal Knowledge Framework.

DELWP and CSIRO are working together to complete a coastal hazard assessment for Port Phillip Bay. The findings of the hazard assessment have not yet been released. In July 2021, DELWP released a draft Marine and Coastal Strategy. Activity 4.4 in that strategy is to deliver statewide hazard maps that assist fit-for-purpose coastal hazard risk assessments in the period 2022–2024.

It is critical that this information is produced on schedule to make sure communities have the necessary information to be engaged and contribute to a nature-based adaptation strategy, avoiding the risk of planned top-down approaches that ignore the behavioural and social barriers that limit the effectiveness of adaptation actions.[109] Local consensus will be important – the inclusion of local knowledge and values and the development of metrics and thresholds for climate change adaptation monitoring and assessment that are meaningful at the local scale (Phase 3).

107. Carnell PE, Reeves SE, Nicholson E, Macreadie P, et al. 2019, 'Mapping ocean wealth Australia: The value of coastal wetlands to people and nature', The Nature Conservancy, Melbourne https://www.natureaustralia.org.au/content/dam/tnc/nature/en/documents/australia/MOW_Report_Web.pdf
108. Ibid.
109. Stafford Smith M, Horrocks L, Harvey L and Hamilton C 2011, 'Rethinking adaptation for a 4°C world', *Philosophical Transactions of the Royal Society* A, 369, pp. 196-216 https://royalsocietypublishing.org/doi/full/10.1098/rsta.2010.0277.

SDG Target 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

Weighted SMCE indicators:

05. *Enterococci* bacteria (25%)
06. Regulated point source discharges to marine waters (25%)
08. Total nutrient loads (25%)
10. Coastal acid sulfate soils (5%)
13. Coastal contaminated land (5%)
50. Frequency and impact of fire on marine and coastal ecosystems (15%)

Narrative outline:

- Maintaining high water quality is critical for environmental and human health.
- Sources of pollution have been identified.
- Pollution levels are measured and monitored with the aim of improving pollution management.
- Pollution is largely related to human activities and land use. However, quantitative microbial risk assessment and faecal source tracking show that most faecal contamination in Port Phillip Bay is from birds and dogs rather than human sources.
- There is only limited quantitative analysis available to understand the extent to which regulated discharges adversely affect receiving marine environments.

Link to future priorities

The analysis of this target supports the following future priorities:

Future priority 2: Update Victoria's Marine and Coastal Knowledge Framework to reflect the scientific assessments of this report.

Future priority 3: Develop thresholds to improve future reporting.

Future priority 4: Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.

Future priority 5: Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

Quantitative microbial risk assessment and faecal source tracking show that most faecal contamination in Port Phillip Bay is from birds and dogs rather than human sources, which means evidence is emerging that the current long-term microbial standards in the Environment Reference Standard are likely to overestimate human health risks.

The EPA has completed a quantitative microbial risk assessment report showing there is a lower health risk than previously anticipated (Water Quality, Part 3). The EPA is working with its partners to better understand water quality and determine if site-specific standards can be developed for Port Phillip Bay beaches. Further research is needed to develop site-specific standards, which would more accurately estimate the risk of illness at specific beaches.

Currently, a quantitative indicator assessment is not viable, to look at data closely, to understand how much (or how little) the regulated discharges adversely affect receiving marine environments.

A need for readily accessible, reliable, national-scale data on Australia's domestic wastewater outfalls prompted the Commonwealth Government in 2015 to commission Clean Ocean Foundation (COF) to develop the National Outfall Database. Working collaboratively with all stakeholders and under the auspices of the National Environmental Science Program, COF has collected and analysed outfall data to produce the National Outfall Database for all of Australia's 186 coastal outfalls.

The indicator narrative in Part 3 is only able to comment on the volumes and nutrient loads discharged to marine waters from regulated point sources, which is comprehensively aggregated and reported by the COF as part of the National Outfall Database.

However, there is limited quantitative analysis available to understand the extent that regulated discharges adversely affect the receiving marine environments. EPA Victoria did not provide data and analysis for this report on the noncompliance of licensed facilities that discharge to marine environments, therefore the extent of noncompliance with licensed discharge limits is unknown.

These actions regarding microbial risk assessment and regulated discharges monitoring would contribute to a catchment-to-reefs focus to drive water quality management, thus improving water quality for Victoria's coastal communities and reducing adverse water quality effects in marine receiving environments, including our valuable marine protected areas (MPAs).

SDG Target 15.8: By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species

Weighted SMCE indicators:

38. Invasive marine species (25%)

39. Coastal invasive plants (25%)

40. Coastal invasive animals (25%)

55. Emergency planning and preparedness (25%)

Narrative outline:

- The effects of invasive species on marine and coastal ecosystems have been identified.
- Such species may be introduced through boating and shipping due to biofouling and ballast discharge.
- Regulation and education are in place to limit the risk of new species being introduced.
- Limits to coordination between pest management agencies lead to a lack of clarity on roles, responsibilities and data custodianship.

Link to future priorities

The analysis of this target supports the following future priorities:

Future priority 2: Update Victoria's Marine and Coastal Knowledge Framework to reflect the scientific assessments of this report.

Future priority 3: Develop thresholds to improve future reporting.

Future priority 4: Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.

Future priority 5: Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

There is a need to assess resourcing to coordinate marine pest management across agencies. The critical gap is coordinating pest management once the pest becomes established in the state and is no longer an immediate biosecurity issue managed by the Department of Jobs, Precincts and Regions. Formally, DELWP becomes the lead agency in this circumstance but DELWP may not be resourced appropriately, and data are often very limited to support decision-making and interventions. Pest management resourcing and coordination need to respond to the full invasion curve, from prevention and preparedness through to on-ground asset-based management.

This is also true of overabundant native species, such as urchins, particularly outside MPAs where Parks Victoria is not the lead management agency.

In coastal areas, there is an opportunity for government and local management authorities to work closely with active and informed community groups to develop comprehensive, well-resourced control programs, designed to address invasive pest animals and plants on coastal public land and abutting private land (e.g., Marna Banggara (formerly Great Southern Ark) and Otway Eden).

Emerging changes to monitoring and reporting regimes need to be developed with an awareness of these management tensions. Biodiversity 2037 reform metrics such as 'Change in suitable habitat', along with the reform's Strategic Management Prospects, could improve pest management and act as cornerstones for future biodiversity reporting.

SDG Target 16.6: Develop effective, accountable and transparent institutions at all levels

Weighted SMCE indicators:

80. Institutional knowledge and capacity (30%)

81. Engagement and inclusiveness (30%)

82. Delivery and accountability (40%)

Narrative outline:

- Efficacy of institutions involved in environmental management is difficult to measure, but there are examples of management effectiveness evaluations being made.
- The Marine Spatial Planning Framework for Victoria sets out Victoria's approach to marine spatial planning. Framework implementation is being progressed through a statewide assessment to determine marine planning areas and identify priorities for more detailed marine spatial planning. Guidelines on how to conduct marine spatial planning in identified priority areas are also being prepared.
- Independent evaluations by parliamentary inquiries or the Victorian Auditor General can result in institutions involved in environmental protection being held accountable.
- Effective stakeholder engagement and the co-creation of policy improves transparency and decision-making processes for those institutions involved in environmental protection.

Link to future priorities

The analysis of this target supports the following future priorities:

Future priority 1: Use spatial information and Earth observation to help identify and protect Victoria's marine assets.

Future priority 4: Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.

Future priority 5: Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

Victoria's Marine National Parks cover 5% of the state's marine waters and, except for a few reference sites outside the protected areas, no monitoring occurs beyond the parks' boundaries. As the 20th anniversary of the parks' establishment approaches (June 2022), it is an appropriate time to take stock and potentially apply lessons learned, for the future management of these sanctuaries.

The Marine Spatial Planning Framework for Victoria will consider how the marine environments' uses and activities are spatially organised. It aims to provide a structure for integrated management and, by identifying current or potential conflicts, can deliver an approach to manage these through policies, management interventions and governance arrangements. This framework sets out guidance and a process for achieving integrated and coordinated planning and management of the marine environment. A major difficulty for marine policy is that issues are often addressed on a sectoral or issue-specific basis. Fisheries, shipping, recreational fishing and boating, renewable energy and marine resources are some examples of policy focus. This limits capacity for a holistic view of the marine environment and its management. The Marine Spatial Planning Framework's intent is to support and provide a process for integrated planning and management across sectors.

The delivery of this framework presents an opportunity to demonstrate how spatial information can improve the proposed system of management effectiveness reporting for marine parks in Victoria. It is important that the framework establishes a foundation to:

- aid comprehensive and ongoing scientific monitoring, mapping and investigation of coastal and marine habitats and ecological processes
- conduct a statewide review to identify gaps in the marine national parks and sanctuaries network and to make recommendations for additions to ensure the network is comprehensive, adequate and representative, and meets international targets (5.2 in Marine and Coastal Policy).

The review could conduct or assist an assessment, to understand Victoria's capacity to increase (in area or number) no-take MPAs. This analysis would be timely considering the recent High Ambition Coalition for Nature and People's target to have 30% of the land and marine environment protected by 2030.

This proposal could also be a pilot leading to a broader approach to management effectiveness reporting of Victoria's natural assets – terrestrial, aquatic, coastal and marine.

SDG Target 17.14: Enhance policy coherence for sustainable development

Weighted SMCE indicators:

54. nature-based adaptation (25%)

55. emergency planning and preparedness (25%)

78. planning and implementation (25%)

80. Institutional knowledge and capacity (25%)

Narrative outline:

- Policy coherence can be defined as mutually reinforcing policy actions which lead to an agreed set of outcomes.
- Policy coherence can be conceptualised in terms of action across different policy sectors (horizontal coherence) as well as between different levels of government and the community (vertical coherence).
- There are difficulties to achieving policy coherence where policy and data are misaligned, preventing effective monitoring, assessment or improvement.
- Engagement with local stakeholders can improve policy coherence and policy results.

Link to future priorities

The analysis of this target supports the following future priorities:

Future priority 1: Use spatial information and Earth observation to help identify and protect Victoria's marine assets.

Future priority 4: Ensure that the Victorian Government continues to implement existing policies and management plans to benefit the environment.

Future priority 5: Trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between Victoria's environment, community and economy.

The challenges of achieving greater policy coherence for environmental sustainability are the increasing complexity of issues facing policy makers and the speed of change.

These dual challenges are inseparable, because complex issues (such as climate change) take time to analyse and address, yet require an urgent and immediate response as the speed of change is unpredictable but often fast (e.g. we know bushfires will be more frequent and severe, but we don't know exactly when and where such events will occur). The need to have effective (and up-to-date) operational responses at the same time as longer-term strategic responses is a problem for policy makers. This also highlights the difficulty of operating in dynamic and changing situations that may require new or innovative responses.

Data, information and knowledge management are at the core of this problem. There are constraints on our existing institutions and processes for gathering and sharing knowledge. In the face of a critical challenge like climate change, we may be collecting and analysing real-time data, but the processes embedded in our institutions may take time to absorb or respond to such data.

As the earlier section in Part 2 on spatial analysis asserted, there are many opportunities to improve decision-making through emerging technologies. However, changing technology also places pressure on the uptake of data in the policy cycle. New data sources and the vast amount of data that can now be captured creates their own problems. The opportunities that emerging spatial technologies provide need to be supported by a bureaucracy which reduces constraint on analytical capacity (i.e., a system that can adopt and employ new data in innovative and constructive ways). The risk of data incoherence is further raised by datasets having differences in terms of purpose, quality, temporal and spatial coverage. The sheer size of some datasets, such as satellite data, requires expertise in data handling, cleaning, and management, even before the data are interrogated for policy purposes.

There are two uses of data in policy delivery: first, it is important for monitoring to ascertain management effectiveness and to inform continuous improvement of policies, strategies and plans; second, it is important for inquiry – to learn more about emerging issues which may require policy responses. These two purposes might require very different data. In this sense, data needs are dynamic and are likely to change over time, which is problematic for time series analysis and can lead to fragmented or stranded datasets which are difficult to use for rigorous environmental reporting.

Future priorities

The SDG Framework 'is ambitious and commits the State of the Environment 2023 report to retrospective and prospective analyses'.[110]

However, this 'narrative' or qualitative approach is only one possible application. There are other (quantitative) models that could be trialled.

Predictive analysis

Predictive analysis will be an important component of this work, to assess the causal interlinkages for decision-making. A range of methods could be used for exploring these interlinkages – qualitative, semiquantitative (matrix/network analysis), quantitative (statistical correlation), and dynamic quantitative (modelling). In this context, it is acknowledged that the SDG targets are not all of one type. Some will inform scientific assessments of the SoE. Others are framed to assist decision-making and prioritisation in relation to environmental issues and systemic challenges and will be applied to directly inform recommendations.

Science for Sustainable Development Framework

Understanding the interlinkages between sustainable development management options leads to better decision-making. Funding of the research outlined below would support a comparative analysis of the multiple benefits and trade-offs inherent in sustainable development decision-making. It could also improve the evidence base, aid predictive analysis and lead to more targeted interventions, when combined with ongoing engagement with practitioners and local authorities about local priorities.

Broadly, there are two approaches to the methods of analysis – the quantitative and modelling approaches.

The quantitative approach aims to establish interlinkages between SDGs and targets by quantitative statistical analysis of the underlying indicators. Historical data are often employed in data mining exercises to understand covariation and correlation across goals and targets, but also across space and time. A quantitative approach would explore interlinkages across the SDGs at local, state and federal scales in Australia. Historical data would be used to explore interlinkages across the SDG system using machine learning approaches.[111]

The modelling approach is consistent with the intention to 'enable strategic, forward-looking analyses and interventions that can accelerate progress towards environmental outcomes'.[112] Allen et al. provide an overview of modelling approaches and their contribution to the SDGs' integrated assessment by reviewing 80 quantitative models that have the potential to support national SDG planning and implementation.[113] The authors assessed these models by applying 10 criteria in their analysis. The main criterion is the identification of a broad integrated systems-based approach, encompassing many SDGs and targets and their interlinkages.

Future priority 5 in this report is to trial different models and ways to represent the complex interlinkages between selected SDG targets, to fully understand the interactions between the environment, community and economy of Victoria.

Sourcing data for this interlinkage work will be difficult, but access to datasets outside the scope of traditional SoE reporting through initiatives such as Digital Twin Victoria will assist and continue to improve. The SDG modelling work proposed would provide the frame, logic and rationale for the innovative program logic presented in this report and, ultimately, enable predictive analysis.

110. Commissioner for Environmental Sustainability (CES) 2020, 'Framework for the Victorian State of the Environment (SoE) 2023 Report', p.17, Melbourne, Victoria https://www.ces.vic.gov.au/sites/default/files/CESV_Framework%20Report%202023_FINAL_WEB_OCT.pdf
111. Asadikia A, Rajabifard A, Kalantari M 2021, 'Systematic prioritisation of SDGs: machine learning approach' *World Development*, 140, 105269 https://doi.org/10.1016/j.worlddev.2020.105269.
112. Commissioner for Environmental Sustainability (CES) 2020, 'Framework for the Victorian State of the Environment (SoE) 2023 report', Melbourne, Victoria https://www.ces.vic.gov.au/sites/default/files/CESV_Framework%20Report%202023_FINAL_WEB_OCT.pdf
113. Allen C, Metternicht G, Weidmann T 2016, 'National pathways to the sustainable development goals (SDGs): A comparative review of scenario modelling tools', *Environmental Science and Policy*, 66, pp. 199–207 https://doi.org/10.1016/j.envsci.2016.09.008.

Environmental–economic accounting

In this report we have broadened the scope of the SMCE analysis required under the legislation, to include both environmental and socioeconomic indicators, and we have explored their interlinkages. Further research is required to fully realise the vision of the Science for Sustainable Development Framework, to:

1. show how the environment and natural capital underpin Victoria's social and economic wellbeing
2. identify trade-offs and areas of tension, and potential co-benefits
3. highlight potential opportunities for collaboration between management sectors in the SDG network (e.g., environment, health, infrastructure)
4. enable predictive analysis to assess the causal interlinkages of specific interventions and inform future recommendations.

The narrative approach adopted in this report is one of a range of methods to be trialled for assessing interlinkages but is limited to qualitative assessment. Semiquantitative (matrix/network analysis), quantitative (statistical correlation), and dynamic quantitative (modelling) approaches will require a targeted research project and an analysis of the applications across all SoE reporting themes.

In this way, the SoE 2023 can be both retrospective (extending the scientific baseline another five years) and prospective. It will measure Victoria's progress on the SDGs, identifying areas in which Victoria is lagging; exploring how economic, social and environmental targets interlink; and showing how recommendations help progress the ecologically sustainable development of Victoria.

Background to environmental–economic accounting in Victoria[114]

Environmental–economic accounting (EEA) gained momentum following the recommendations of the 1992 Rio 'Earth Summit',[115] which recognised the need for more holistic indicators of society's development beyond economic output (i.e. gross domestic product (GDP)) to include broader social and environmental indicators. The intention is to ensure economic and societal prosperity can be sustained into the future by recognising the status of the underlying stock of environmental assets on which the economy and society depend (acknowledging the costs of economy growth such as pollution and habitat loss). It specifically recommended that countries implement environmental–economic accounts at the earliest date.

In response, the United Nations Statistical Division (UNSD) published guidance on integrated environmental–economic accounting (in 1993, 2003, 2012 and 2021) and the latest (2021) version was adopted as the international standard for organising information on the environment and its contribution to economic and other human activity. The UN System of Environmental–Economic Accounting (SEEA) framework is consistent with the international standard of System of National Accounts (i.e. GDP) in order to report on the interactions between the economy and the environment at the national level, most often as 'satellite accounts' to national GDP accounts.

Governments around the world, including Australian Commonwealth, state and territory governments, have begun developing and implementing EEA to inform public policy development. The Commonwealth Government has the National Strategy and Action Plan for a common approach to EEA, which was endorsed by environment ministers in April 2018.

Ecosystem accounts are a type of EEA that take stock of current ecosystem assets – in terms of their extent, location and condition – and quantify and value the flow of ecosystem services that these assets generate for people, who enjoy benefits from them. Figure 12 sets out the ecosystem accounting framework.

114. The content in this section has been provided by DELWP.
115. The recommendations of the UN Conference on Environment and Development in Rio de Janeiro are set out in Agenda 21. This is a non-binding action plan of the United Nations on sustainable development https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf Accessed 1 October 2021.

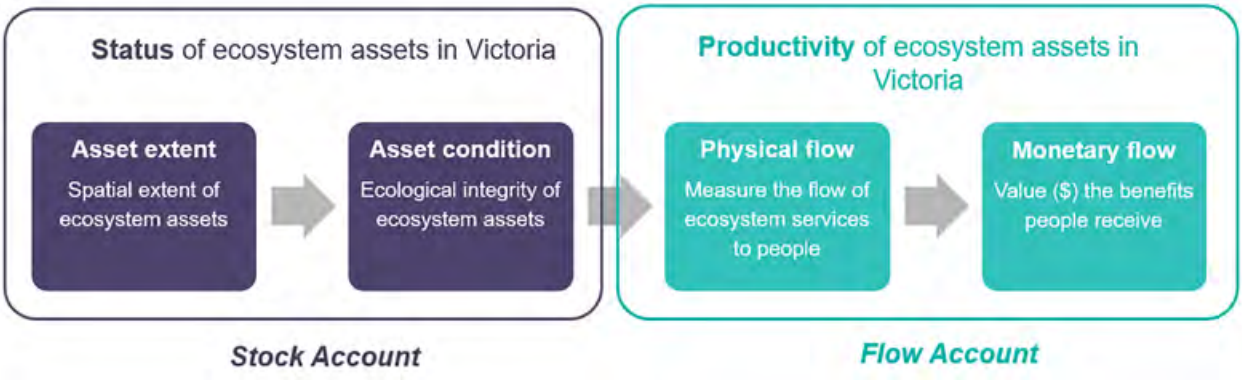


Figure 12: Ecosystem accounting framework.[116]

The interactions between the economy and the environment are reported on in ecosystem accounts by isolating the contribution of the environment to goods and services that are captured in conventional economic (GDP) accounts. However, the accounting framework also extends to include the broader (non-market or public good) values that are supported by the environment (and delivered by government), but which are not captured in GDP accounts. This broader framing of value provides decision-makers with an understanding of the total societal value provided by the natural environment, not just its contribution to supporting tourism, agriculture, fishing and forestry, for example.

Table 4 illustrates the potential structure of a comprehensive and mutually exclusive set of ecosystem accounts for a land area (e.g. an entire country, state or region) where the account reports information on the relationships between ecosystem asset status and productivity in terms of the range of ecosystem services produced (including both 'market' and 'non-market' benefits). Accounts do not necessarily need to cover all cells in this table – an indicative scope is presented for illustrative purposes, with dots representing the ecosystem asset–service relationships that might be considered for an assessment (the actual scope would depend on data availability, resourcing and timing, analytical capability and priorities, for instance).

116. Department of Environment, Land, Water and planning (DELWP) 2021, 'Environmental-economic accounting in Victoria: background to environmental-economic accounting in Victoria', summary for the office of the Commissioner for Environmental Sustainability, Melbourne, Victoria.
117. Ibid.

Table 4: Overview of ecosystem accounting structure.[117]

		Ecosystem assets								
		Alpine	Coastal margins	Farmland	Forest	Freshwater/ Wetland	Grassland	Heath/ Shrubland	Marine	Urban
Provisioning services	Biomass – biofuels	◊	◊	◊	◊	◊			◊	
	Biomass – timber	◊			◊					
	Biomass – food	◊	◊	◊	◊	◊			◊	◊
	Water provision	◊			◊	◊	◊	◊		◊
Regulating services	Air quality regulation	◊			◊		◊	◊		◊
	Coastal protection		◊			◊			◊	
	Flood risk regulation	◊	◊		◊	◊	◊	◊	◊	◊
	Global climate regulation	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Landslide regulation	◊	◊		◊		◊	◊		
	Local climate regulation							◊	◊	◊
	Noise / smell regulation									◊
	Water quality regulation	◊			◊	◊	◊	◊		◊
Cultural servicesa	Aesthetics	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Cultural heritage	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Education and research	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Existence / option value	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Recreation and tourism	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Social cohesion	◊	◊	◊	◊	◊	◊	◊	◊	◊
Bundle	Amenity (liveability)	◊	◊	◊	◊	◊	◊	◊	◊	◊

Ecosystem accounts consist of several linked subaccounts, developed as follows:

Ecosystem asset extent account: this account reports information on the extent (hectares) of environmental assets in the study area. The precise definition or classification of assets is based on an agreed systematic classification or typology of environmental assets (e.g., habitats) in Victoria and Australia from the relevant literature, and includes coastal margins, marine, freshwaters and wetlands, heathland or shrubland, urban, forests, alpine, grassland and farmland.

Ecosystem asset condition account: this account compiles information on a range of metrics which capture the ecological condition and socio-economic characteristics of ecosystem assets in the study area. The specific metrics reported will depend primarily on information availability. Consideration will be given to what is useful from a policy or management perspective, and scientific and economic understanding of the importance of that metric in determining the assets' capacity to support ecosystem services.

Physical account of ecosystem service flows: this account quantifies the physical provision of ecosystem services, over time, based on an agreed systematic classification or typology of ecosystem services from the literature (e.g. the common international classification of ecosystem services).[118] Examples of metrics (for different ecosystem services) include visit numbers (for recreation and tourism), tonnes of carbon sequestered (climate regulation) and kilograms of fish harvested (food provision).

Monetary account of ecosystem service flows: this account values the physical provision of different ecosystem services over time using different economic valuation techniques. For example, people's willingness to pay (a welfare value, based on non-market values) or resource rent based on actual market transactions (exchange values, based on the amount actually paid minus the cost of other (non-natural) capital assets).

Figure 13 and Figure 14 illustrate the type of information captured in the stock and flow accounts for a coastal and marine ecosystem account.

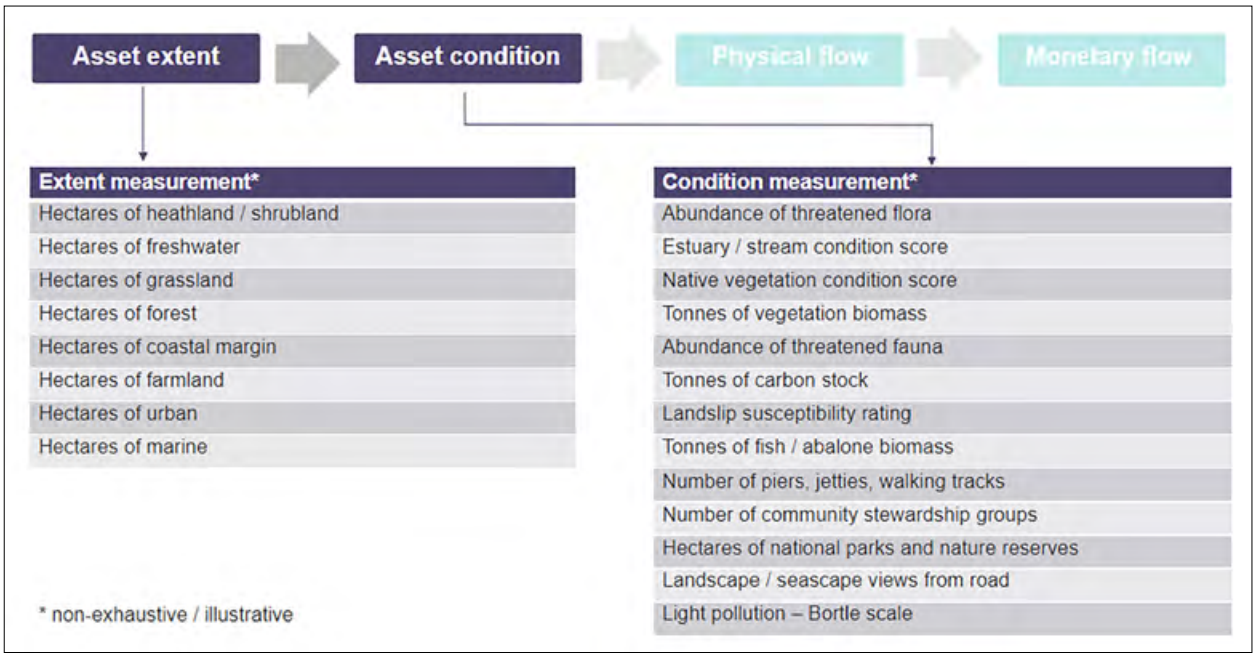
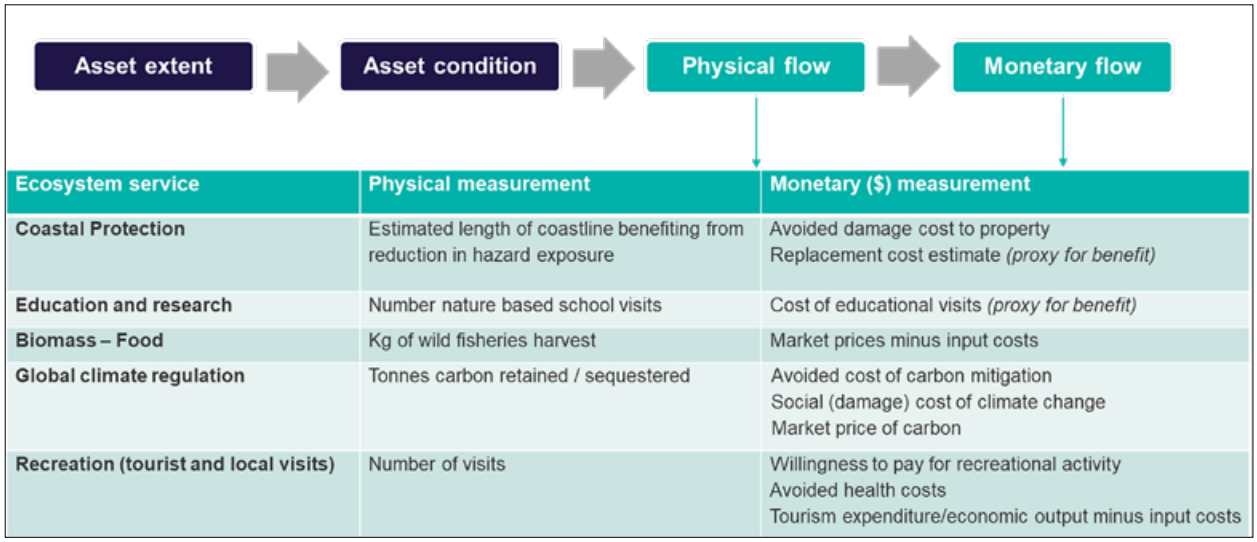


Figure 13: Illustrative stock account (coastal and marine ecosystem account).[119]

118. Haines-Young R and Potschin MB 2018, 'Common international classification of ecosystem services (CICES) v5.1 and guidance on the application of the revised structure', prepared for the European Environment Agency by Fabis Consulting Ltd, Nottingham, UK https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf

119. Department of Environment, Land, Water and planning (DELWP) 2021, 'Environmental–economic accounting in Victoria: Background to environmental–economic accounting in Victoria', summary for the office of the Commissioner for Environmental Sustainability, Melbourne, Victoria.



Ecosystem service	Physical measurement	Monetary ($) measurement
Coastal Protection	Estimated length of coastline benefiting from reduction in hazard exposure	Avoided damage cost to property Replacement cost estimate *(proxy for benefit)*
Education and research	Number nature based school visits	Cost of educational visits *(proxy for benefit)*
Biomass – Food	Kg of wild fisheries harvest	Market prices minus input costs
Global climate regulation	Tonnes carbon retained / sequestered	Avoided cost of carbon mitigation Social (damage) cost of climate change Market price of carbon
Recreation (tourist and local visits)	Number of visits	Willingness to pay for recreational activity Avoided health costs Tourism expenditure/economic output minus input costs

Figure 14: Illustrative flow account (coastal and marine ecosystem account).[120]

Ecosystem accounts are used by governments across the world to understand the value of the environment to society. Incorporating this information into public sector decision-making (e.g. strategic planning, policy and investment appraisals) can support governments to recognise all the costs and benefits associated with interventions – not only the market consequences that are easily quantified or valued.

Ecosystem accounts might also include information that is relevant to inform future policy or ecosystem asset management. This could include details on:

- welfare values (for use in policy appraisal)
- socio-economic characteristics that co-produce benefits from ecosystems
- future or historical changes in ecosystem asset status and productivity
- disservices (e.g. pests, disease and fire)
- negative pressures (e.g. pollution, population growth and climate change)
- positive dependencies (e.g. the removal of impurities from river water by upstream ecosystem filtration)
- expenditures on maintaining, restoring or expanding ecosystem assets
- links to other reporting frameworks (e.g. the UN Sustainable Development Goals)
- income and employment dependencies
- socio-economic distribution of benefits.

Including this broader information means diverging from a sole focus on quantifying and monetising the natural environment's value for the purpose of developing 'satellite accounts' to national GDP accounts. Such a divergence will not preclude this focus, providing the underlying SEEA Framework is adhered to.

Existing ecosystem accounts in Victoria

DELWP is developing accounting applications based on the SEEA Framework to provide better, integrated and more consistent information and analysis on our environmental assets in Victoria: information on which assets have been maintained, restored or destroyed, which are improving or declining in condition, and how the health of these assets affects our wellbeing as a society.

This framework will support government policy, planning and investment decisions affecting the environment. It will also strengthen the ability of local government, business, not-for-profit and community stakeholders to recognise the benefits of protecting and investing in the environment.

120. Ibid.

DELWP's initial ecosystem accounting work (in the early 2010s) was aimed at demonstrating concepts using available information. The more recent program of work has been developed in response to identified policy needs across the department. The existing ecosystem accounts developed for Victoria are a snapshot of ecosystem status and productivity, at a point in time, and have been developed for much of Victoria's land or water area, (Figure 13). One of the snapshot accounts currently under development by DELWP is a baseline account for the Great Ocean Road, including the marine and coastal ecosystems of the Great Ocean Road region.

Figure 15 also shows that DELWP has recently used the information in the 2019 forest ecosystem accounts (for Regional Forest Agreement areas) to assess the effects of the 2019-20 bushfires and the associated social, environmental and economic outcomes. This demonstrates one way that ecosystem accounts can be used to assess the result of pressures on ecosystem assets on societal and economic prosperity.

In addition to developing ecosystem accounts for Victoria, DELWP continues to participate in the development of a common national approach to EEA (led by the Commonwealth Government), which is based on the UN SEEA. This includes senior executive membership of the Interjurisdictional Environmental–Economic Accounting Steering Committee and a leadership role in chairing the interjurisdictional urban ecosystem accounting working group in Australia. This collaborative exchange of concepts, methods and datasets across the public sector in Australia facilitates alignment in EEA practices nationally (as appropriate).

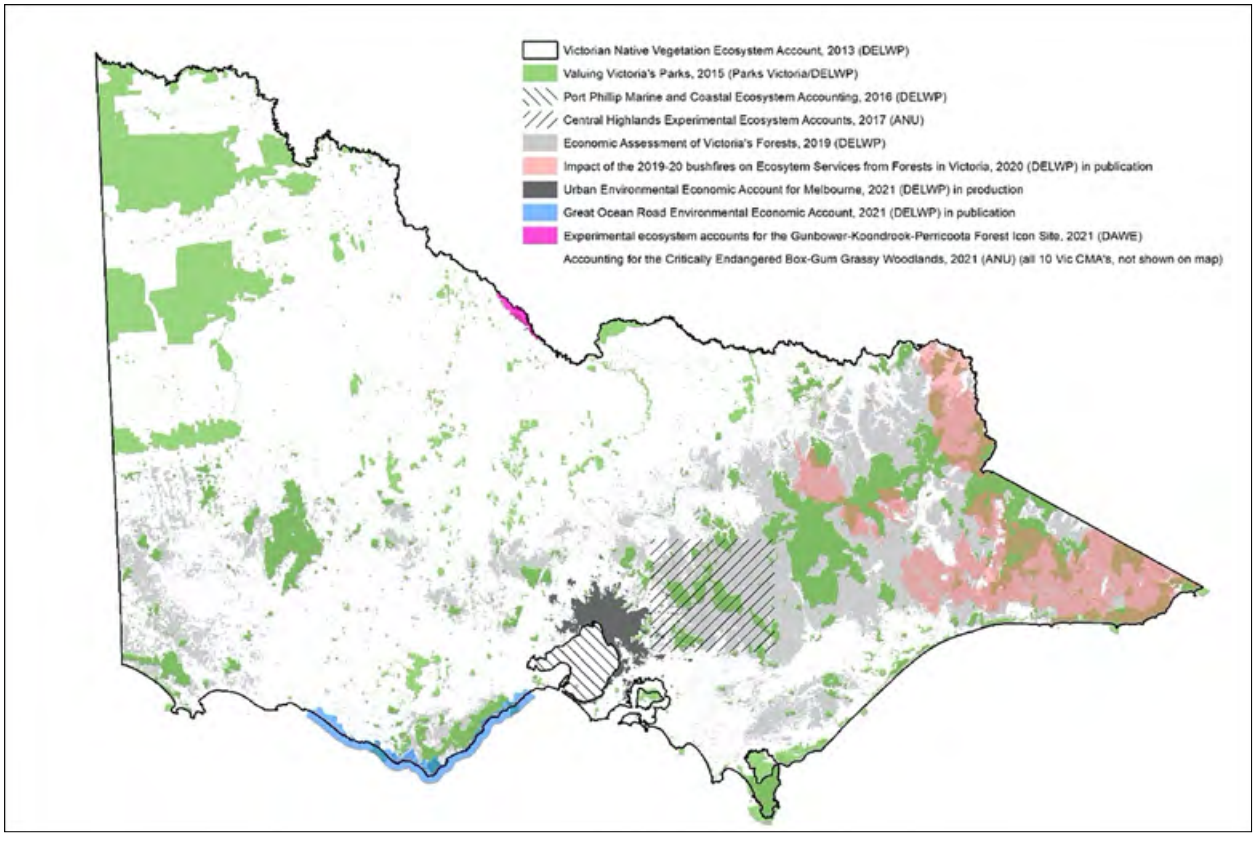


Figure 15: Current coverage and recency of ecosystem accounts in Victoria.[121]

121. Ibid.

Commissioner *for* Environmental Sustainability Victoria

Appendix A

Analysis of spatial information technologies applications for marine and coastal science

Appendix A : Analysis of spatial information technologies applications for marine and coastal science[122]

Spatial technology category	SMCE indicators that this technology currently assists	SMCE indicator that this technology could assist in the next reporting cycle (to 2024)	Examples of this technology being employed internationally	
Earth observation (EO) and remote sensing	Saltmarsh Mangroves Seagrass Light pollution Coastal erosion	Algae component of water quality (physio-chemical), the chlorophyll–a component of water quality (estuaries), phytoplankton and plankton Coastal erosion, areas of coastal vulnerability, climate change impact on marine and coastal infrastructure and sea level, and coastal inundation Water clarity component of water quality (physio-chemical), the turbidity component of water quality (estuaries), total fine sediment loads and the sediment components of regulated point source discharges and stormwater Litter and other pollutant components of regulated point source discharges and stormwater, and litter and plastics Saltmarsh | Seagrass | Mangroves Coastal air quality Water temperature	Use Digital Earth Australia (DEA) Sandbox to implement the US method of saltmarsh mapping Use DEA Sandbox to implement synthetic aperture radar (SAR) detection of effluent plumes and detection of macro-plastics from optical data and indices from the literature.	
Smart sensors and the Internet of Things (IoT)	Plankton (Integrated Marine Observing System – IMOS) Nitrogen cycle Wave energy (sensors on buoys) Seawater intrusion into coastal aquifers Coastal air quality Rainfall Air temperature Water temperature Sea-level and coastal inundation Ocean acidification	Water quality (physio-chemical), water quality (estuaries), phytoplankton, regulated point source discharges, stormwater, and total fine sediment loads Coastal air quality Phytoplankton and plankton (and many other indicators addressed by the parameters measured) Adverse effects of poor water quality, little penguins, coastal populations (visitors), tourism and recreational boating	In the US, National Oceanic and Atmospheric Administration (NOAA), in partnership with the coastal states, has a National Estuarine Research Reserve System-Wide Monitoring Program which provides real-time water, weather and nutrient data for 29 sites protected for long-term research, ecosystem monitoring, education and coastal stewardship.	

122. Victorian Environmental Assessment Council 2019, 'Assessment of the values of Victoria's marine environment', Victorian Government, Melbourne https://www.veac.vic.gov.au/investigations-assessments/previous-assessments/document/getDownload?fid=MjM= Accessed 24 May 2021.

	Opportunities for uptake of other Australian jurisdictions' marine or coastal applications in Victoria	Opportunities to apply the technology (currently used for other purposes in Victoria) to marine and coastal outcomes	Future applications of the technology (beyond 2024)
	DEA provides Sentinel data and the Normalised Difference Chlorophyll Index that can be used in their Sandbox environment Use the DEA Coastlines product to identify areas for detailed investigation of coastal erosion Use the DEA Sandbox to implement a total suspended solid algorithm from the literature Use DEA Sandbox Sentinel-1 SAR and Sentinel-2 time series imagery with the Normalised Difference Vegetation Index indices	ARI and DELWP produce Multi-temporal Land Cover and Native Vegetation Extent data for Victoria (marine and coastal vegetation specific) RMIT University is developing hotspot detection algorithms from Himawari 8 imagery which will be used by DELWP during the fire season and could apply to SMCE Indicator 50 Frequency and impact of fire on marine and coastal ecosystems Potentially apply machine learning techniques such as that used in Sweden and Finland to assess coastal acid sulfate soils	Emerging satellite-as-a-service providers e.g. Exodus Orbitals, ISISPACE and Loft Orbital if specific EO data are required Potentially use reflectance and salinity as methods become more established to measure water nutrients Sentinel-5P data in DEA for coastal air quality The CSIRO and the SmartSat CRC are developing a national water quality monitoring system called AquaWatch. Using sea-surface temperature satellite and salinity data to estimate ocean acidification
	The EPA also has an automated water quality monitoring system on board the Spirit of Tasmania ferry, in partnership with IMOS. The system collects continuous measurements every day while travelling, and measures, salinity, temperature, phytoplankton and turbidity. A new, permanent IMOS National Reference Station could be established in Victoria, as in other Australian states, which would measure a range of parameters for various indicators.	The City of Melbourne recently implemented an automated IoT pedestrian counting system. It helps to monitor and evaluate the effects of pedestrian infrastructure investments, and better understand the environmental impacts and benefits of walking. A similar system could be implemented for the SMCE, with coastal sensor locations at tourist, boating, fishing and penguin hotspots. OysterQual – a project looking at measuring water quality of remote coastal waters for oyster farming site selection SIGWater – IoT connectivity for space monitoring groundwater in South Australia could be redeployed to other applications.	DNA nanosensors can be used to detect environmental pollutants. They are easy to design, cost-effective, and an increasing number of DNA sequences are being devised to detect a wider range of pollutants.

Spatial technology category	SMCE indicators that this technology currently assists	SMCE indicator that this technology could assist in the next reporting cycle (to 2024)	Examples of this technology being employed internationally	
Remotely piloted vehicle (RPV) systems	Coastal erosion	Species of conservation concern, diadromous fish, marine mammals and invasive marine species (and water quality (toxicants) Macroalgae on intertidal reefs	Monitoring macroalgal biodiversity in New Zealand, South-west Atlantic US NOAA uses underwater RPV to collect water samples for analysis of environmental DNA.	
GPS and tracking	Little penguins Marine mammals Litter and plastics	Potentially all fauna indicators with animal tracking programs Potentially all fauna indicators, especially diadromous fish, marine mammals and larger commercially and recreationally important invertebrates, by establishing a permanent IMOS station Potentially all fauna indicators, especially marine and coastal waterbirds, migratory shorebirds and piscivorous birds, by using mini transmitters and saving in Movebank database	In the US, NOAA also has an IOOS Animal Telemetry Network, including real-time tag deployments, satellite telemetry and acoustic telemetry. The ICARUS (International Cooperation for Animal Research Using Space) initiative is an example of this. The initiative has a receiver on the International Space Station which began operational use in March 2021, as well as mini transmitters which weigh only 5 grams. The transmitters have a GPS function and can withstand cold, heat, moisture and dust and can transmit their data by radio for months or years, to the receiver in space. The program is initially targeted at birds, so it could be used for the indicators marine and coastal waterbirds, migratory shorebirds, piscivorous birds.	
Citizen science	Invertebrates on subtidal reefs Subtidal reef fish Marine and coastal waterbirds Migratory shorebirds Piscivorous birds Citizen science	All fauna and flora indicators using data from the Atlas of Living Australia Stormwater, litter and plastics, illegal activities, invasive marine species, invasive coastal plants and invasive coastal animals, using data from Snap Send Solve	There are many databases based on citizen science programs such as MangroveWatch, SeagrassNet, Seagrass-Watch and Phytoplankton Monitoring Network.	

	Opportunities for uptake of other Australian jurisdictions' marine or coastal applications in Victoria	Opportunities to apply the technology (currently used for other purposes in Victoria) to marine and coastal outcomes	Future applications of the technology (beyond 2024)
	The Australian Institute of Marine Science (AIMS) have approximately 10 commercial-grade RPVs which they use for a range of applications such as surveying intertidal reefs, water analysis via aerial sample collection, ocean colour ground truthing to validate satellite data, and algal bloom monitoring.	ARI uses environmental DNA in freshwater and with manual collection; saltwater applications and RPV usage could be considered. Land Use Victoria's Great Ocean Road reality mesh.	RPV imagery and structure from motion or deep learning for important invertebrates or shellfish when methods are established – SMCE Indicators 20: Mobile invertebrates on intertidal reefs, 21: Sessile invertebrates on intertidal reefs and 35: Shellfish reefs.
	Queensland has acoustic telemetry arrays, funded by the Department of Environment and Science, which provide the infrastructure to understand the distribution and movement of important marine species along the east coast of Queensland. Victoria could borrow a receiver and conduct a trial study with the aim of establishing more permanent receivers. This could be complemented by a tagging program potentially including diadromous fish, little penguins, marine mammals and larger commercially and recreationally important invertebrates to contribute to the assessment of these indicators and the IMOS database.	National Livestock Identification System for the supply chain management of meat and dairy products – different types of animal tags are used and electronic tags have transponders with radio frequency identification device numbers for animal identification and tracking. They are not typically GPS tags, although Victoria's On-Farm IoT Trial does include GPS tags.	Probably only reduced size smaller tags, longer battery life and ubiquitous, low-cost, high-accuracy devices enabling the tracking of many more animals
	New South Wales (NSW) CoastSnap beach monitoring There are many databases, including Sea Search, Virtual Reef Diver and Redmap Australia Point Lonsdale Sand Monitoring Program.	Use Strava data to create global heatmaps for SMCE Indicator 75: Community connection to the coast	Citizen sensing which will enable people to use low-cost or self-built sensors for data collection, to learn more about the issues they care about in order to empower themselves

Spatial technology category	SMCE indicators that this technology currently assists	SMCE indicator that this technology could assist in the next reporting cycle (to 2024)	Examples of this technology being employed internationally	
Artificial intelligence (AI) and machine learning (ML)	Marine and coastal infrastructure	Litter and plastics: MARLIT is an open access web app using deep learning, that aids the detection of floating plastics in the sea with RPV and aircraft aerial imagery. For the conservation of coastal ecosystems in protected areas, use Victoria's Land Cover Time series via NatureKit 2.0 Boat counting method using ML and GPS tracking methods	Bird breeding sites counting and mapping in Botswana, West Africa and Turkey US-built models to map concentrations of nitrogen and phosphorus in water bodies across the country in 1994–2018 using random forest classification and an ML algorithm Sweden produced a distribution map of acid sulfate soils along the coast of northern Sweden using ML. The output was a map of surface deposits, vegetation and land-use classification based on satellite data, and a high-resolution digital elevation model based on LiDAR as input data.	
Big data and analytics (including GIS)	Many SMCE indicators across most themes	Areas of coastal vulnerability, coastal erosion, climate change effect on marine and coastal infrastructure and sea level, and coastal inundation: use DEA Coastlines and other products via NationalMap Use of marine and coastal areas: adverse effects of poor water quality, little penguins, coastal populations (visitors), and tourism: obtain People Tracker method to analyse people movement from social-media big data, or investigate and establish an alternative method for using big data (mobile phone or social media) to track visitor populations in an ongoing capacity Frequency and effect of fire on marine and coastal ecosystems: obtain fire data from Spatial Datamart Victoria for spatial analysis (e.g., fire history) Areas of coastal vulnerability, coastal erosion, climate change effect on marine and coastal infrastructure and sea level, and coastal erosion: use the Coastal Hazard Decision Support System when available	Analysis of social big data in South Korea in 2019 and 2020 paper Another example is People Tracker for analysing people movement from social-media–based big data to provide decision support for government authorities. The pilot study was for Fiji using Flickr photos. Other examples include Google mobility analytics and Apple mobility. Fireball International provides an early detection, assessment and mapping system for rapid, effective fire suppression using AI on big data in the form of ground-based, aerial and satellite images.	

	Opportunities for uptake of other Australian jurisdictions' marine or coastal applications in Victoria	Opportunities to apply the technology (currently used for other purposes in Victoria) to marine and coastal outcomes	Future applications of the technology (beyond 2024)
	'Seagrass', a 2019 article describes how IBM used AI for image segmentation of underwater video to identify seagrass in South Australia. The data produced can now be used to predict the health of seagrass and how it will change over time. The NSW Marine Estate Management Authority strategy mentions 'exploring ways of using artificial intelligence to map and monitor habitats and species'. Curtin University and AIMS used deep learning for automated analysis of BRUVS (Baited Remote Underwater Video Stations) fish data which provides a scalable way to analyse video.	ARI and DELWP produce Multi-temporal Land Cover and Native Vegetation Extent data for Victoria. Marine and coastal vegetation specific. FrontierSI's ML project in automatic feature extraction for trees in Victoria could be modified for coastal vegetation.	Develop an ML algorithm for detecting sewerage discharges and implement a system with telemetry, rainfall data and analytics to enable real-time detection of spills – SMCE indicator: Regulated point source discharges and potentially stormwater. Establish an ML research program to investigate opportunities to implement ML algorithms for important indicators, or establish an advisory group to determine the use of AI and ML.
	DEA has a number of products available including DEA Coastlines (which has its own viewer), National Intertidal Digital Elevation Model, Intertidal Extents Model, and High and Low Tide Composites which can be viewed on NationalMap. The DEA also has a Sandbox environment which is a free learning and analysis environment for getting started with DEA and the Open Data Cube (ODC). It has several sample notebooks, such as for chlorophyll monitoring, coastal erosion, intertidal elevation, radar water detection and shipping lane identification, that demonstrate capability and enable big data analytics. The CSIRO also has a platform built on the ODC called Earth Analytics Science and Innovation (EASI) platform.	The Joint Fuel Management Program has an interactive map showing where and when DELWP and PV intend to carry out fire management operations on public land, as well as the fire history for the last five years. Fire history (and many other fire-related datasets) can also be downloaded from the Spatial Datamart Victoria website. These could then be analysed in GIS, along with a time series analysis to assess the frequency and effect of fire on marine and coastal ecosystems indicator.	More online systems to enable people to derive insights from big data, potentially using machine learning, will probably emerge.

Spatial technology category	SMCE indicators that this technology currently assists	SMCE indicator that this technology could assist in the next reporting cycle (to 2024)	Examples of this technology being employed internationally	
Spatial datasets and data portals	Many SMCE indicators across most themes	Many indicators across most themes GoFishVIC App – if de-identified data from this app could be obtained from the Victorian Fisheries Authority, it could be used to assess commercially and recreationally important invertebrates and fish, recreational boating and fishing's contribution to the Victorian economy, and recreational fishing.	Waterbird Population Estimates – an international wetlands database that may support the marine and coastal waterbirds indicator	

	Opportunities for uptake of other Australian jurisdictions' marine or coastal applications in Victoria	Opportunities to apply the technology (currently used for other purposes in Victoria) to marine and coastal outcomes	Future applications of the technology (beyond 2024)
	National Marine Mammal Data Portal – the Department of Agriculture, Water and the Environment (DAWE) provides this database, which is based on mammal sightings (rather than tracking information) and could contribute to Indicator 31: Marine mammals. AusSeabed is a national seabed mapping coordination program providing bathymetry data that could be of use to seafloor integrity and health indicators such as conservation of marine ecosystems in protected areas. Seagrass presence data – TERN Australia's Terrestrial Ecosystem Research Infrastructure has considerable information including this marine data on seagrass presence and absence. Although it dates back to 2005 it may assist with seagrass and other indicators. Seamap Australia – this Australian seabed habitat classification scheme and spatial database could help seafloor integrity and health indicators. CoastAdapt – this National Climate Change Adaptation Research Facility information delivery and decision support framework helps users understand climate change and the responses available to manage the impacts. It may assist climate and climate change impacts indicators.	Merge all the existing Victorian data and portals into one Victorian statewide open data portal for environmental data like the NSW SEED portal	Agricultural property data – The Guardian Australia collated large datasets from every state and territory and created a database of land ownership. Recently, FrontierSI conducted a project to define agricultural property with the intent of creating a dataset in the future. Greening the Greyfields tools are spatial planning tools for revitalising the middle suburbs of Australia and New Zealand. Similar tools could be developed for the coast. Digital Atlas of Australia – planned in the 2021–2022 federal budget, this will be a free interactive platform, allowing access to authoritative national datasets on Australia's geography, people, economy, employment, infrastructure, health, land and the environment.

Spatial technology category	SMCE indicators that this technology currently assists	SMCE indicator that this technology could assist in the next reporting cycle (to 2024)	Examples of this technology being employed internationally	
Simulation and modelling	Total nutrient loads Total fine sediment loads	Stormwater Species of conservation concern Regulated point source discharges Total nutrient loads	International study using numerical model simulations to improve the understanding of micro-plastic distribution and pathways in the marine environment.	

	Opportunities for uptake of other Australian jurisdictions' marine or coastal applications in Victoria	Opportunities to apply the technology (currently used for other purposes in Victoria) to marine and coastal outcomes	Future applications of the technology (beyond 2024)
	Stormwater: the DEA has an Enhanced Normalised Difference Impervious Surfaces Index and an urban change detection notebook that could determine impervious surface area and contribute to stormwater modelling in conjunction with BoM rainfall data. In addition, the eWater Source tool is Australia's National Hydrological Modelling Platform designed for all areas of water management including rainfall-runoff models and water quality analysis based on catchment land-use scenarios. Regulated point source discharges: if the EPA provides point data of discharges for Indicator 06: Regulated point source discharges to marine waters, the flow of pollutants to surrounding areas or the change over time from these point source discharges could be modelled in a GIS. NSW maps outflow events and the effects on habitats. Total nutrient loads: catchment modelling could be done for nitrogen and phosphorous runoff using export coefficients associated with EO land cover or land use. Export coefficients are usually derived from literature and field experiments to determine the rate at which nutrients are lost from each source to the surface drainage network. AIMS' eReefs Visualisation Portal has implemented models for the marine environment (Great Barrier Reef) including a hydrodynamic model, a biogeochemical model of water quality (nutrients and suspended sediment) and key ecological processes (coral, seagrass and plankton).	Use Melbourne Water's stormwater models or industry software MUSIC or Source to generate impervious area and stormwater modelling Use ARI's Habitat distribution models via NatureKit 2.0	The Ocean Data Action Coalition envisages implementing an ocean avatar or ocean digital twin for sustainable ocean management. It has begun building the core of this with the Ocean Data Platform, an open platform that collates and visualises ocean data, but realising the ocean avatar is still a long way off. EcoCommons will provide ecological and environmental modelling tools.

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Appendix B

Comprehensiveness assessment of selected marine and coastal Sustainable Development Goal targets

Appendix B : Comprehensiveness assessment of selected marine and coastal Sustainable Development Goal targets

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
2 ZERO HUNGER	2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	Theme 8: Communities	68	Aquaculture	30%
			Theme 8: Communities	70	Agriculture	20%
			Theme 1: Water quality and catchment inputs	08	Total nutrient loads	40%
			Theme 6: Climate and climate change impacts	50	Frequency and impact of fire on marine and coastal ecosystems	10%
	2.5	By 2020, maintain the genetic diversity of seeds, cultivated plants, and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the use of genetic resources and associated traditional knowledge, as internationally agreed	n/a	B:21*	Area of management in priority locations	50%
			n/a	Fo:05*	Number of in situ and ex situ conservation efforts for forest-dependent species	50%

*Note: Marked indicators are from State of Environment 2018 Report rather than SMCE 2021 Report

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	3.9	By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Theme 2: Litter and pollution	14	Coastal air quality	40%
			Theme 1: Water quality and catchment inputs	05	*Enterococci* bacteria	40%
			Theme 6: Climate and climate change impacts	50	Frequency and impact of fire on marine and coastal ecosystems	10%
			Theme 2: Litter and pollution	13	Coastal contaminated land	5%
			Theme 1: Water quality and catchment inputs	10	Coastal acid sulfate soils	5%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
6 CLEAN WATER AND SANITATION	6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	Theme 1: Water quality and catchment inputs	02	Toxicants	15%
			Theme 1: Water quality and catchment inputs	05	*Enterococci* bacteria	50%
			Theme 1: Water quality and catchment inputs	06	Regulated point source discharges to marine waters	10%
			Theme 1: Water quality and catchment inputs	07	Stormwater	10%
			Theme 1: Water quality and catchment inputs	10	Coastal acid sulfate soils	15%
	6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.	Theme 1: Water quality and catchment inputs	03	Water quality (estuaries)	10%
			Theme 3: Biodiversity	18	Wetland and estuary vegetation	20%
			Theme 3: Biodiversity	15	Conservation of coastal ecosystems in protected areas	40%
			Theme 6: Climate and climate change impacts	41	Rainfall	20%
			Theme 6: Climate and climate change impacts	49	Seawater intrusion into coastal aquifers	10%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	8.9	By 2030, devise and implement policies to promote sustainable tourism that create jobs and promote local culture and products	Theme 8: Communities	62	Tourism	60%
			Theme 8: Communities	64	Recreational boating	10%
			Theme 8: Communities	65	Recreational fishing	10%
			Theme 8: Communities	63	Recreational boating and fishing contribution to the Victorian economy	20%
	9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human wellbeing, with a focus on affordable and equitable access for all	Theme 6: Climate and climate change impacts	51	Climate change impact on marine and coastal infrastructure	45%
			Theme 8: Communities	66	Shipping and ports	15%
			Theme 6: Climate and climate change impacts	48	Coastal erosion	15%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	25%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	10.2	By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion, economic or other status	Theme 9: Stewardship and collaborative management	81	Engagement and inclusiveness	60%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	20%
			Theme 8: Communities	62	Tourism	10%
			Theme 8: Communities	71	Built and public benefit infrastructure	10%
	11.3	By 2030, enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Theme 9: Stewardship and collaborative management	81	Engagement and inclusiveness	35%
			Theme 9: Stewardship and collaborative management	78	Planning and implementation	35%
			Theme 8: Communities	58	Significant landscapes	10%
			Theme 7: Managing coastal hazard risks	52	Considering climate change risks in land-use planning	10%
			Theme 8: Communities	59	Coastal settlements	10%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Theme 8: Communities	60	Cultural heritage	40%
			Theme 3: Biodiversity	15	Conservation of coastal ecosystems in protected areas	30%
			Theme 4: Seafloor integrity and health	32	Conservation of marine ecosystems in protected areas	30%
	11.6	By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Theme 8: Communities	59	Coastal settlements	45%
			Theme 2: Litter and pollution	14	Coastal air quality	15%
			Theme 1: Water quality and catchment inputs	06	Regulated point source discharges to marine waters	15%
			Theme 2: Litter and pollution	11	Litter and plastics	15%
			Theme 8: Communities	73	Illegal activities	10%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	11.7	By 2030, provide universal access to safe, inclusive and accessible, green and community spaces, in particular for women and children, older people and people with disability	Theme 9: Stewardship and collaborative management	81	Engagement and inclusiveness	40%
			Theme 8: Communities	61	Use of marine and coastal areas	15%
			Theme 9: Stewardship and collaborative management	75	Community connection to the coast	25%
			Theme 9: Stewardship and collaborative management	78	Planning and implementation	20%
	11.a	Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	Theme 9: Stewardship and collaborative management	78	Planning and implementation	40%
			Theme 8: Communities	58	Significant landscapes	20%
			Theme 8: Communities	59	Coastal settlements	20%
			Theme 6: Climate and climate change impacts	45	Areas of coastal vulnerability	20%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	12.2	By 2030, achieve the sustainable management and efficient use of natural resources	Theme 3: Biodiversity	15	Conservation of coastal ecosystems in protected areas	20%
			Theme 4: Seafloor integrity and health	32	Conservation of marine ecosystems in protected areas	20%
			Theme 8: Communities	68	Aquaculture	40%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	20%
	12.4	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimise their adverse effects on human health and the environment	Theme 2: Litter and pollution	14	Coastal air quality	25%
			Theme 1: Water quality and catchment inputs	05	*Enterococci* bacteria	25%
			Theme 1: Water quality and catchment inputs	08	Total nutrient loads	25%
			Theme 1: Water quality and catchment inputs	02	Toxicants	25%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	12.8	By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	Theme 9: Stewardship and collaborative management	75	Community connection to the coast	20%
			Theme 9: Stewardship and collaborative management	82	Delivery and accountability	40%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	40%
	12.b	Develop and implement tools to monitor sustainable development effects on sustainable tourism that create jobs and promote local culture and products	Theme 8: Communities	62	Tourism	70%
			Theme 8: Communities	60	Cultural heritage	30%

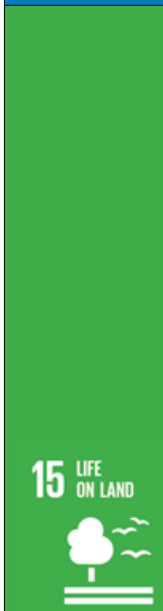
Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Theme 7: Managing coastal hazard risks	54	Nature-based adaptation	20%
			Theme 6: Climate and climate change impacts	45	Areas of coastal vulnerability	40%
			Theme 6: Climate and climate change impacts	46	Sea-level and coastal inundation	10%
			Theme 7: Managing coastal hazard risks	55	Emergency planning and preparedness	20%
			Theme 8: Communities	56	Population (resident)	10%
	13.2	Integrate climate change measures into national policies, strategies and planning	Theme 7: Managing coastal hazard risks	54	Nature-based adaptation	30%
			Theme 7: Managing coastal hazard risks	52	Considering climate change risks in land-use planning	30%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	10%
			Theme 7: Managing coastal hazard risks	55	Emergency planning and preparedness	15%
			Theme 7: Managing coastal hazard risks	53	Climate change adaptation plans	15%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Theme 7: Managing coastal hazard risks	55	Emergency planning and preparedness	15%
			Theme 7: Managing coastal hazard risks	53	Climate change adaptation plans	35%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	35%
			Theme 7: Managing coastal hazard risks	52	Considering climate change risks in land-use planning	15%
	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	Theme 1: Water quality and catchment inputs	08	Total nutrient loads	25%
			Theme 1: Water quality and catchment inputs	06	Regulated point source discharges to marine waters	25%
			Theme 6: Climate and climate change impacts	50	Frequency and impact of fire on marine and coastal ecosystems	15%
			Theme 1: Water quality and catchment inputs	05	*Enterococci* bacteria	25%
			Theme 2: Litter and pollution	13	Coastal contaminated land	5%
			Theme 1: Water quality and catchment inputs	10	Coastal acid sulfate soils	5%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse effects, including by strengthening their resilience, and taking action for their restoration to achieve healthy and productive oceans	Theme 3: Biodiversity	15	Conservation of Coastal Ecosystems in Protected Areas	30%
			Theme 4: Seafloor Integrity and Health	32	Conservation of Coastal Ecosystems in Protected Areas	30%
			Theme 8: Communities	68	Aquaculture	10%
			Theme 7: Managing coastal hazard risks	52	Considering climate change risks in land-use planning	15%
			Theme 7: Managing coastal hazard risks	55	Emergency planning and preparedness	15%
	14.3	Minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	Theme 6: Climate and climate change impacts	44	Ocean acidification	100%
	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, 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	Theme 8: Communities	67	Commercial fishing	40%
			Theme 8: Communities	65	Recreational fishing	40%
			Theme 8: Communities	68	Aquaculture	20%
	14.5	By 2020, conserve at least 10% of coastal and marine areas, consistent with national and international law and based on the best available scientific information	Theme 9: Stewardship and collaborative management	78	Planning and implementation	100%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	14.6	By 2020, prohibit certain forms of fisher subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing similar new subsidies, recognising that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organisation fisheries subsidies negotiation	Theme 8: Communities	67	Commercial fishing	30%
			Theme 8: Communities	65	Recreational fishing	30%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	40%
	14.b	Provide access for small-scale artisanal fishers to marine resources and markets	Cultural landscape health and management	To be developed	See note at bottom of table	n/a
	15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	Theme 3: Biodiversity	18	Wetland and estuary vegetation	10%
			Theme 3: Biodiversity	15	Conservation of coastal ecosystems in protected areas	30%
			Theme 9: Stewardship and collaborative management	75	Community connection to the coast	10%
			Theme 9: Stewardship and collaborative management	74	Stewardship	10%
			Theme 9: Stewardship and collaborative management	82	Delivery and accountability	40%

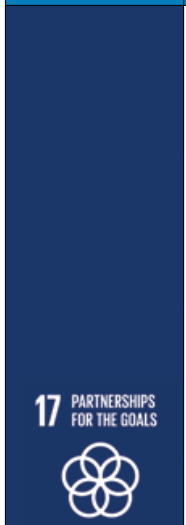
Note: In Victoria, Target 14.b could focus on working with Traditional Owners in recognition of their relationship with marine and coastal cultural heritage and resources. Existing protections and arrangements for access to, and use of, Country are supported, while recognising that there is ongoing development and adaptation of policy in this regard. The Sea Country partnerships currently underway in Victoria may be a preliminary investigation of this potential. More broadly, all the targets in this table need to be considered in terms of Victorian Traditional Owner aspirations and recognition (see Part 1: Cultural Landscape Health and Management).

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	15.5	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	Theme 3: Biodiversity	15	Conservation of coastal ecosystems in protected areas	30%
			Theme 3: Biodiversity	19	Species of conservation concern	40%
			Theme 4: Seafloor integrity and health	32	Conservation of marine ecosystems in protected areas	30%
	15.6	Promote fair and equitable sharing of the benefits arising from the use of genetic resources and promote appropriate access to such resources, as internationally agreed	n/a	B:21*	Area of management in priority locations	50%
			n/a	Fo:05*	Number of in situ and ex situ conservation efforts for forest dependent species	50%
	15.7	Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	Theme 8: Communities	73	Illegal activities	100%
	15.8	By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	Theme 7: Managing coastal hazard risks	55	Emergency planning and preparedness	25%
			Theme 5: Pests and invasive species	38	Invasive marine species	25%
			Theme 5: Pests and invasive species	39	Coastal invasive plants	25%
			Theme 5: Pests and invasive species	40	Coastal invasive animals	25%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	Theme 7: Managing coastal hazard risks	52	Considering climate change risks in land-use planning	15%
			Theme 8: Communities	58	Significant landscapes	15%
			Theme 8: Communities	59	Coastal settlements	15%
			Theme 9: Stewardship and collaborative management	78	Planning and implementation	55%
	15.a	Mobilise and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	Theme 9: Stewardship and collaborative management	82	Delivery and accountability	50%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	50%
	15.c	Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities	Theme 8: Communities	73	Illegal activities	100%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	16.6	Develop effective, accountable and transparent institutions at all levels	Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	30%
			Theme 9: Stewardship and collaborative management	82	Delivery and accountability	40%
			Theme 9: Stewardship and collaborative management	81	Engagement and inclusiveness	30%
	16.7	Ensure responsive, inclusive, participatory and representative decision-making at all levels	Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	30%
			Theme 9: Stewardship and collaborative management	82	Delivery and accountability	30%
			Theme 9: Stewardship and collaborative management	81	Engagement and inclusiveness	40%
	16.b	Promote and enforce non-discriminatory laws and policies for sustainable development	Theme 9: Stewardship and collaborative management	81	Engagement and inclusiveness	55%
			Theme 8: Communities	58	Significant landscapes	15%
			Theme 9: Stewardship and collaborative management	82	Delivery and accountability	15%
			Theme 7: Managing coastal hazard risks	54	Nature-based adaptation	15%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	17.14	Enhance policy coherence for sustainable development	Theme 7: Managing coastal hazard risks	54	Nature-based adaptation	20%
			Theme 9: Stewardship and collaborative management	82	Delivery and accountability	20%
			Theme 7: Managing coastal hazard risks	55	Emergency planning and preparedness	20%
			Theme 9: Stewardship and collaborative management	78	Planning and implementation	20%
			Theme 9: Stewardship and collaborative management	80	Institutional knowledge and capacity	20%

Goal	Target	Target description	Indicator theme	Aligned SMCE indicator number	Aligned SMCE indicator description	Weighting (%)
	17.17	Encourage and promote effective public, public–private and civil society partnerships, building on the experience and resourcing strategies of partnerships	Theme 9: Stewardship and collaborative management	78	Planning and implementation	40%
			Theme 9: Stewardship and collaborative management	75	Community connection to the coast	20%
			Theme 9: Stewardship and collaborative management	77	Citizen science	10%
			Theme 9: Stewardship and collaborative management	81	Engagement and inclusiveness	10%
			Theme 9: Stewardship and collaborative management	82	Delivery and accountability	10%
			Theme 9: Stewardship and collaborative Management	80	Institutional knowledge and capacity	10%

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Appendix C

Indicator summaries by theme

Appendix C

Indicator summaries by theme

This report assesses 82 indicators. These indicators were developed during an extensive and iterative co-creation period with stakeholders in 2020. The indicators fulfil the requirements of the Marine and Coastal Act 2018 (s.37(2)) that an SMCE Report must include the following information:

- the condition of the marine and coastal environment
- the environmental, social and economic benefits of the marine and coastal environment
- the threats to the marine and coastal environment.

This report card summarises the scientific assessments of each indicator, which are provided metrics for each indicator, an overall comment on the assessment, the status, trend and data confidence for each indicator, and the source of the data.

Where appropriate, the corresponding indicator assessments from the State of the Bays 2016 and/or the State of the Environment 2018 reports have been included.

Region

The assessments have been conducted on a statewide and/or regional scale based on the localisation of the impacts associated with each indicator and/or the spatial scale of the evidence supporting the assessment.

Figure 16 shows the spatial extent of marine and coastal reporting by the CES as a timeline from the State of the Bays 2016 Report (Port Phillip Bay and Western Port), to the State of the Marine and Coastal Environment 2021 Report, which includes six marine biounits, and the State of the Marine and Coastal Environment 2024 Report, which is expected to cover Victoria's entire marine and coastal environment. Figure 16 also shows a map of all 26 Victorian marine biounits.

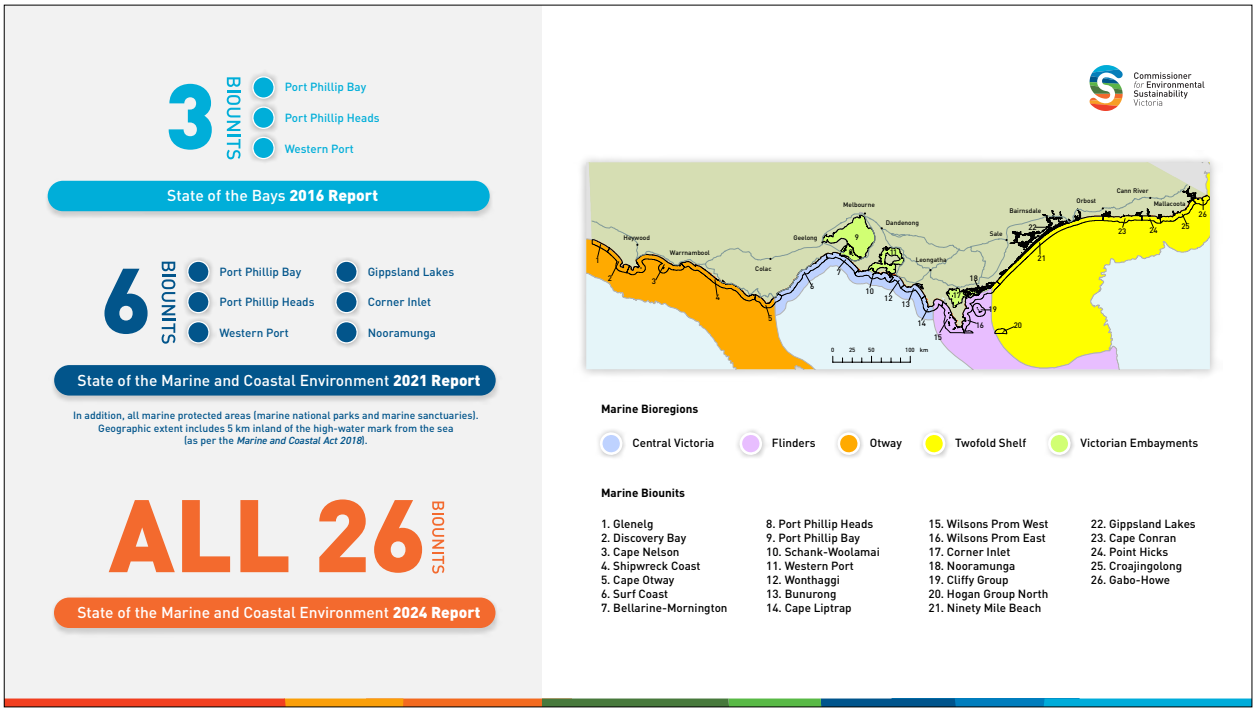

Figure 16: Spatial extent of the SMCE 2021 Report, represented as six Victorian marine biounits.[123]

123. Victorian Environmental Assessment Council 2019, 'Assessment of the values of Victoria's marine environment', Victorian Government, Melbourne https://www.veac.vic.gov.au/investigations-assessments/previous-assessments/document/getDownload?fid=MjM= Accessed 24 May 2021.

Status

The status summary presents an overall analysis of the assessment for each selected indicator. An indicator can be assessed as having a good, fair or poor status (see status thresholds below). Where there is insufficient data, the indicator status is assessed as unknown.

The legend for status in the report card is:

Good: Environmental condition is healthy across Victoria, OR pressure is likely to have negligible impact on environmental condition/human health, OR comprehensive protection of natural ecosystems and biodiversity is evident.

Fair: Environmental condition is neither positive nor negative and may be variable across Victoria, OR pressure is likely to have limited impact on environmental condition/human health, OR moderate protection of natural ecosystems and biodiversity is evident.

Poor: Environmental condition is under significant stress, OR pressure is likely to have significant negative impact on environmental condition/human health, OR inadequate protection of natural ecosystems and biodiversity is evident.

Unknown: Data are insufficient to assess status or trend.

N/A (not applicable): An indicator status assessment has not been made, because this indicator is not relevant for this region or because the assessment of status is inappropriate for the indicator.

N **Narrative**

Trend

The trend summary presents an overall analysis of the trend assessments for each selected indicator. The trend identifies whether the status of the indicator is deteriorating, improving or remaining stable.

The legend for trend in the report card reads as follows:

↗ **Improving**

→ **Stable**

↙ **Deteriorating**

? **Unclear**

N/A **N/A Not applicable:** An indicator trend assessment has not been made because this indicator is not relevant for this region, or because the assessment of trend is inappropriate for the indicator.

Data

Data confidence reflects on knowledge gaps and data limitations when assessing the status and trend of the indicator.

The legend for data quality in the report card is:

High: Adequate high-quality evidence and high level of consensus.

Moderate: Limited evidence or limited consensus.

Low: An assessment can be made, but there is only minimal evidence to guide the assessment.

Insufficient: There is negligible evidence (that is, suitable data and/or thresholds) and no status and trend assessments can be made.

N/A **N/A (not applicable):** An indicator data confidence assessment has not been made, because status and trend assessments have not been made for this indicator.

Theme 1: Water quality and catchment inputs

Indicator 01: Water quality (physicochemical)

Region		2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay							
Western Port							
Corner Inlet-Nooramunga			?			N/A	
Gippsland Lakes	Lake King					N/A	
	Lake Victoria					N/A	
	Lake Wellington					N/A	

Data source:	EPA, Melbourne Water, DELWP
Measures:	Water quality index scores

Comments:

Port Phillip Bay – These assessments are based on the Water Quality Index scores for Port Phillip Bay, which have been rated as good or very good each year since monitoring and reporting began in 2002. Confidence in the status and trend assessments is high because the Water Quality Index is benchmarked against objectives in the Environment Reference Standard (ERS), while there is adequate spatial and temporal monitoring data.

Western Port – These assessments are based on the Water Quality Index scores for Western Port, which have been good each year since monitoring and reporting began in 2000, except in 2017–18 (when water quality in Western Port Bay was rated as fair). Confidence in the status and trend assessments is high because the Water Quality Index is benchmarked against objectives in the ERS, while there is adequate spatial and temporal monitoring data.

The water quality indicator that was assessed as poor for Western Port in the 2018 report has been assessed as good in this report. This is not necessarily a reflection of improved environmental condition; the improved rating for Western Port is mainly because the indicator assessment in 2021 is based on the water quality results solely for Western Port rather than a combination of the marine water quality in Western Port and the water quality in the catchment, as was done for the SoE 2018 Report. The catchment inputs information is provided as a complementary and explanatory narrative for the water quality indicator, with nutrient and sediment loads assessed in separate indicators.

Corner Inlet-Nooramunga – Water quality is not currently routinely measured in the marine environment of the Corner Inlet and Nooramunga biounits. Therefore, the status and trend assessments have been assessed as unknown and unclear, respectively. The evidence to assess this indicator is minimal, therefore an indicator confidence assessment cannot be made. The water quality targets in the Water Quality Improvement Plan (WQIP) for Corner Inlet are likely to be used as thresholds for future assessments.

Gippsland Lakes – These assessments are based on the Water Quality Index scores for Gippsland Lakes. The eastern lakes (Lake King and Lake Victoria) have been rated as good for six of the past seven years, while Lake Wellington has been rated as poor for the past three years, and poor or very poor in seven of the past 10 years. Confidence in the status and trend assessments is high because the Water Quality Index is benchmarked against the environmental quality objectives in the ERS and is available at several sites across the Gippsland Lakes, with monthly time series data available back to 2000.

Indicator 02: Toxicants

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		?			N/A	N/A
Western Port		?	Moderate (status), Low (trend)		N/A	N/A
Corner Inlet-Nooramunga		?			N/A	N/A
Gippsland Lakes		?	Moderate (status), Low (trend)		N/A	N/A

Data source:	EPA, Melbourne Water, academic researchers
Measures:	Assessment against toxicants listed in ERS and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Comments:

Port Phillip Bay – There is no routine monitoring of toxicants to enable an assessment against toxicants listed in the ERS and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.[124] Recent research has focused on the PFAS (per-and polyfluoroalkyl substances) group of manufactured chemicals, with results so far indicating where the greatest concentrations are being found and what the likely sources of contamination are. Because these studies provide point-in-time assessments, the trend is unclear. The status has been rated as fair because the environmental condition is variable, but, based on a limited number of focused studies, is unlikely to be under significant widespread stress. However, confidence in this assessment is low, because there are no Victorian or national PFAS thresholds to base assessments on, although a 2019 study assessed PFAS in estuaries in Port Phillip Bay using the European environment quality standards and found that none of the PFAS observed at estuary sites had concentrations higher than the EU standards.

Western Port – Although a 2013 study concluded that there are some localised areas in the Western Port catchment where toxicants are at levels of concern, toxicant concentrations in Western Port were generally below guideline values and therefore are likely to be a low risk to ecosystem health. Research from 2018 found frequent and widespread contamination by pesticides across the north-east catchments that discharge into Western Port. Pesticides were present in surface waters and sediments in complex mixtures and often at concentrations likely to harm resident flora and fauna. Because these research studies provide point-in-time assessments, the trend is unclear. This contributes to the confidence being rated as low for the trend because, although there is moderate confidence in the status based on research completed in 2013 and 2018, there is no ongoing toxicant assessment program in Western Port. Recent efforts have focused on understanding the major sources to the bay in the catchment.

Corner Inlet-Nooramunga – A risk assessment of toxicant threats in Corner Inlet revealed no medium, high or extreme risk to seagrass. Otherwise, there is no monitoring data to enable status or trend assessments. The absence of toxicant monitoring has been previously identified as a knowledge gap in this region. The evidence to assess this indicator is minimal, therefore an indicator confidence assessment cannot be made.

Gippsland Lakes – Concentrations of nickel, mercury and arsenic exceeding Australian and New Zealand Environment and Conservation Council guideline values for sediment quality were measured in Lake Wellington and Lake Victoria for a 2015–16 study.[125] All other locations had toxicant concentrations within guideline levels. Because this research is a point-in-time assessment, the trend is unclear. This is why confidence is moderate for status but only low for trend.

124. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand 2000, 'National water quality management strategy, Paper no. 4: Australian and New Zealand guidelines for fresh and marine water quality. Volume 1: The guidelines', https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf Accessed 19 July 2021.
125. Reeves J and Trewarn A 2016, 'Assessment of heavy metals and other contaminants of the Gippsland Lakes', report commissioned by Department of Environment, Land, Water and Planning, Federation University Australia, Mt Helen, Victoria, http://www.loveourlakes.net.au/wp-content/uploads/2014/01/Gippsland-Lakes-Heavy-Metals-Report.pdf Accessed 23 September 2021.

Theme 1: Water quality and catchment inputs

Indicator 03: Water quality (estuaries)

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		?	High (status) Low (trend)		N/A	N/A
Western Port		?	High (status), Low (trend)		N/A	N/A
Corner Inlet-Nooramunga		?	High (status), Low (trend)		N/A	N/A
Gippsland Lakes		?	High (status), Low (trend)		N/A	N/A
Statewide		?	High (status), Low (trend)		N/A	N/A

Data source:	DELWP
Measures:	The Index of Estuary Condition water quality sub-index

Comments:

Through the 2021 Index of Estuary Condition (IEC) assessments, there is high confidence in the status assessment for estuarine water quality in this indicator. Because this is the first IEC, and IECs are designed as point-in-time assessments, no time series data are available to assess trends.

Port Phillip Bay – As part of the IEC, water quality assessments were completed for 11 estuaries in the Port Phillip catchment region, with two estuaries rated as excellent for water quality, three as good, two as fair, two as poor and two as very poor. The status assessment of fair reflects variable water quality in the estuaries that flow into Port Phillip Bay.

Western Port – As part of the IEC, water quality assessments were completed for nine of the 10 estuaries in the Western Port catchment region, with five estuaries receiving ratings of very poor for water quality, three estuaries as fair and one estuary as good.

Corner Inlet-Nooramunga – As part of the IEC, water quality assessments were completed for 11 estuaries in the West Gippsland catchment region for those estuaries that flow into Corner Inlet and Nooramunga. One estuary was rated as excellent for water quality, two estuaries as good, three as fair, one as poor and four as very poor. The status assessment of fair is due to variable water quality in the estuaries that flow into Corner Inlet and Nooramunga.

Gippsland Lakes – As part of the IEC, water quality assessments were completed for 14 estuaries in the West and East Gippsland catchment regions for those estuaries that flow into the Gippsland Lakes. Two estuaries were rated as excellent for water quality, four estuaries as good, four as fair, one as poor and three as very poor. The status assessment of fair is due to variable water quality in the estuaries that flow into the Gippsland Lakes.

Statewide – Water quality was good or excellent in 54% of the state's estuaries. It was poor or very poor in 25% of them – usually estuaries with catchments that were predominantly urban or agricultural. The status assessment of fair reflects variable water quality across the state, although it should be noted that more estuaries recorded good or excellent water quality than poor or very poor.

Theme 1: Water quality and catchment inputs

Indicator 04: Plankton

Region		2021 status	2021 trend	2021 data	2016 status	2016 trend	2016 data
Port Phillip Bay							
Western Port							
Corner Inlet-Nooramunga			?			N/A	N/A
Gippsland Lakes	Lake King					N/A	N/A
	Lake Victoria					N/A	N/A
	Lake Wellington					N/A	N/A
Statewide		N	N	N		N/A	N/A

Data source:	EPA, Integrated Marine Observing System (IMOS)
Measures:	Chlorophyll-a (µg/L) | Total phytoplankton (cells/L)

Comments:

Port Phillip Bay – Chlorophyll-a is a commonly used measure of water quality, and concentrations indicate phytoplankton abundance and productivity in aquatic environments. The results show that chlorophyll-a ratings in Port Phillip Bay fluctuated between fair and very good from 2001–02 until 2012–13, but have been very good since then. Confidence in the status and trend assessments is high, because Chlorophyll-a is assessed against the objectives in the ERS, while there is adequate spatial and temporal monitoring data.

Western Port – Chlorophyll-a is a commonly used measure of water quality, and concentrations indicate phytoplankton abundance and productivity in aquatic environments. In Western Port chlorophyll-a was rated as fair to poor from 2000–01 to 2011–12, while it has been rated as good to very good since 2014–15, indicating a good status and improving trend. Confidence in the status and trend assessments is high because chlorophyll-a is assessed against the objectives in the ERS, while there is adequate spatial and temporal monitoring data.

Corner Inlet-Nooramunga – Phytoplankton is not currently routinely measured in the marine environment of the Corner Inlet and Nooramunga biounits. Therefore, the status and trend assessments have been assessed as unknown and unclear, respectively. The evidence to assess this indicator is minimal, therefore an indicator confidence assessment cannot be made.

Gippsland Lakes – Chlorophyll-a is a commonly used measure of water quality, and concentrations indicate phytoplankton abundance and productivity in aquatic environments. The results show chlorophyll-a ratings in Lake Wellington have been poor to very poor since 2007–08, which has been translated to a status assessment of poor and a stable trend that reflects poor to very poor ratings for more than a decade. Chlorophyll-a ratings have been more favourable in the eastern Lakes (Lake Victoria and Lake King), with five of the past six years rated as good for chlorophyll-a. Confidence in the status and trend assessments is high because chlorophyll-a is assessed against the objectives in the ERS, while there is adequate spatial and temporal monitoring data.

Theme 1: Water quality and catchment inputs

Indicator 05: *Enterococci* bacteria

Region	2021 status	2021 trend	2021 data	2016 status	2016 trend	2016 data
Port Phillip Bay		→			→	

Data source:	EPA
Measures:	Number of beaches meeting short-term and long-term standards for primary and secondary contact

Comments:

Port Phillip Bay – The fair status assessment is due to all beaches meeting standards for secondary contact (for example, boating and canoeing) and most meeting standards for primary contact (for example, swimming) during dry weather. However, most beaches do not meet standards for all-weather primary contact. Stormwater pollution is often a key reason why beaches don't meet standards. Water quality has been stable over time for all weather conditions. Confidence in the assessment is high based on the quality of the analytical data used to complete the assessment against standards.

Indicator 06: Regulated point source discharges to marine waters

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		?			N/A	N/A
Corner Inlet-Nooramunga		?			N/A	N/A
Statewide					?	

Data source:	EPA
Measures:	Volumes and nutrient loads discharged to marine waters from regulated point sources

Comments:

Port Phillip Bay and Corner Inlet-Nooramunga – There is good information available on the volumes and nutrient loads discharged to marine waters from regulated point sources. However, there is limited quantitative analysis available to understand the extent to which regulated discharges affect the receiving marine environments. There is no available analysis of non-compliance of licensed facilities that discharge to marine environments, so the extent of non-compliance with licensed discharge limits is unknown.

Theme 1: Water quality and catchment inputs

Indicator 07: Stormwater

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		?	Moderate (status), Low (trend)		N/A	N/A
Western Port		?	Moderate (status, Low (trend)		N/A	N/A
Corner Inlet-Nooramunga		?			N/A	N/A
Gippsland Lakes		?			N/A	N/A

Data source:	Melbourne Water
Measures:	Directly connected imperviousness, which is the proportion of the impervious surface that is directly connected to a stream through a conventional drainage connection

Comments:

Port Phillip Bay – The status of fair is due to variable stormwater conditions across Port Phillip Bay's catchments. There are very strong regional differences in the overall assessment for the bay. For example, stormwater has only minor effects on stream health in the Werribee catchment, while stream health is being severely affected by stormwater in the Dandenong catchment. Despite the analysis by catchment, there has been no public reporting on whether the Victorian Government's target of limiting nutrient and sediment loads to 2017 levels is being met, so there is only a moderate confidence in the stormwater status assessment. No time series data are available to provide a trend assessment.

Western Port – The status of good is due to Melbourne Water's assessment that stormwater has only minor effects on stream health in Western Port. No time series data are available to provide a trend assessment. Given that there are no data available on the stormwater loads into Western Port, confidence in these assessments is moderate rather than high.

Corner Inlet-Nooramunga – The stormwater impact on marine water quality in Corner Inlet and Nooramunga remains largely unknown. The evidence to assess this indicator is minimal, so an indicator confidence assessment cannot be made.

Gippsland Lakes – There are no available assessments of the contribution of stormwater to pollutant loads entering the Gippsland Lakes. The evidence to assess this indicator is minimal, so an indicator confidence assessment cannot be made.

Theme 1: Water quality and catchment inputs

Indicator 08: Total nutrient loads

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay					N/A	N/A
Western Port			Low (status), Moderate (trend)		N/A	N/A
Corner Inlet-Nooramunga			Moderate (status), Low (trend)		N/A	N/A
Gippsland Lakes					N/A	N/A

Data source:	Melbourne Water, academic researchers
Measures:	Total nitrogen and phosphorus loads (t/yr)

Comments:

Port Phillip Bay – Estimated nutrient loads over 2016–19 are within one quartile of the modelled 2000–19 long-term average, suggesting a stable trend over this time. This preliminary finding is based on interim results from a continuing project, with further work underway to improve confidence in the modelled estimates. Given that the Port Phillip Bay Environmental Management Plan 2017–2027 sets a priority target for nutrient loads to not exceed 2017 levels, the estimated stable trend from 2016–19 indicates good status, but information is insufficient to determine whether annual nitrogen load objectives in the ERS are being met.

Western Port – The evidence currently available suggests that nutrients are not having a significant effect on the Western Port environment. Estimated nutrient loads over 2016–19 are within one quartile of the 2000–19 long-term average, suggesting a stable trend over this time. This preliminary finding is based on interim results from a continuing project, with further work underway to improve confidence in the modelled estimates. Confidence in the status assessment is low because there is no pollutant load target for nutrient loads for Western Port.

Corner Inlet-Nooramunga – Periodic research has shown that high nutrient loads are entering Corner Inlet and that these are linked with infrequent algal bloom occurrences in the Inlet. There is no routine monitoring to assess nutrient loads, so confidence in the status assessment is moderate and the trend is unclear, due to the absence of time series data. The nutrient load targets in the Water Quality Improvement Plan for Corner Inlet are likely to be used as thresholds for future assessments.

Gippsland Lakes – Nutrient loads and flow for the most recent five years of data are within 20% of the long-term median, while total phosphorous loads are regularly not meeting the 100 tonnes per year maximum target in the Environment Reference Standard. This information informs the status rating of fair. The inflow of nitrogen and phosphorus was above the long-term median for the past five years of data (to 2016), indicating a deteriorating trend. The absence of recently analysed data (the most recent data included in the assessment is from 2016) means that confidence is moderate rather than high.

Theme 1: Water quality and catchment inputs

Indicator 09: Total sediment loads

Region		2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		Good	→	Moderate	Unknown	N/A	N/A
Western Port		Poor	→	Moderate	Unknown	N/A	N/A
Corner Inlet-Nooramunga		Good	?	Poor	Unknown	N/A	N/A
Gippsland Lakes	Lake King	Moderate	?	Poor	Unknown	N/A	N/A
	Lake Victoria	Moderate	?	Poor	Unknown	N/A	N/A
	Lake Wellington	Poor	?	Poor	Unknown	N/A	N/A

Data source:	Melbourne Water, academic researchers
Measures:	Total suspended solids loads (t/yr)

Comments:

Port Phillip Bay – Estimated sediment loads for 2016–19 are within one quartile of the modelled 2000–19 long-term average, suggesting a stable trend over this time. This preliminary finding is based on interim results from a continuing project, with further work underway to improve confidence in the modelled estimates. Given that the Port Phillip Bay Environmental Management Plan 2017–2027 sets a priority target for sediment loads to not exceed 2017 levels, the estimated stable trend from 2016–19 is indicative of good status. However, information is insufficient to determine whether annual total suspended solids load objectives in the ERS are being met.

Western Port – Estimated sediment loads for 2016–19 are within one quartile of the modelled 2000–19 long-term average, suggesting a stable trend over this time. This preliminary finding is based on interim results from a continuing project, with further work underway to improve confidence in the modelled estimates. The interim results show that total suspended solids loads for Western Port for recent years are estimated to be above the ERS marine pollutant load objective of 28,000 tonnes of total suspended solids per year. Confidence in the status assessment is moderate rather than high because even though the status can be benchmarked against the ERS, the data are from interim results only, as part of a continuing project.

Corner Inlet-Nooramunga – The limited available evidence suggests that sediment loads are not having a significant effect on general marine and coastal habitats in Corner Inlet and Nooramunga. This has led to a status assessment of good, but with only low confidence.

Gippsland Lakes – Recent studies have measured sediment loads to the Gippsland Lakes and determined their major sources. Because these studies are point-in-time assessments, no time series of data exist and the trend is unclear. Status has been rated as poor because water clarity in some parts of the Gippsland Lakes (Lake Wellington) has recently been rated as very poor, and riverine sediment loads probably contribute to this rating, as they can damage seagrass. There are no specific thresholds available for this assessment, so confidence is low.

Indicator 10: Coastal acid sulfate soils

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	?	●	●	N/A	N/A
Western Port	●	?	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	?	●	●	N/A	N/A
Gippsland Lakes	●	?	●	●	N/A	N/A

Data source:	Department of Jobs, Precincts and Regions
Measures:	Area of potential coastal acid sulfate soil within 5 km of the high-water mark adjacent to marine biounits

Comments:

Potential acid sulfate soil sites have been mapped along the Victorian coastline. Because this mapping is a point-in-time assessment, the trend is unclear. Because there are no thresholds to guide status and trend assessments and there is no available evidence on the effects of coastal acid sulfate soils, an indicator confidence assessment cannot be made.

Port Phillip Bay – The aggregated area of potential coastal acid sulfate soil sites is 12,000 hectares, which is a significant area of land but not near a complete coverage of the Port Phillip Bay coastline.

Western Port – The aggregated area of potential coastal acid sulfate soil sites is 8,000 hectares, which is a significant area of land but not near a complete coverage of the Western Port coastline.

Corner Inlet-Nooramunga – The aggregated area of potential coastal acid sulfate soil sites is 20,000 hectares, which is a significant area of land but not near a complete coverage of the Corner Inlet and Nooramunga coastline.

Gippsland Lakes – The status has been rated as poor for Lake Wellington and fair for the eastern lakes because the aggregated area of potential coastal acid sulfate soil sites is 43,000 hectares, which is a significant area of land. Coastal areas surrounding the Gippsland Lakes have a greater area of potential coastal acid sulfate soil than the combined potential area along the Port Phillip Bay, Western Port and Corner Inlet and Nooramunga coastlines. The area of potential coastal acid sulfate soil sites is nearly a complete coverage of the Lake Wellington coastline.

Theme 2: Litter and pollution

Indicator 11: Litter and plastics

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	↙	●	●	N/A	N/A
Western Port	●	?	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	?	●	●	N/A	N/A
Gippsland Lakes	●	?	●	●	N/A	N/A

Data source:	Port Phillip EcoCentre, Tangaroa Blue Foundation, academic researchers
Measures:	Number of litter items (including plastic and microplastic) in catchment waterways flowing into marine environments

Comments:

Port Phillip Bay – A deteriorating trend is provided with moderate confidence due to the estimated amount of litter increasing in both the Maribyrnong and the Yarra. The status is unknown because, although the number of litter items and microplastics flowing into Port Phillip Bay has been estimated, there is an absence of thresholds that can be used to guide the assessment. The lack of any thresholds based on quantitative analysis of the effects of litter and plastics means that no status assessment can be provided. In other words, we do not know if the current status of litter and plastics is good, fair or poor, but we have moderate confidence that the amount of litter and microplastics is increasing.

Western Port – There are no specific analyses of litter in Western Port, therefore the status and trend have been assessed as unknown and unclear, respectively. Given the relatively smaller urban environment, litter and microplastics are likely to pose a lesser risk in Western Port than in Port Phillip Bay, where more studies have been completed.

Corner Inlet-Nooramunga, Gippsland Lakes – No litter and plastic pollution data are available for Corner Inlet and Nooramunga or the Gippsland Lakes. Given the relatively smaller urban environment of these regions, litter and microplastics are likely to pose a lesser risk than in Port Phillip Bay, where more studies have been completed.

Theme 2: Litter and pollution

Indicator 12: Light pollution

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		?			N/A	N/A
Western Port		?			N/A	N/A
Corner Inlet-Nooramunga		?			N/A	N/A
Gippsland Lakes		?			N/A	N/A
Statewide					?	

Data source:	https://www.lightpollutionmap.info/, academic researchers
Measures:	Artificial light at night measured as radiance (Watts per square cm)

Comments:

There is insufficient information to provide status and trend assessments for this indicator. The evidence to assess this indicator is minimal, therefore an indicator confidence assessment cannot be made.

Theme 2: Litter and pollution

Indicator 13: Coastal contaminated land

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		?			N/A	N/A
Western Port		?			N/A	N/A
Corner Inlet-Nooramunga		?			N/A	N/A
Gippsland Lakes		?			N/A	N/A
Statewide					?	

Data source:	EPA
Measures:	Numbers of contaminated and potentially contaminated land locations within 5 km of the coastline for various datasets published on Victoria Unearthed

Comments:

Because information available via Victoria Unearthed is point-in-time spatial data, the trend is unclear. Confidence for this assessment is low because, although the quality of the data is good, there are no thresholds available to guide the status assessments.

Port Phillip Bay – The status assessment of fair is based on there being several sites within 5 km of the Port Phillip Bay coastline that are known to be contaminated or that are the location of current activity involving a relatively high risk of contamination. Examples of contamination include the groundwater contamination that has been identified beneath Fishermans Bend. The status assessment is a subjective interpretation that moderate protection of natural ecosystems and biodiversity is evident due to the management of the Priority Sites Register, with the relatively large number of contaminated sites along the Port Phillip Bay coastline relative to other Victorian coastal regions indicating that coastal contaminated land is exerting moderate pressure on environmental condition and human health.

Western Port – The status assessment of good is based on there being only a few sites within 5 km of the Western Port coastline that are known to be contaminated or that are the location of current activity involving a relatively high risk of contamination. The status assessment is a subjective interpretation that there is a reasonably small number of contaminated sites along the Western Port coastline, indicating that coastal contaminated land is generally exerting minimal pressure on environmental condition and human health in this region.

Corner Inlet-Nooramunga – The status assessment of good is based on there being only a few sites within 5 km of the Corner Inlet and Nooramunga coastline that are known to be contaminated or that are the location of current activity involving a relatively high risk of contamination. The status assessment is a subjective interpretation that there is a reasonably small number of contaminated sites along the Corner Inlet and Nooramunga coastline, indicating that coastal contaminated land is generally exerting minimal pressure on environmental condition and human health in this region.

Gippsland Lakes – The status assessment of good is based on there being only a few sites within 5 km of the Gippsland Lakes coastline that are known to be contaminated or that are the location of current activity involving a relatively high risk of contamination. The status assessment is a subjective interpretation that there is a reasonably small number of contaminated sites along the Gippsland Lakes coastline, indicating that coastal contaminated land is generally exerting minimal pressure on environmental condition and human health in this region.

Theme 2: Litter and pollution

Indicator 14: Coastal air quality

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	(ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide) (fine particle pollution)	→	(near shipping terminals) (elsewhere)	●	N/A	N/A
Western Port	●	?	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	?	●	●	N/A	N/A
Gippsland Lakes	(fine particle pollution during bushfire periods) (all other times)	?	(fine particulate pollution during bushfire periods) (all other times)	●	N/A	N/A

Data source:	EPA, academic researchers
Measures:	Number of exceedences of air quality standards

Comments:

Port Phillip Bay – The status assessments are based on the compliance of air quality at Victorian air quality monitoring stations with the National Environment Protection (Ambient Air Quality) Measure. Focused research on air quality near shipping terminals using lower-quality air monitoring sensors provides evidence of high concentrations of fine particle pollution near Station Pier resulting in poor air quality with a moderate confidence.

Western Port, Corner Inlet-Nooramunga – EPA does not currently measure air quality along the Western Port, Corner Inlet or Nooramunga coastlines.

Gippsland Lakes – The status assessments are based on the compliance of air quality at Victorian air quality monitoring stations with the National Environment Protection (Ambient Air Quality) Measure. Air quality monitoring does not routinely occur along the Gippsland Lakes coastline, with recent monitoring only conducted as part of the emergency management response to significant amounts of bushfire smoke in the region.

Theme 3: Biodiversity

Indicator 15: Conservation of coastal ecosystems in protected areas

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	Parks Victoria
Measures:	Percentage of the land within 5 km of the high-water mark managed as national and state parks or as coastal reserves Conservation status of ecological vegetation classes Area of ecological vegetation classes within 5 km of the high-water mark

Comments:

Statewide – This is a broad indicator that covers a range of coastal ecosystems and conservation efforts. A variety of protection is given to coastal ecological vegetation classes; some classes have been more affected by changing coastal land use. The status of fair is due to a range of national parks and other conservation areas having generally good coverage (that is, extending along approximately 70% of the Victorian coastline), countered by there being some data limitations for threatened and invasive species, while some ecological vegetation classes could be given greater protection. There is no evidence to support a trend assessment. Due to the lack of an existing overarching threshold for conservation of coastal ecosystems, confidence in this status assessment is low.

Indicator 16: Saltmarsh

Region		2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay			→			→	
Western Port			→			↙	
Corner Inlet-Nooramunga	Corner Inlet		→			N/A	N/A
	Nooramunga		→			N/A	N/A
	Nooramunga islands		→			N/A	N/A
Gippsland Lakes			?			?	

Data source:	Academic researchers, DELWP
Measures:	Extent of saltmarsh | Change in saltmarsh extent since European settlement

Comments:

Port Phillip Bay – Although there have been significant losses of saltmarsh cover since European settlement, approximately half of the saltmarsh cover remains today. The limit of acceptable change (LAC) for saltmarsh in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site is that total saltmarsh extent will not decline below 900 hectares. This is being met. Limited information on saltmarsh condition suggests that most saltmarsh communities were 'healthy or near-stressed'. The status of fair is based on a balance of the significant losses of saltmarsh cover since European settlement, with the LAC for saltmarsh being met in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site, where more than half of the saltmarsh communities are not under significant stress. Confidence in the assessments is moderate rather than high, because the most recent assessments of saltmarsh extent and condition are from 2011.

Western Port – There has been minimal loss of saltmarsh cover since European settlement, with approximately 90% of the saltmarsh cover remaining in 2012. The LAC for saltmarsh in the Western Port Ramsar site is that total saltmarsh extent will not decline below 900 hectares. This is being met. Based on this, the status for this indicator has been assessed as good.

Corner Inlet-Nooramunga – The status for Corner Inlet has been rated as fair because, although more than half of the saltmarsh cover has been lost since European settlement, the LAC for saltmarsh in the Corner Inlet Ramsar site is that total saltmarsh extent will not decline below 2,775 hectares, which is being met. Nooramunga's status is fair because the saltmarsh losses have been less extensive (20%), while the saltmarsh area around the Nooramunga islands is rated as good and estimated to be 6% greater now than in the pre-1750s period.

Gippsland Lakes – There has been some loss of saltmarsh cover since European settlement, with approximately 65–100% of the saltmarsh cover remaining in 2012, the losses occurring variably across the lakes. The LAC for saltmarsh in the Gippsland Lakes Ramsar site is that the total mapped area of salt flat, saltpan and salt meadow habitat at Lake Reeve Reserve extent will not decline below 2,517 hectares. This is being met, with the most recent assessment, completed in 2021, estimating that there is more than 5,000 hectares of saltmarsh habitat in the Ramsar site. The status of fair is based on variable losses of saltmarsh cover since European settlement, but the LAC for saltmarsh is being met in the Gippsland Lakes Ramsar site.

Theme 3: Biodiversity

Indicator 17: Mangroves

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	?	●	●	N/A	N/A
Western Port	●	↗	●	●	?	●
Corner Inlet-Nooramunga	●	→	●	●	?	●

Data source:	Academic researchers, DELWP
Measures:	Extent of mangroves | Change in mangrove extent since European settlement

Comments:

Port Phillip Bay – There are currently 52 hectares of mangroves in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site, which meets the LAC for mangroves in the Ramsar site. This is reflected in a status of good. There is no pre-European settlement baseline data for comparison. Therefore, the trend is unclear. Confidence in the assessments is moderate rather than high, because the most recent assessments of mangrove extent and condition are from 2011.

Western Port – There has been minimal loss of mangrove habitat in Western Port since European settlement, with approximately 90% of the mangrove habitat remaining in 2012. This assessment was used to inform an estimate of 1,700 hectares of mangrove extent in the Western Port Ramsar site, which meets the LAC for mangroves in the Ramsar site to remain above 900 hectares. This is reflected in a status of good, while the trend is rated as improving based on advice from DELWP that the mangrove extent in the Western Port Ramsar site has increased by 40% since 1982. Confidence in the assessments is rated as moderate rather than high because the most recent assessments of mangrove extent and condition are nearly a decade old.

Corner Inlet-Nooramunga – There has been minimal loss of mangrove habitat since European settlement, with approximately 80% of the mangrove habitat in Corner Inlet and Nooramunga remaining in 2012. Corner Inlet and Nooramunga have the most extensive stands of mangrove along Victoria's coast. Based on this information, the status for this indicator has been assessed as good. The LAC for mangroves in the Corner Inlet Ramsar site is that total mangrove extent will not decline below 1,600 hectares. This is being met, with the most recent assessment estimating that there are more than 3,800 hectares of saltmarsh in the Ramsar site.

Indicator 18: Wetland and estuarine vegetation

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		?			N/A	N/A
Western Port		?			N/A	N/A
Corner Inlet-Nooramunga		?			N/A	N/A
Gippsland Lakes	(estuarine flora) (wetland habitat extent) (condition of paperbark-dominated wetlands)	?	(estuarine flora) (wetland habitat extent, condition of paperbark-dominated wetlands)		N/A	N/A
Statewide		?			N/A	N/A

Data source:	Academic researchers, DELWP
Measures:	The Index of Estuary Condition flora sub-index

Comments:

Port Phillip Bay – Through the 2021 Index of Estuary Condition (IEC) assessments, there is high confidence in the status assessment for estuarine flora in this indicator. As part of the IEC, flora assessments for nine of the 11 estuaries in the Port Phillip catchment region were completed, with two estuaries rated as good for flora, five as fair and two as poor.

Western Port – As part of the IEC, flora assessments for eight of the 10 estuaries in the Western Port catchment region were completed, with two estuaries rated as excellent for flora, four as good and two as fair. Through the 2021 IEC assessments, only two estuaries were rated on both fringing and submerged vegetation, with the six estuaries receiving the best ratings not assessed for submerged vegetation. Because of this, there is moderate, rather than high, confidence in the status assessment for estuarine flora in this indicator.

Corner Inlet-Nooramunga – Through the 2021 IEC assessments, there is high confidence in the status assessment for estuarine flora in this indicator. As part of the IEC, flora assessments for 11 estuaries were completed in the West Gippsland catchment region for those estuaries that flow into Corner Inlet and Nooramunga. One estuary was rated as excellent for flora, three as good, six as fair, and one rated poor.

Gippsland Lakes – Even though many of the paperbark-dominated wetlands of the Gippsland Lakes are in poor ecological condition, the LAC for freshwater wetland habitat extent was assessed as being met in 2021, while the LAC for brackish wetland habitat extent is likely to be met. Through the 2021 IEC assessments, there is high confidence in the status assessment for estuarine flora in this indicator. As part of the IEC, flora assessments for 14 estuaries were completed in the West and East Gippsland catchment regions for those estuaries that flow into the Gippsland Lakes. Three estuaries were rated as excellent for flora, seven estuaries were rated as good, two as fair, with two rated poor.

Statewide – As part of the IEC, flora assessments for 100 estuaries across Victoria were completed. Half of the state's estuaries had flora in excellent or good condition, and only 11% had flora in poor condition. No estuaries had flora in very poor condition.

Theme 3: Biodiversity

Indicator 19: Species of conservation concern

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	?	●	●	N/A	N/A
Western Port	●	?	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	?	●	●	N/A	N/A
Gippsland Lakes	●	?	●	●	N/A	N/A
Statewide	●	?	●	●	N/A	N/A

Data source:	Victorian Biodiversity Atlas
Measures:	Victorian Biodiversity Atlas

Comments:

The data analysed and reported for this indicator provides information on the number of species of conservation concern. The status and trend assessments are unknown and unclear, respectively, because no information is available to ascertain how these species are being tracked and managed, and no trend data are available to assess how these species are tracking over time.

Indicator 20: Mobile invertebrates on intertidal reefs

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	→	●	●	?	●
Other marine protected areas	●	→	●	●	→	●

Data source:	Parks Victoria
Measures:	Parks Victoria control charts

Comments:

Port Phillip Bay – The status assessment of good is based on the available information provided as part of Parks Victoria's long-term Intertidal Reef Monitoring Program. No reports have been published since 2014, with the only subsequent information contributing to this status assessment being draft control charts from 2018. Due to the lack of recent evidence, confidence in the status and trend assessments is low. Parks Victoria is progressing monitoring and assessment, with a technical report in preparation for the Port Phillip Heads Marine National Park, which is likely to fill knowledge gaps and increase confidence in this indicator assessment in future SMCE Reports.

Other marine protected areas – The status assessment of good is based on the available information provided as part of Parks Victoria's long-term Intertidal Reef Monitoring Program. That program ceased in 2014, with the only subsequent information contributing to this status assessment being draft control charts from 2018. Due to the lack of recent evidence, confidence in the status and trend assessments is low. Parks Victoria is progressing monitoring and assessment, with plans to publish technical reports in the next couple of years for Port Phillip Heads, Wilsons Promontory, Cape Howe and Discovery Bay marine national parks, which will fill intertidal reef knowledge gaps in marine protected areas and increase confidence in this indicator assessment in future SMCE Reports.

Indicator 21: Sessile invertebrates on intertidal reefs

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Other marine protected areas						

Data source:	Parks Victoria
Measures:	Parks Victoria control charts

Comments:

Port Phillip Bay – The status assessment of good is based on the available information provided as part of Parks Victoria's long-term Intertidal Reef Monitoring Program. No reports have been published since 2014, with the only subsequent information contributing to this status assessment being draft control charts from 2018. Due to the lack of recent evidence, confidence in the status and trend assessments is low. Parks Victoria is progressing monitoring and assessment, with a technical report in preparation for the Port Phillip Heads Marine National Park, which is likely to fill knowledge gaps and increase confidence in this indicator assessment in future SMCE Reports.

Other marine protected areas – The status assessment of good is based on the available information provided as part of Parks Victoria's long-term Intertidal Reef Monitoring Program. That program ceased in 2014, with the only subsequent information contributing to this status assessment being draft control charts from 2018. Due to the lack of recent evidence, confidence in the status and trend assessments is low. Parks Victoria is progressing monitoring and assessment, with plans to publish technical reports in the next couple of years for Port Phillip Heads, Wilsons Promontory, Cape Howe and Discovery Bay marine national parks, which will fill intertidal reef knowledge gaps in marine protected areas and increase confidence in this indicator assessment in future SMCE Reports.

Theme 3: Biodiversity

Indicator 22: Invertebrates on subtidal reefs

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay		 (north) (south)			 (north) (south)	
Other marine protected areas						

Data source:	Parks Victoria, Reel Life Surveys
Measures:	Parks Victoria control charts | The number of mobile macroinvertebrate species recorded on individual Reef Life Surveys (species per 50 m^2)

Comments:

Port Phillip Bay – The status assessment of fair is based on the available information provided as part of Parks Victoria's long-term Subtidal Reef Monitoring Program, and the (more recent) Reef Life Survey. The Reef Life Survey data shows that the trend over the past decade is an increasing number of species in the Port Phillip Bay's north, with fluctuations in the south but a generally stable underlying trend.

Other marine protected areas – The status assessment of good is based on the available information from Parks Victoria's long-term Subtidal Reef Monitoring Program, the more recent Reef Life Survey, and the 2020 Technical Report for Point Addis Marine National Park. Parks Victoria draft control charts assessed mobile megafaunal invertebrates as good in 12 of the parks, fair in one and unknown in one. The Reef Life Survey data shows that the trend over the past decade is an increasing number of species in Port Phillip Bay's north, with variability in the south. Broadly though, across Victoria's marine protected areas, the trend is unclear.

Theme 3: Biodiversity

Indicator 23: Commercially and recreationally important invertebrates

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	(commercial scallop, short-spined sea urchin)	(commercial scallop, short-spined sea urchin)	(commercial scallop, short-spined sea urchin)		N/A	N/A
Statewide	(southern calamari, Maori octopus) (southern rock lobster) (blacklip abalone) (pipi, greenlip abalone)	(southern calamari, Maori octopus, southern rock lobster) (blacklip abalone) (pipi, greenlip abalone)	(southern calamari, southern rock lobster) (Maori octopus, blacklip abalone) (pipi, greenlip abalone)		N/A	N/A

Data source:	Victorian Fisheries Authority (VFA)
Measures:	Landings (tonnes) | Catch per unit of effort (fish per angler hour) Recruitment (using fishery independent sampling of recruits and or pre-recruits) Percentage of fishers satisfied with their fishing experience

Comments:

Port Phillip Bay (commercial scallop) – As time progresses, the effect of natural variation in scallop abundance on dive fishery will become apparent. At present, given the very minimal landings of commercial scallops, it is highly unlikely that the Port Phillip Bay commercial scallop dive fishery is causing recruitment impairment, and thus the stock can be considered as sustainable in accordance with the Status of Australian Fish Stocks classification, which translates to a good status and stable trend for this report.

Port Phillip Bay (short-spined sea urchin) – There is no information to suggest that the stock is in any danger of depletion. Based on the available evidence, stock of the short-spined sea urchin in Port Phillip Bay is sustainable in accordance with the Status of Australian Fish Stocks classification, which translates to a good status and stable trend for this report.

Statewide (southern calamari) – There is no evidence to suggest recruitment impairment and, in the context of this species' biology and the relatively low level of fishing pressure, the stock is expected to remain sustainable into the future.

Statewide (Maori octopus) – There is minimal reason to believe that this species is at risk of depletion under current fishing practices. This implies that stocks of Maori octopus in Victoria are sustainable.

Statewide (pipi) – Based on the available information, the current status of Victoria's pipi stock is uncertain.

Statewide (southern rock lobster) – The southern Australian stock is sustainable, but Victorian catch per unit effort (CPUE) is at very low levels, and the abundance of undersize lobsters is at or near record lows in the western and eastern zones of the Victorian fishery. Balancing this information, the status is fair with a stable trend.

Statewide (blacklip abalone) – Based on the two fisheries management units with the largest catches in Victoria both being classified as having depleting stocks, the status of this indicator has been assessed as poor, with a deteriorating trend.

Statewide (greenlip abalone) – There is insufficient information available to classify status.

Theme 3: Biodiversity

Indicator 24: Commercially and recreationally important fish

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	(snapper, King George whiting) (southern sand flathead)	(King George whiting) (snapper, southern sand flathead)	(snapper, King George whiting) (southern sand flathead)		N/A	N/A
Western Port	(snapper, King George whiting)	(King George whiting) (snapper)	(snapper) (King George whiting)		N/A	N/A
Corner Inlet-Nooramunga	(King George whiting, rock flathead)	(King George whiting) (rock flathead)	(King George whiting, rock flathead)		N/A	N/A
Gippsland Lakes	(black bream, dusky flathead)	(dusky flathead) (black bream)	(black bream, dusky flathead)		N/A	N/A
Statewide	(bluethroat, purple wrasse)	(bluethroat, purple wrasse)	(bluethroat, purple wrasse)		?	

Data source:	VFA, academic researchers
Measures:	Landings (tonnes) | Catch per unit of effort (fish per angler hour) Recruitment (using fishery independent sampling of recruits and or pre-recruits) Percentage of fishers satisfied with their fishing experience

Comments:

Port Phillip Bay (snapper) – The recreational fishery for adult snapper in Port Phillip Bay is considered sustainable at its current level, appearing to have stabilised since 2014. Commercial fishing pressure has reduced substantially in recent years, while record snapper spawning in the region during 2018 is likely to result in a snapper population boom in Port Phillip Bay during 2022 and 2023.

Port Phillip Bay (King George whiting) – The recent strong post-larval recruitment is expected to drive a strong increase in catch per unit of effort (CPUE) over the next few years, so the stock should remain sustainable.

Port Phillip Bay (southern sand flathead) – The evidence suggests that the stock has now stabilised at a lower biomass under a lower recruitment regime, and that recruitment has been sufficient to balance natural and fishing mortality at this lower level.

Western Port (snapper) – There is a declining trend in the recreational fishery for adult snapper in Western Port. Recent strong recruitment is expected to reverse any declining biomass trends and drive a rebuilding of adult biomass and improved fishery performance over the next five to 10 years.

Western Port (King George whiting) – There is only limited data for King George whiting in Western Port. A slight decline in recreational fishing CPUE was measured during the 2010s, but recent strong post-larval recruitment is expected to drive a rapid increase in CPUE over the next few years, so the stock should remain sustainable.

Corner Inlet-Nooramunga (King George whiting) – The likelihood of recent strong post-larval recruitment based on sampling in Port Phillip Bay is expected to support an increasing CPUE for King George whiting in Corner Inlet over the next few years, so the stock should remain sustainable.

Corner Inlet-Nooramunga (rock flathead) – In recent years a greater commercial effort is being made to catch rock flathead, and this is resulting in a greater catch. However, a decreasing CPUE shows that rock flathead is becoming more difficult to catch in Corner Inlet and Nooramunga. If this combination continues, a further deterioration of rock flathead in Corner Inlet and Nooramunga is expected.

Gippsland Lakes (black bream) – Due to the recent CPUE data for both commercial and recreational fishers trending near the reference period minimums, and uncertainty in how recruitment replenishes the adult stock, the Gippsland Lakes, black bream stock was assessed as depleting in the VFA's most recent stock assessment report (published in 2020). This analysis has been translated into status and trend assessments of poor and deteriorating, respectively, in this report.

Gippsland Lakes (dusky flathead) – Current levels of fishing pressure on dusky flathead are well below historic highs, yet the CPUE has remained below average in recent years. Based on this, Gippsland Lakes dusky flathead stock was described as depleting in the Status of Key Victorian Fish Stocks report published by the VFA in 2020. This analysis has been translated into status and trend assessments of poor and stable, respectively, in this report.

Statewide (bluethroat and purple wrasse) – The current harvest and effort appear to present a low risk for the stock becoming recruitment overfished at a statewide scale, bearing in mind a depleting trend in the east, which was occurring before licence transferability. Statewide, fishing for blue throat and purple wrasse appears to be sustainable.

Theme 3: Biodiversity

Indicator 25: Subtidal reef fish

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	(north)  (south) 	(north)  (south) 		(north)  (south) 	(north)  (south) 	(north)  (south) 
Other marine protected areas						

Data source:	Parks Victoria, Reef Life Surveys, ReefWatch
Measures:	Parks Victoria control charts | The number of mobile macroinvertebrate species recorded on individual Reef Life Surveys (species per 50 m^2) | Fish species sightings and abundances

Comments:

Port Phillip Bay – The data shows a pattern of fewer fish species in the north of the bay and more in the south, particularly around the entrance to the bay. During the past decade, there has been a decline in the number of fish species in the north and a slight increase in the number of species in southern Port Phillip Bay.

Other marine protected areas – Parks Victoria's integrated dataset and control charts show that the condition of large mobile fish (including sharks and rays) on subtidal reefs in marine national parks and sanctuaries beyond Port Phillip Bay was assessed as good in 14 parks, fair in one and unknown in one. Confidence is moderate rather than high because the data in some marine protected areas are now several years out of date, although monitoring and assessment programs are underway to provide contemporary data and analysis, which will be incorporated into future SMCE Reports. Advances in use of baited remote underwater videos are enabling the monitoring of time series fish assemblages for the entire depth range of marine national parks.

Theme 3: Biodiversity

Indicator 26: Diadromous fish

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	N	N	N	●	N/A	N/A
Western Port	N	N	N	●	N/A	N/A
Gippsland Lakes	N	N	N	●	N/A	N/A
Statewide	●	?	●	●	N/A	N/A

Data source:	Academic researchers, DELWP, Melbourne Water
Measures:	Ramsar site limits of acceptable change assessments for Australian grayling

Comments:

Statewide – There is no routine monitoring or assessment of diadromous fish in Victoria, so status and trend assessments cannot be made for this indicator. However, the narrative highlights research that has been done to understand migration habits and enable waterway managers to increase delivery of environmental water and thereby improve immigration by diadromous fishes in Victorian coastal rivers.

Port Phillip Bay, Western Port and Gippsland Lakes – DELWP has advised that the limits of acceptable change (LACs) for the Australian grayling (*Protroctes maraena*) in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site, the Western Port Ramsar site and the Gippsland Lakes Ramsar site were all assessed as being met during the most recent LAC assessments (in 2020).

Indicator 27: Marine and coastal waterbirds

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Western Port						
Corner Inlet-Nooramunga						
Gippsland Lakes					Species-dependent	

Data source:	BirdLife Australia, academic researchers, DELWP, Melbourne Water
Measures:	Waterbird abundance, breeding and diversity

Comments:

Port Phillip Bay – The LAC assessments from 2020 show that LACs for waterbird abundance and diversity were being met in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site. The most recent LAC assessment for waterbird breeding took place in 2016 and there was insufficient data to assess this LAC. For threatened waterbird species, the most recent LAC assessment took place in 2020, and the LAC was met for all species except the lesser sand plover (*Charadrius mongolus*). Data from 2019–20 show record numbers of many types of waterbirds near the Western Treatment Plant. The status rating is fair rather than good because the 2020 count of the straw-necked ibis (*Threskiornis spinicollis*) was the lowest since 2017, while the LAC for the lesser sand plover was not met.

Western Port – Population trends were determined for 39 of the 85 observed waterbird species (excluding seabirds). Populations of 22 of the 39 species declined between 1973 and 2015, 15 remained stable (despite fluctuations and some changes in distribution), and two have increased. This indicator assessment summarises these results, with an overall trend assessment of deteriorating because populations of the majority of waterbird species have declined. The status has been rated as fair because waterbirds are still present in significant numbers in Western Port, which is noted as an important habitat for waterbirds.

Corner Inlet-Nooramunga – The LAC assessments from 2020 show that LACs for waterbird abundance and threatened species were being met in the Corner Inlet Ramsar site for non-migratory birds. There was insufficient information to assess the LAC for waterbird breeding, which has resulted in a confidence assessment of moderate.

Gippsland Lakes – The LAC assessments from 2021 show that the LAC for waterbird abundance is being met, while there was insufficient information to assess the LAC for waterbird breeding. This is reflected in a fair status and moderate confidence.

Theme 3: Biodiversity

Indicator 28: Migratory shorebirds

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	↙	●	●	↙	●
Western Port	●	↙	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	↙	●	●	↙	●
Gippsland Lakes	●	?	●	●	N/A	N/A

Data source:	BirdLife Australia, academic researchers, DELWP, Melbourne Water
Measures:	Migratory shorebird abundance and breeding

Comments:

Port Phillip Bay – The numbers of red-necked stint (*Calidris ruficollis*), curlew sandpipers (*Calidris ferruginea*) and sharp-tailed sandpipers (Calidris acuminate) are declining in line with populations throughout the world over the past 20 years. The status is rated as fair because there are still significant numbers of migratory shorebirds stopping at sites along Port Phillip Bay (for example, more than 10,000 sharp-tailed sandpipers were counted near the Western Treatment Plant in 2019–20), while a 2020 assessment found LACs for key migratory shorebird species were being met in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site.

Western Port – Declines have been observed in several species of trans-equatorial migratory shorebirds that visit Western Port. The status has been rated as fair because migratory shorebirds are still present in significant numbers in Western Port, which is noted as an important habitat for waterbirds.

Corner Inlet-Nooramunga – A review of 30 years of data (1981–2011) for migratory shorebird numbers in Corner Inlet and Nooramunga revealed a 23% decline in the combined numbers of all species. Despite the deteriorating trend, the status has been rated as fair because the combined population is still estimated to be approximately 25,000–30,000.

Gippsland Lakes – The LAC assessments from 2021 show that the LAC for waterbird abundance is being met for the red-necked stint and sharp-tailed sandpiper. Both species have been recorded multiple times in the past five years (2017–2021).

Theme 3: Biodiversity

Indicator 29: Piscivorous (fish-eating) birds

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Western Port						
Corner Inlet-Nooramunga						

Data source:	BirdLife Australia, academic researchers, DELWP, Melbourne Water
Measures:	Piscivorous bird abundance and diversity

Comments:

Port Phillip Bay – The status is rated as good, because Mud Island supports very large numbers of fish-eating waterbirds, mainly of petrels and gulls. A 2020 assessment found that LACs were being met for piscivorous species in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site.

Western Port – Research shows that Western Port's populations of terns, cormorants and the Australian pelican (*Pelecanus conspicillatus*) decreased between 1974 and 2012. Although the data quality to support these assessments is good, confidence in these assessments is only rated as moderate. This is because there are no clear criteria and thresholds to assess the status, and the most recent data are now nearly a decade old.

Corner Inlet-Nooramunga – A study completed in 2015 analysed data from 1987 to 2012. The researchers found increasing population trends for terns, cormorants and the Australian pelican at west Corner Inlet. The results of this study are the basis of the status and trend assessments of good and improving, respectively.

Indicator 30: Little penguins

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Western Port						

Data source:	Earthcare St Kilda, Phillip Island Nature Parks
Measures:	Estimated population size, number of unique penguins tracked, number of chicks microchipped

Comments:

Port Phillip Bay – Little penguin numbers at St Kilda Harbour breakwater have grown to an estimated 1,400 since they were first observed in the 1960s. Based on this, the status has been rated as good and the trend as improving, although confidence is only moderate because there is no routine monitoring of the population and there are no existing thresholds available to guide the assessment.

Western Port (Bass Coast Shire) – Extensive conservation work since the 1980s has resulted in an increase in little penguin numbers from 12,000 in the mid-1980s to an estimated 32,000 in 2021. Based on this the status has been rated as good. The trend is improving based on unpublished surveys available for trend analysis across recent years.

Theme 3: Biodiversity

Indicator 31: Marine mammals

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	(dolphins)	(dolphins)	(dolphins)		N/A	N/A
Western Port	(dolphins, seals)	(dolphins) (seals)	(seals) (dolphins)		N/A	N/A
Gippsland Lakes	(dolphins)	(dolphins)	(dolphins)		N/A	N/A

Data source:	Dolphin Research Institute, Marine Mammal Foundation, Phillip Island Nature Parks, academic researchers
Measures:	Marine mammal population estimates

Comments:

Port Phillip Bay (dolphins) – There is contention about the species of dolphins residing in Port Phillip Bay, but there is strong agreement that there is a stable population of more than 100. Although this might seem small, it is likely to have been reasonably stable for a long time (since the 1960s), which is why the status is rated as fair rather than poor.

Western Port (dolphins) – The Dolphin Research Institute estimates that Western Port has a resident population of 20 dolphins. There is no evidence to suggest a decline of these numbers over the past three decades. The very small population size means that the consequences of significant mortality events can be proportionally significant on the dolphin population in Western Port, so the status has been rated as poor to reflect this vulnerability.

Western Port (seals) – There are an estimated 20,000 to 30,000 Australian fur seals in the Seal Rocks colony at the western entrance to Western Port, including bulls, seals and pups. Phillip Island Nature Parks and collaborators have identified statistically significant declining trends in pup numbers since 2007 at Seal Rocks.

Gippsland Lakes (dolphins) – There has been a relatively stable population of between 60 and 100 dolphins living in the Gippsland Lakes, although a significant mortality event and skin infections for the resident dolphins in 2020 have been linked with the 2019–20 bushfires, which is reflected in a deteriorating trend assessment. The small population means the consequences of significant mortality events can be proportionally significant on the dolphin population in the lakes, so the status has been rated as poor to reflect this vulnerability.

Theme 4: Seafloor integrity and health

Indicator 32: Conservation of marine ecosystems in protected areas

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Other marine protected areas				 (Victoria's five marine bioregions)	 (seals)	 (seals)
Gippsland Lakes						
Data source:	Parks Victoria					
Measures:	Percentage of Victoria's state waters that are protected | Percentage of Victoria's marine protected areas that are no-take zones where removing animals and plants is banned | Percentage of marine parks reported to be in good condition					

Comments:

This is a broad indicator that covers a range of marine protected areas and conservation efforts. In total, Victoria's marine protected areas cover 106,106 hectares or 10.4% of state waters. Based on 10.4% of all Victoria's marine coastal waters being covered by marine protected areas, Victoria does satisfy an international target for at least 10% marine protected area coverage. However, only 5.2% of Victoria's state waters are no-take zones where removing animals and plants is banned – Victoria has the second-lowest proportion of no-take areas of any Australian state or territory.

Parks Victoria reports that the condition of natural values is good or very good in 93% of marine parks.

Based on this broad range of evidence, with Victoria's marine protected areas generally in good condition and meeting the international target to conserve at least 10% of coastal and marine areas, but with a smaller spatial coverage of no-take zones relative to most other Australian jurisdictions, the status of this indicator is rated as fair. The trend is rated as stable, because the area protected in marine parks has remained unchanged since 2002, while the condition of marine protected areas remains generally good.

Theme 4: Seafloor integrity and health

Indicator 33: Nitrogen cycle

Region		2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay							
Western Port							
Gippsland Lakes	Lake King						
	Lake Victoria						
	Lake Wellington						

Data source:	DELWP, Melbourne Water, academic researchers
Measures:	Denitrification efficiency | The ratio of nitrogen fixation to denitrification Dissolved inorganic nitrogen concentrations

Comments:

Port Phillip Bay – The denitrification efficiency (DE) process generally maintains nutrients in Port Phillip Bay at an optimal level for biodiversity. No event since 1994 has been large enough to reduce DE for more than a month. A status assessment of good has been made on the basis that a threshold of DE lower than 60% in Port Phillip Bay (40% for Hobsons Bay) indicates that the denitrification process is disrupted. Confidence in the assessment is only moderate, because no data since 2014 are available.

Western Port – In most parts of Western Port, the ratio of nitrogen fixation to denitrification is high (that is, nitrogen fixation is more common than denitrification). Low denitrification indicates that the water column is starved of nutrients because the vegetation is processing it. This ratio is inverted in less-vegetated areas of Western Port (that is, denitrification is higher than nitrogen fixation). There is only a small number of research studies that have investigated this, so confidence in the status assessment is low.

Gippsland Lakes – These status and trend ratings for the Gippsland Lakes are based on dissolved inorganic nitrogen concentration assessments using thresholds derived from the framework established in the Australian and New Zealand Water Quality Guidelines. Dissolved inorganic nitrogen concentrations in Lake King are rated as good, but in Lakes Victoria and Wellington were above the threshold for all five years from 2010 to 2015. Although there is a pattern of increased concentrations in high rainfall years, there are no sustained trends.

Theme 4: Seafloor integrity and health

Indicator 34: Seagrass

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Western Port						
Corner Inlet-Nooramunga						
Gippsland Lakes						
Other marine protected areas						

Data source:	Academic researchers, Melbourne Water
Measures:	Seagrass extent Seagrass condition (includes a range of variables such as shoot length, density and biomass, along with epiphyte cover, epifauna, water temperature and light)

Comments:

Port Phillip Bay – During the last major drought (1997–2009), Port Phillip Bay lost considerable areas of seagrass. There is insufficient information to measure the extent of recovery, if any, since the drought ended in 2010. The LAC for seagrass in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site is that total seagrass extent will not decline below 1,500 hectares for a period of greater than 20 continuous years. This is being met, although most of the data used to make this assessment are now more than 20 years old. The condition of seagrass in Port Phillip Bay is good but based on only four years of data (2008–11). This information on seagrass extent and condition has been combined into a status assessment of fair. Due to the short time series and lack of recent data from the past decade, the trend is unclear and confidence in the assessment is low.

Western Port – In the mid-1970s to early 1980s extensive loss (up to 75%) of intertidal seagrasses was observed. Seagrass recovery has been observed since then, although coverage is still less than during the 1970s. The LAC for seagrass in the Western Port Ramsar site is that total seagrass extent will not decline below 5,400 hectares. This is being met. Even though the LAC for seagrass is being met, because of the documented and extensive historical seagrass losses and the lack of a major recovery in recent years, the status has been rated as poor, but the trend is improving.

Corner Inlet-Nooramunga – Despite a long history of slow seagrass decline in Corner Inlet, where seagrass extent had declined on average by 0.5 km^2 per year between 1965 and 2013, the cover of seagrass appears to have stabilised between 2013 and 2018, and then increased between 2018 and 2020. Based on this information, the status has been assessed as fair and the trend as improving.

Gippsland Lakes – The LAC for seagrass in the Gippsland Lakes Ramsar site is being met for one of the two components of the LAC, with the other unable to be assessed. No trend can be determined for seagrass in the Gippsland Lakes, as there are only two points in time upon which extent and condition can be compared. Seagrass extent can be highly variable. The decline from 1997 to 2016 does not provide any indication of variability over time or tell us whether seagrass extent expanded and contracted several times over that period or is on a trajectory of decline.

Other marine protected areas – Parks Victoria data show a 9% decline in seagrass extent in marine protected areas over a three-year period from 2015. The change in seagrass extent is variable across Victoria's marine protected areas and is small enough in magnitude for the trend to be rated as stable. For example, there have been increases during the past decade in Corner Inlet and Nooramunga Marine and Coastal Parks, while there has been a decrease of *Amphibolis antartica* seagrass extent in the Port Phillip Heads Marine National Park from a high of 12% cover in 2003 to a low of 4% in 2019. The most recent estimate is that there is 18,287 hectares of seagrass habitat in Victorian Marine Protected Areas.

Theme 4: Seafloor integrity and health

Indicator 35: Shellfish reefs

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Western Port						
Corner Inlet-Nooramunga						
Gippsland Lakes						

Data source:	Academic researchers
Measures:	Extent of shellfish reefs

Comments:

Port Phillip Bay – Historically, there were large areas of blue mussel (*Mytilus edulis galloprovincialis*) and native flat oyster (*Ostrea angasi*) reefs in Port Phillip Bay. While flat oysters and blue mussel can still be found throughout Port Phillip Bay, there are currently no known areas of extensive mussel or flat oyster reefs on the bay sediments. The trend has been rated as improving because of a current restoration project that has built 5.5 hectares of shellfish reef in Port Phillip Bay since 2015. The confidence is rated as moderate rather than high because it is unknown whether the conditions that support the continuing enhancement and maintenance of these oyster reefs are improving.

Western Port – Historically, there were large areas of native flat oyster reefs in Western Port. Anecdotal evidence reported as part of a 2016 research project indicates that sporadic oyster harvesting has not occurred since the mid-20th century, suggesting that the extent of native flat oyster reefs is now minimal. However, the lack of recent quantitative analysis means that confidence in this indicator assessment is low.

Corner Inlet-Nooramunga – The past distribution of native flat oyster in Corner Inlet and Nooramunga is estimated to be almost the entire enclosed waterway and some sandy stretches on the open coast. The species is still present in many locations in Corner Inlet and Nooramunga but consists mainly of isolated clumps or individuals and no longer forms a continuous reef matrix.

Gippsland Lakes – Large mussel reefs can still be found in the entrance region of the Gippsland Lakes, which is why the status is fair despite the extent of shellfish reefs having declined in the 20th century. No significant changes to shellfish reefs have been noted this century, so the trend has been assessed as stable.

Theme 4: Seafloor integrity and health

Indicator 36: Macroalgae on intertidal reefs

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Other marine protected areas						
Data source:	Parks Victoria					
Measures:	Parks Victoria's control charts for the condition of brown algae communities on intertidal reefs					

Comments:

Port Phillip Bay – The status assessment of good is based on information provided as part of Parks Victoria's long-term Intertidal Reef Monitoring Program. No reports have been published since 2014, but Parks Victoria advises that monitoring and assessment are continuing and the most recent findings are consistent with those previously published – an updated technical report is in preparation by Parks Victoria.

Other marine protected areas – The status assessment of fair is based on information provided as part of Parks Victoria's long-term Intertidal Reef Monitoring Program to 2014, draft control charts from 2018, and a 2020 publication focusing on Point Addis Marine National Park. The absence of regular published reporting for many marine protected areas is reflected in an unclear trend and a confidence assessment of moderate rather than high.

Theme 4: Seafloor integrity and health

Indicator 37: Macroalgae-dominated subtidal reefs

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	(Port Phillip Heads Marine National Park) (Ricketts Point Marine Sanctuary) (Point Cooke and Jawbone marine sanctuaries)	→		(north) (south)	(north) ↙ (south)	(north) (south)
Other marine protected areas		?			?	
Data source:	Parks Victoria					
Measures:	Parks Victoria control charts					

Comments:

Port Phillip Bay – A range of evidence from research studies and Parks Victoria's long-term Subtidal Reef Monitoring Program shows that the condition and extent of macroalgae on subtidal reefs in Port Phillip Bay is poor for Point Cooke and Jawbone marine sanctuaries, fair for Ricketts Point Marine Sanctuary, and good for Port Phillip Heads Marine National Park. The recent trend is stable, although it is worth noting that there was a significant deterioration in kelp loss during the early 2000s in association with the millennium drought.

Other marine protected areas – The status assessment of fair is based on the available information provided as part of Parks Victoria's long-term Subtidal Reef Monitoring Program to 2014, draft control charts from 2018, and a 2020 publication focusing on Point Addis. The absence of regular published reporting for many marine protected areas is reflected in a confidence assessment of moderate rather than high. Parks Victoria is progressing monitoring and assessment, with plans to publish technical reports in the next couple of years for Port Phillip Heads, Wilsons Promontory, Cape Howe and Discovery Bay marine national parks, which will help fill gaps in knowledge on intertidal reefs in marine protected areas and increase confidence in this indicator assessment in future SMCE Reports.

Theme 5: Pests and invasive species

Indicator 38: Invasive marine species

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay						
Western Port						
Corner Inlet-Nooramunga						
Gippsland Lakes						
Other marine protected areas						

Data source:	Department of Jobs, Precincts and Regions
Measures:	Number of invasive marine species | Change in the number of marine species Abundance of invasive marine species | Impact of invasive marine species

Comments:

Port Phillip Bay – There are now more than 160 invasive marine species in Port Phillip Bay. The damage caused by some of these is significant, notably the northern Pacific seastar (*Asterias amurensis*), which has been shown to cause changes in fish populations in Port Phillip Bay. New invasive species continue to arrive, most recently the Asian shore crab (*Hemigrapsus sanguineus*), first detected at Mount Martha in late 2020.

Western Port – The status assessment of fair reflects the presence of several invasive marine species in Western Port, although the size and number of infestations are significantly lower than in Port Phillip Bay.

Corner Inlet-Nooramunga – The status assessment of good reflects that Corner Inlet has remained relatively free of invasive marine species. The deteriorating trend is based on *Undaria pinnatifida*, a kelp also known as wakame, being observed in the region since 2018.

Gippsland Lakes – The status assessment of fair reflects research published in 2016 which determined that the Gippsland Lakes' risk profile for invasive marine species is lower than that of many other major ports along the Australian coast. The deteriorating trend is based on the arrival of the northern Pacific seastar and the Pacific oyster (*Magallana gigas*), with both species being observed in the lakes in recent years.

Other marine protected areas – The status assessment of fair reflects research highlighting the risks that invasive marine species pose to marine protected areas. For example, wakame is an introduced kelp that was first detected in 1996 near Point Wilson 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. Not enough information is available to determine the trend. Confidence in the status and trend indicator assessments is rated as moderate.

Theme 5: Pests and invasive species

Indicator 39: Coastal invasive plants

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	●	?	●	●	N/A	N/A
Data source:	DELWP, Department of Jobs, Precincts and Regions, Parks Victoria					
Measures:	Area of treatment works to control weeds on land within 5 km of the Victorian coastline The impact of weeds | Threat of transformer weeds | Benefit minus cost of weed control Number of locations where invasive plants have been detected within 5 km of the Victorian coastline					

Comments:

Statewide – Only limited time series data exist to track the impact of coastal invasive plants over time. The status of fair is due to varying impacts of invasive plants along the Victorian coastline.

Indicator 40: Coastal invasive animals

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	●	?	●	●	N/A	N/A
Data source:	Statewide (SW)					
Measures:	Area of treatment works to control cats, deer, foxes, goats, pigs and rabbits within 5 km of the Victorian coastline | The impact of pest animals | Benefit minus cost of fox control Number of locations where invasive animals have been detected within 5 km of the Victorian coastline					

Comments:

Statewide – Only limited time series data exist to track the impact of coastal invasive animals over time. The status of fair is due to varying impacts of invasive animals along the Victorian coastline.

Theme 6: Climate and climate change impacts

Indicator 41: Rainfall

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	↙	●	●	N/A	N/A
Western Port	●	→	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	↙	●	●	N/A	N/A
Gippsland Lakes	●	↙	●	●	N/A	N/A
Statewide				●	↙	●

Data source:	BoM, CSIRO, DELWP
Measures:	Rolling 10-year average of annual rainfall | Rolling 10-year average of cool-season (April to October) rainfall | Percentage change in rainfall from 1980–99 to 2000–19

Comments:

Confidence in the status and trend assessments is rated as moderate rather than high because even though the data quality on rainfall is good, understanding of the impacts of rainfall on coastal settlements is constantly evolving.

Port Phillip Bay, Corner Inlet-Nooramunga, Gippsland Lakes – The status and trend assessments of fair and deteriorating respectively reflect the fluctuating pressure being exerted on the water resources and agricultural sectors by wetter years interspersing a predominantly drying climate. Greater reduction in rainfall during the cool seasons is particularly important, given the harm this can cause to streamflows and the reduced reliability for water storage filling seasons.

Western Port – The status and trend assessments of fair and stable respectively reflect the fluctuating pressure being exerted on the water resources and agricultural sectors by wetter and drier years.

Theme 6: Climate and climate change impacts

Indicator 42: Air temperature

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	↙	●	●	N/A	N/A
Western Port	●	↙	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	↙	●	●	N/A	N/A
Gippsland Lakes	●	↙	●	●	N/A	N/A
Statewide	N	N	N	●	↙	●

Data source:	BoM, CSIRO, DELWP
Measures:	Rolling 10-year average of annual mean maximum temperature | Rolling 10-year average of summer mean maximum temperature | Temperature change (average daily maximum temperature in °C) per decade from the 1980s to the 2010s | Number of days when the daily maximum temperature exceeds 35°C

Comments:

Confidence in the status and trend assessments is rated as moderate rather than high because, even though the data quality on temperature is good, knowledge on the impacts of increasing temperatures is constantly evolving.

Port Phillip Bay – The status and trend assessments of fair and deteriorating respectively reflect the increasing pressure being exerted on human health, biodiversity and coastal infrastructure. Melbourne was 0.96°C warmer in the 2010s than in the 1990s, highlighting the rapid rate of recent warming.

Western Port – The status and trend assessments of fair and deteriorating respectively reflect the increasing pressure being exerted on human health, biodiversity and coastal infrastructure. Temperature measurements made at coastal settlements along Western Port show that temperatures have increased by approximately 1°C from the 1990s to the 2010s, highlighting the rapid rate of recent warming.

Corner Inlet-Nooramunga – The status and trend assessments of fair and deteriorating respectively reflect the increasing pressure being exerted on human health, biodiversity and coastal infrastructure. Wilsons Promontory was 0.8°C warmer in the 2010s than in the 1990s, highlighting the rapid rate of recent warming.

Gippsland Lakes – The status and trend assessments of fair and deteriorating respectively reflect the increasing pressure being exerted on human health, biodiversity and coastal infrastructure. The rolling 10-year average temperature has increased significantly at East Sale, by 1.14°C, from the 1950s to the 2010s, with the rate of increase being most pronounced during the past 20 years. The 2010s were 0.74°C warmer than the 1990s, highlighting the rapid rate of recent warming.

Theme 6: Climate and climate change impacts

Indicator 43: Water temperature

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	BoM, CSIRO, DELWP
Measures:	Trends in sea-surface temperatures (°C per decade)

Comments:

Statewide – The increasing frequency of marine heatwaves around Australia in recent years has permanently harmed marine ecosystem health, marine habitats and species. These harms include depleting kelp forests and sea grasses, a poleward shift in some marine species, and increased occurrence of disease. This information is the basis of the status and trend assessments of poor and deteriorating, respectively.

Indicator 44: Ocean acidification

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide			Low (status), High (trend)			

Data source:	BoM, CSIRO, DELWP
Measures:	Change in pH of surface waters

Comments:

Ocean surface waters around Australia have increased in acidity by more than 30% from the 1880s to the 2010s. The increase in acidity has become mare rapid in recent decades. There are limited studies on the effects of ocean acidification around Victoria, so the status is rated fair, but with low confidence. There is high confidence in the trend assessment.

Theme 6: Climate and climate change impacts

Indicator 45: Areas of coastal vulnerability

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	?	●	●	N/A	N/A
Western Port	●	?	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	↙	●	●	N/A	N/A
Gippsland Lakes	●	↙	●	●	N/A	N/A
Statewide	N	N	N	●	N/A	N/A

Data source:	DELWP, academic researchers
Measures:	This indicator is designed to describe the types of hazards, report on where these hazards are, and how much area they cover.

Comments:

Port Phillip Bay – There is currently not enough published information to provide status and trend assessments for this indicator.

Western Port – The most recent comprehensive assessment of coastal inundation and erosion hazards for Western Port occurred in 2014. A range of hazards were identified, but the spatial extent of the area of coastal vulnerability is unknown.

Corner Inlet-Nooramunga – Modelling predicts that Corner Inlet will be affected extensively by climate change, with the effects worsening over time. A range of hazards were identified, but the spatial extent of the area of coastal vulnerability is unknown, so confidence in the status and trend assessments is only rated as moderate.

Gippsland Lakes – The most recent comprehensive assessment of coastal inundation and erosion hazards for the Gippsland Lakes occurred in 2014. A range of hazards was identified, but the spatial extent of the area of coastal vulnerability is unknown. The findings converged on increasing effects, which is reflected in a deteriorating trend. The status has been rated as fair due to there currently being damage associated with coastal risks such as inundation and erosion, but these are still relatively infrequent. For example, there is currently a 10% chance each year that Lakes Entrance will be subjected to inundation during a flood event.

Theme 6: Climate and climate change impacts

Indicator 46: Sea-level and coastal inundation

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	↙	●	●	N/A	N/A
Western Port	●	↙	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	?	●	●	N/A	N/A
Gippsland Lakes	●	?	●	●	N/A	N/A
Statewide	●	↙	●	●	↙	●

Data source:	BoM
Measures:	Annual mean sea level | Annual maximum sea level

Comments:

Port Phillip Bay, Western Port – The status and trend assessments of fair and deteriorating respectively reflect the increasing pressure being exerted on human coastal settlements and infrastructure.

Corner Inlet-Nooramunga – The status assessment of fair reflects the pressure being exerted on human coastal settlements and infrastructure. Confidence in the assessments is moderate rather than high, because the time series of tidal gauge data covers less than two decades and has many gaps.

Gippsland Lakes – The status assessment of fair reflects the pressure being exerted on human coastal settlements and infrastructure. Confidence in the assessments is moderate rather than high, because the time series of tidal gauge data covers only the last 12 years.

Statewide – Future rises in sea level are projected with high confidence. Sea levels are expected to rise by approximately 12 cm at various places along Victoria's coastline by 2030, with a rise of approximately 40 cm projected by 2070. The status and trend assessments of fair and deteriorating respectively reflect the increasing pressure being exerted on human coastal settlements and infrastructure.

Theme 6: Climate and climate change impacts

Indicator 47: Wave climate

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	?	●	●	N/A	N/A
Statewide	●	?	●	●	N/A	N/A

Data source:	Academic researchers
Measures:	Percentage of load on structures from meteorological and oceanographic forcing (that is, the combined wind, wave and climate conditions)

Comments:

Port Phillip Bay – A recent study of Port Phillip Bay's wave climate deepened the understanding of its characteristics and effects. Extreme sea levels are often not associated with large extreme wave events in Port Phillip Bay, while meteorological and oceanographic forcing (that is, the combined wind, wave and climate conditions) is a major cause of damage to marine and coastal infrastructure – this combination of various wave climate parameters produces approximately 70% of loads on structures. Because the research used for this indicator assessment is more of a characterisation of current wave climate rather than an analysis of the effects of a changing wave climate due to climate change, the status has been rated as unknown, and the trend is unclear.

Statewide – A recent study of Victoria's wave climate deepened the understanding of its characteristics. Despite this research, Victoria's relatively high-wave-energy coastline is a major gap in Australia's knowledge of the open coast wave climate of Australia, due to a lack of permanent wave buoys. There has been no statewide analysis of the effects of Victoria's wave climate, with the published research focusing on the significant effects that are estimated to occur at a global scale. Confidence in this indicator is rated as low, because of the lack of local studies and data.

Theme 6: Climate and climate change impacts

Indicator 48: Coastal erosion

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	●	?	●	●	N/A	N/A
Western Port	●	↙	●	●	N/A	N/A
Corner Inlet-Nooramunga	●	↙	●	●	N/A	N/A
Gippsland Lakes	●	↙	●	●	N/A	N/A
Statewide	●	?	●	●	N/A	N/A

Data source:	DELWP
Measures:	Area of coast defined as an erosion hotspot (that is, where there has been a landward shift in shoreline position between 1986 and 2017 at a rate greater than 0.5 m per year) Area of coastline defined as highly or very highly vulnerable to erosion

Comments:

Port Phillip Bay – The results of a 2017 erosion vulnerability assessment have been used to guide the status assessment for this indicator. Thirty-one percent of Port Phillip Bay's coastline has a very high or high vulnerability to coastal erosion, which is reflected in a status assessment of fair for this indicator. Because this mapping is a point-in-time assessment, the trend is unclear.

Western Port – Two studies in recent years have measured the Lang Lang coastline (at the head of Western Port) as eroding, on average, by approximately 30 cm per year, while coastal bank erosion has also been estimated to be responsible for one-third of the sediment delivered to Western Port annually. The results of a 2017 erosion vulnerability assessment have also been used to guide the status assessment for this indicator: 27% of Western Port's coastline has a very high or high vulnerability to coastal erosion. This information is reflected in a status assessment of fair for this indicator, with a deteriorating trend.

Corner Inlet-Nooramunga – The results of a 2017 erosion vulnerability assessment have been used to guide the status assessment for this indicator. Thirty-four percent of Corner Inlet and Nooramunga's coastline has a very high or high vulnerability to coastal erosion, which is reflected in a status assessment of fair. Because this mapping is a point-in-time assessment, the trend is unclear.

Gippsland Lakes – The results of a 2017 erosion vulnerability assessment have been used to guide the status assessment for this indicator. More than 100 kilometres of the Gippsland coastline is rated as having a very high vulnerability to coastal erosion. This means that more than one-quarter of the entire Victorian coastline most at risk of erosion is located along the Gippsland Lakes, which is reflected in a status assessment of poor. Because this mapping is a point-in-time assessment, the trend is unclear.

Statewide – Researchers have estimated that erosion hotspots (defined as showing a landward shift in shoreline position between 1986 and 2017 at a rate greater than 0.5 m per year) extend over 76.6 km of the coastline, equivalent to approximately 6.2% of the Victorian coast. Because this mapping is a point-in-time assessment, the trend is unclear.

Theme 6: Climate and climate change impacts

Indicator 49: Seawater intrusion into coastal aquifers

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		?			N/A	N/A
Data source:	Academic researchers					
Measures:	Vulnerability ratings for seawater intrusion into coastal aquifers					

Comments:

Statewide – There is insufficient information to provide status and trend assessments for this indicator. The evidence to assess this indicator is minimal, therefore an indicator confidence assessment cannot be made.

Indicator 50: Frequency and impact of fire on marine and coastal ecosystems

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Gippsland Lakes		?			N/A	N/A
Data source:	Academic researchers					
Measures:	Change in water quality, algal bloom frequency and nutrient loads before, during and after significant fire activity					

Comments:

Gippsland Lakes – The status assessment of fair is due to the Gippsland Lakes water quality being temporarily adversely affected by the large bushfires in the 2019–20 fire season. Previous fires in 2003 and 2006–07 were linked with algal blooms. No data on the frequency and impact of fires along the Gippsland Lakes coastline are available to ascertain a trend.

Theme 6: Climate and climate change impacts

Indicator 51: Climate change impact on marine and coastal infrastructure

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Port Phillip Bay	○	?	○	●	N/A	N/A
Western Port	●	↙	●	●	N/A	N/A
Gippsland Lakes	●	↙	●	●	N/A	N/A
Statewide	●	↙	●	●	N/A	N/A

Data source:	DELWP, AURIN (Australian Urban Research Infrastructure Network)
Measures:	Number and proportion of buildings expected to be inundated by 2100 under a high-emissions scenario with an expected sea-level rise of 82 cm and a one-in-100-year storm tide, by coastal local government area Total capital improved value of properties vulnerable to flooding

Comments:

Port Phillip Bay – DELWP and CSIRO are collaborating on a coastal hazard assessment for Port Phillip Bay. This assessment will enable impact assessments and projections for inundation (flooding), groundwater change, and erosion.

Western Port – A significant number of coastal infrastructure assets, valued in the billions of dollars, are at risk from climate change. For example, based on flood mapping information available in 2008, an estimated 18,000 properties with a total capital improved value of almost $2 billion are vulnerable to flooding.[126] The effects of climate change are expected to dramatically increase the likelihood of this flood risk, with projections suggesting that a current one-in-100-year storm surge could become a one-in-one to one-in-four-year storm surge by 2070.

Gippsland Lakes – A range of recent studies highlights significant likelihood of impact from climate change on coastal infrastructure, including properties, the road network and utilities (for example, powerlines) along the Gippsland Lakes coastline. The studies do not provide quantitative estimates of the extent of the impact and the economic value of the vulnerable infrastructure, so confidence in the status and trend assessments is low.

Statewide – The status and trend assessments are based on analysis of the Victorian Coastal Inundation digital dataset; Microsoft's Australia Building Footprints dataset; and the research synthesis and commentary provided in Infrastructure Victoria's Draft 30-Year Infrastructure Strategy, which was released in December 2020.

There has been no statewide quantitative analysis of the risks to, and impacts on, Victoria's marine and coastal infrastructure from climate change, so confidence in this indicator's status and trend assessments is low. However, the examples provided in the indicator narrative all suggest a poor status and an unclear trend, although there is expected to be a deteriorating trend in the future as the effects of climate change are projected to increase.

126. Kinrade P and Preston B 2008, 'Impacts of climate change on settlements in the Western Port region: people, property and places. Final report', Australian Government Department of Climate Change, and Department of Sustainability and Environment, Victoria.

Theme 7: Managing coastal hazard risks

Indicator 52: Considering climate change risks in land-use planning

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	DELWP
Measures:	Percentage of Victorian coastal councils assessed as having Advanced or Intermediate consideration of climate change in land-use planning

Comments:

Statewide – The status assessment of fair reflects data from 2018 that shows 70% of the 22 Victorian coastal councils were assessed as having Advanced or Intermediate consideration of climate change in land-use planning. Because this mapping is a point-in-time assessment, the trend is unclear. As climate change risks regularly evolve, it is possible that coastal councils have advanced their consideration of climate change in land-use planning since 2018, so confidence in the indicator assessment is only rated as moderate.

Indicator 53: Climate change adaptation plans

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	catchment management authorities
Measures:	Number of catchment management authorities that have developed and are implementing climate change adaptation plans or strategies

Comments:

Statewide – The status assessment of fair reflects the fact that considerable work is being done to adapt to climate change based on the best scientific information. For example, all 10 catchment management authorities across Victoria have developed and are implementing climate change adaptation plans or strategies based on the latest climate change projections by the CSIRO and formulated in conjunction with Australia's principal research organisations. The trend is improving because more guidance material to enable organisations to develop climate change adaptation plans has been published during recent years. The low confidence rating reflects the fact that only a minimal amount of evidence is available to assess the development and implementation of climate change adaptation plans.

Theme 7: Managing coastal hazard risks

Indicator 54: Nature-based adaptation

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		?			N/A	N/A

Data source:	DELWP
Measures:	Soil carbon stocks (tonnes of organic carbon per hectare) in saltmarsh, mangrove and seagrass ecosystems mapped across Victoria Potential carbon sequestration gains from 2020 to 2100 by restoring coastal wetlands in areas inundated by levee breaching and sea-level rise Economic benefit of carbon sequestration

Comments:

The status assessment of poor reflects research published during 2019 which found that saltmarshes, mangroves and seagrasses in Victoria are currently capturing approximately 2% of the carbon that would be possible to be captured by 2050 if coastal wetlands can naturally retreat. Because this research is a point-in-time assessment, the trend is unclear.

Indicator 55: Emergency planning and preparedness

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		↗			N/A	N/A

Data source:	Emergency Management Victoria
Measures:	As per the Emergency Management Act 2013, the State Emergency Management Plan contains provisions for the mitigation of, response to and recovery from emergencies, and specifies the roles and responsibilities of agencies in managing emergencies.

Comments:

The status assessment of good reflects the existence of the State Emergency Management Plan, which sets out arrangements for integrated, coordinated and comprehensive emergency management at the state level. The trend is assessed as improving due to anecdotal evidence of the maturation of the Victorian Government's improving capability and capacity to plan, prepare and respond to emergencies, with incident air monitoring cited as an example.

Theme 8: Communities

Indicator 56: Population (resident)

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	N	N			N/A	N/A

Data source:	ABS, DELWP
Measures:	Resident coastal population growth rate by town/suburb/Statistical Areas Level 2 Projected coastal population growth rate by Statistical Areas Level 2

Comments:

Resident population growth remains high in specific locations along the Victorian coast.

Land-use planning policies have channelled most of this growth into designated locations.

There are detailed and rigorous data available on population growth, and government is able to make projections of future growth.

Although a vast amount of data about resident populations is collected, the nature and scale of its environmental impacts will depend on many other factors, such as peoples' values and behaviour, the use of infrastructure and technology to minimise impact, and the planning regimes that influence where people can settle. For this reason, a formal assessment of this indicator has not been undertaken. Instead, a narrative outlines the patterns of population change along the Victorian coast and the implications of this for environmental management.

Indicator 57: Population (visitors)

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	N	N			N/A	N/A

Data source:	DELWP Planning, Business Victoria, Phillip Island Nature Parks
Measures:	Estimates of peak population Tourist visitor numbers Visitor numbers and coastal visitor management strategies – Phillip Island

Comments:

Problems such as overcrowding and congestion are often related to visitor rather than resident populations.

In many areas, data on visitor populations are poorer than for resident populations.

Land-use planning is less effective for visitor populations; this creates issues of people management rather than settlement planning.

The impact of population on the environment is not linear – it is dependent on behaviour, technology and the regulatory environment.

The COVID-19 pandemic has severely disrupted international travel, which will cause short-term to medium-term reductions in international visitor numbers to major coastal attractions such as Phillip Island and the Great Ocean Road. However, the majority of visitors to these destinations are domestic.

Domestic travel restrictions have also affected regional visitation rates in the short term.

Data on visitor populations is not as robust as that collected for resident populations. The mobility of visitors makes such measurement inherently difficult. Even where data are available, the nature and scale of environmental impacts will depend on many other factors, such as peoples' values and behaviour and the management regimes and infrastructure which are in place to minimise impact. For this reason, an assessment of this indicator has not been undertaken. Instead, a narrative outlines the nature and scale of visitor populations along the Victorian coast and the implications of this for environmental management.

Theme 8: Communities

Indicator 58: Significant landscapes

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		→			N/A	N/A

Data source:	DELWP Planning
Measures:	Number of permits for dwellings or other buildings in areas covered by a Special Landscape Overlay Number of planning Declarations of Distinctive Areas and Landscapes Number of approvals for statements of planning policy for Distinctive Areas and Landscapes

Comments:

Victorian land-use planning legislation is improving protection, through Declarations of Distinctive Areas and Landscapes.

Planning permit data are able to provide quantitative assessments of how many planning permits are being issued for residential development in areas subject to a Special Landscape Overlay. However, it cannot show the degree to which qualitative aspects of building design are improving or diminishing landscape quality.

The trend assessment reflects that, on balance, planning controls are being strengthened to protect important landscapes, but we have no monitoring systems in place to determine whether the end results protect the qualities of significant landscapes.

Indicator 59: Coastal settlements

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	N	N			N/A	N/A

Data source:	ABS, Agriculture Victoria, DELWP Planning
Measures:	Building approvals | Land-use change Vegetation removal | Development outside urban boundaries

Comments:

Settlements generally represent an urbanisation of land use and associated infrastructure such as roads and pathways.

This process represents a significant change in land use, potentially reducing natural habitat and introducing impervious surfaces. There may also be a significant change in landscape amenity as built form replaces, or is incorporated into, natural environments.

The rezoning of land from rural to urban uses could be tracked using amendments data. However, the dataset is difficult to use for monitoring, because it was established to streamline amendment processes rather than as an analytical tool. Further work would be needed to enable the dataset to be used to track changes in urban and rural land use.

Although information on the growth of settlements in Victoria is available, it is not possible to make an overall assessment of status and trend for this indicator. While some people will view urbanisation as fundamentally damaging to the environment, the provision of housing is a basic element of human wellbeing, and the availability of affordable housing a matter of social and environmental justice. Future assessment of this type of indicator might therefore focus on the degree to which built form is meeting environmental standards.

Theme 8: Communities

Indicator 60: Cultural heritage

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	First Peoples – State Relations Group, Heritage Victoria
Measures:	Number of items included on Aboriginal Cultural Heritage Register Number of cultural heritage management plans Number of coastal heritage items/sites included on the Victorian Heritage Register Value of investment ($) through the Living Heritage program for coastal heritage Number of registered coastal heritage sites under threat from natural hazards

Comments:

Legislative protection is given to a range of cultural heritage for both Aboriginal and non-Aboriginal Victorians, on land and in marine environments.

Data are available on the number of items registered as having cultural significance, subject to certain restrictions in the case of Aboriginal cultural heritage.

While a variety of data are available, constraints in undertaking non-standard analyses of Heritage Victoria data (e.g., using the data in geographical information systems) limit its potential use.

Although cultural heritage can be assessed quantitatively (number of sites), it is important to monitor the qualitative status of sites and the degree to which investment is supporting their preservation and protection.

Indicator 61: Use of marine and coastal areas

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	DELWP (Ipsos), Parks Victoria
Measures:	Activities undertaken while visiting the Victorian coast Value of the coast

Comments:

The assessment of this indicator is based on the social and economic benefits derived from the use of marine and coastal areas, rather than on environmental impact (which is explored in other sections).

Victorian coastal areas are used by a range of people for a variety of purposes. Many of these activities bring health benefits and support economic activity in coastal communities.

Appropriate management of people and their activities can minimise environmental harm. This is of particular importance as populations (resident or visitor) grow.

Survey-based data do not always lend themselves to time-series analysis. Hence assessment of trend has not been undertaken for this indicator.

Theme 8: Communities

Indicator 62: Tourism

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		→			N/A	N/A

Data source:	Business Victoria 2020, Parks Victoria, Tourism Victoria
Measures:	Visitor numbers and total spend for selected Victorian tourism regions Number of visitors to coastal and marine parks Annual number of tourists visiting significant coastal tourist attractions

Comments:

Tourism is supported through government policy and is seen as a valuable source of jobs and revenue for Victorian coastal communities.

At present there appear to be limited links between tourism growth policies and visitor management or environmental management strategies. This has the potential to lead to management conflict and lack of policy coherence.

Although data are available, they tend to be geographically broad and survey-based, which makes detailed assessment of tourist impact very difficult.

Environmental certification schemes do not yet enable comprehensive assessment of tourism operators' environmental credentials.

The COVID-19 pandemic has severely disrupted international travel, which will cause short-term to medium-term reductions in international visitor numbers to major coastal attractions such as Phillip Island and the Great Ocean Road. However, the majority of visitors to these destinations are domestic.

Domestic travel restrictions have also affected regional visitation rates in the short term.

Indicator 63: Recreational boating and fishing contribution to the Victorian economy

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		↙			N/A	N/A

Data source:	Better Boating Victoria, VFA
Measures:	Recreational boating and fishing contribution to the Victorian economy Revenue from licence fees

Comments:

The assessment of this indicator is based on the economic and social benefits derived from these marine and coastal activities, rather than on environmental impact (which is explored in other sections).

Recreational boating and fishing are supported through government policy, and are seen as a valuable source of jobs and revenue for the Victorian economy.

Recreational boating and fishing are also recognised as benefiting human health by providing a relaxing activity that improves mental and social health.

COVID-19 restrictions have led to a decline in the number of licences issued, and subsequent revenue from recreational fishing and boating. While this has led to a deteriorating trend assessment, it is likely to improve once travel restrictions are eased.

Theme 8: Communities

Indicator 64: Recreational boating

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	Victorian Fisheries Authority, Better Boating Victoria, academic researchers
Measures:	Participation in recreational boating | Number of boat licence holders

Comments:

Licensing arrangements enable generally good data on the scale and nature of boating, although the effects of boating on specific habitats and geographical areas are more elusive.

Despite COVID-19 restrictions having affected activities such as recreational fishing and boating, this is not reflected in the number of registered vessels or the number of people with current boating licences. In fact, both have increased over the past year. This suggests that activity will recover quickly once travel restrictions are eased.

Indicator 65: Recreational fishing

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	VFA, academic researchers
Measures:	Number of recreational fishers | Hours spent in recreational fishing Quantity of fish caught through recreational fishing | Environmental impacts of recreational fishing Preferred species | Fish restocking programs (quantity)

Comments:

Increasingly, there are programs aiming to foster responsible fisher behaviour that improves environmental outcomes. These range from legislative, regulatory and compliance measures through to citizen science programs involving anglers in environmental research.

Although some data on recreational fishing are available, there remain gaps in our understanding of its scale and consequences. This is partly due to the dispersed nature of the activity and a reliance on survey-based data.

Lack of data means that we cannot assess the overall consequences of recreational fishing on fish stocks and ecological wellbeing.

Theme 8: Communities

Indicator 66: Shipping and ports

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		→			N/A	N/A
Data source:	Bureau of Infrastructure and Transport Research Economics; Department of Infrastructure, Transport, Regional Development and Communications; Port of Melbourne, Gippsland Ports, Department of Agriculture, Water and the Environment					
Measures:	Volume of shipping | Value of shipping Stormwater and ballast discharge | Number of spills and pollution events Introduction of pest species through ballast and biofouling | Channel dredging					

Comments:

Shipping continues to be an important part of Victoria's transport system, and the associated trade flows make a positive contribution to the Victorian economy.

Some of the risks associated with shipping, for example oil spills, are events of low probability but high consequence. It is therefore difficult to use past data to determine the likelihood of future events. However, the potential for major harm from such events requires effective regulation and emergency response systems. Victoria has both of these, but diligence is still required to maintain readiness for unexpected events.

The increase in environmental reporting and use of the UN SDGs by port authorities is a positive development, although it is too early to have a long enough time series of data to determine trends for environmental effects.

Introduction of pest species remains a significant threat that could undermine environmental quality.

Indicator 67: Commercial fishing

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		→			N/A	N/A
Data source:	ABS, Fisheries Research and Development Corporation, VFA, academic researchers					
Measures:	Value of commercial fishing production | Quantity of commercial fishing production Employment in fishing-related industries | Cetacean entanglements					

Comments:

Commercial fishing (for both domestic consumption and export) continues to be an important part of the Victorian economy.

Commercial fishing relies on healthy marine and coastal environments. Regulatory and management regimes aim to balance resource demand with environmental health.

Although Victoria's fisheries management systems are more effective than those of many other parts of the world, there are still some threats, such as overfishing, illegal and unreported fishing, introduction of pests, bycatch, and entanglements.

Theme 8: Communities

Indicator 68: Aquaculture

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						
Data source:	Fisheries Research and Development Corporation, Agriculture Victoria					
Measures:	Value of aquaculture production | Quantity of aquaculture production					

Comments:

Aquaculture is an increasingly important source of seafood in Victoria, for both the domestic and export markets.

Abalone and blue mussels are the main species farmed in Victorian coastal waters. Guidelines and protocols are in place for these and other aquaculture species, along with regulation and licensing systems to help prevent the spread of invasive marine species in the aquaculture industry. Monitoring of aquaculture farms is also undertaken by the EPA.

Disease is a potential threat to the industry. In 2021 the marine area near Portland was formally closed for a time, to prevent the spread of abalone viral ganglioneuritis. The process of closure and restriction suggests that management regimes are responsive to such threats. However, costs to the aquaculture industry and to others affected by such closures (commercial and recreational fishers, divers) can be high.

As some farms grow much larger, there may be an increasing risk in relation to biosecurity and pollution. Countering this, however, is a concurrent improvement in biosecurity technology and management regimes.

Indicator 69: Resources and energy generation

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						
Data source:	Department of the Environment and Energy, DELWP, Department of Jobs, Precincts and Regions, academic researchers					
Measures:	Offshore oil production in Victoria | Gas production in Victoria Electricity (MW) generated from renewable marine sources (wave, tidal, offshore wind)					

Comments:

Generation of wind and solar energy has been increasing in recent years and more projects are planned as Victoria makes the transition to low-carbon sources of energy.

Oil, gas and coal production still contribute to Victoria's energy sector and export markets.

Victoria does not have any operating offshore wind generation, although three proposals are being considered.

Some sources, such as wave, tidal and geothermal energy, have been the subject of trials and research projects, but none has yet emerged as a major contender in Victoria's energy-production market.

Although hydrogen power is not yet contributing to Victoria's energy generation, a pilot project currently in train aims to produce and transport liquid hydrogen from the Latrobe Valley, through the Port of Hastings, to Japan.

Global initiatives towards decarbonisation are likely to place pressure on Victoria's fossil fuel use in the coming decade, requiring a more rapid transition to renewable energy sources.

Theme 8: Communities

Indicator 70: Agriculture

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	Agriculture Victoria, DELWP Planning, Melbourne Water
Measures:	Agricultural runoff – contaminants reaching marine and coastal ecosystems (nutrients/toxins) Change in land use from agricultural to residential and urban land uses Loss of agricultural land

Comments:

Agriculture is a major land use that provides economic benefits and food for the wider community. Agriculture can be done in a sustainable way: farmers can be stewards of their land by maintaining or improving soils, vegetation and other environmental features.

Agriculture presents environmental risks, such as the water runoff with high nutrient loads from fertiliser or toxins from agricultural chemicals like pesticides. Limiting contaminated runoff is the focus of a number of policy initiatives that focus on recycling high-nutrient water and managing the application of chemicals.

Although research in the Western Port catchment has shown that the largest proportion of fine sediment load in catchment runoff is from grazing and cropping, this reflects the fact that grazing and cropping comprise a high proportion of catchment land use. In contrast, urban uses, though occupying smaller land area, have greater consequences for runoff.

Changes to agricultural land use can be measured using land-use data. This is providing a basis for protecting high-quality agricultural land through land-use planning in areas where agricultural land is under threat from urban and residential uses.

Indicator 71: Built and public benefit infrastructure

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	DELWP Coastal Programs, Victorian Auditor-General's Office
Measures:	Number of assets in coastal areas Built assets at risk of climate change (sea-level rise) impacts

Comments:

The condition of coastal assets and infrastructure is currently undergoing review. It is therefore difficult to fully assess their status.

Siting and design guidelines have been developed for coastal infrastructure which is likely to strengthen the resilience of any new construction. However, given the legacy of built assets currently sited along the coast, it is evident that climate change presents a clear threat to coastal and marine infrastructure through rising seas levels and more extreme weather events.

The trend assessment of stable recognises that although assets have been recently reviewed with a view to improving their condition, there is a clear threat to many of these assets due to climate change. Thus, levels of improvement are likely to be balanced by the loss or degradation of some coastal infrastructure in coming decades.

Theme 8: Communities

Indicator 72: Recreational boating infrastructure

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	Better Boating Victoria, DELWP, VEAC
Measures:	Boating infrastructure upgrades | Boating infrastructure with proximity to marine and coastal assets Climate change impacts on boating infrastructure

Comments:

With the establishment of the Better Boating Fund, there is a funding mechanism to enable upgrading of boating facilities along the Victorian Coast.

Investment is being undertaken to improve boating infrastructure across Victoria. Over time, the effectiveness of this program will be able to be tracked.

In some cases, the location of boat ramps is in proximity to significant protected areas (for example, RAMSAR sites or national parks) and this requires heightened attention being given to the management issues.

Nevertheless, coastal boating infrastructure remains under threat from climate change due to sea-level rise and increasing frequency of severe weather events. This is now being taken into consideration in new proposals dealing with boating infrastructure.

Government policy is encouraging expansion of boating and fishing. The impact of this increase will require mitigation efforts to minimise negative environmental, social or cultural impacts.

Indicator 73: Illegal activities

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	EPA, Maritime Safety Victoria, VFA, DELWP, Office of the Conservation Regulator
Measures:	Number of boating infringements | Number of fishing infringements Number of environmental infringements | Point source discharges – non-compliance

Comments:

Illegal activities affecting marine and coastal environments fall within the responsibility of many different agencies depending on whether they relate to fishing, boating, or environmental damage. It is therefore difficult to gain an overall picture of compliance or environmental impact even where data are available.

While good data are available for some illegal activities (for example for boating and fishing infringements) other compliance data are affected by when and where compliance activities are undertaken. Hence, they may provide an incomplete picture of the character and prevalence of illegal activities.

An important factor in achieving compliance is the role of engagement and education. Parks Victoria found that rules affecting marine national parks and sanctuaries are not always understood by visitors. This finding suggests the need for further communication and engagement with users to explain, not only the existence of these rules, but the purpose behind them.

Theme 9: Stewardship and collaborative management

Indicator 74: Stewardship

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		?			N/A	N/A

Data source:	DELWP
Measures:	Marine and Coastal Stewardship Index (comprising: environmental objectives, effort, outcome, accountability and adaptive management)

Comments:

Many policies and on-ground activities represent actions of stewardship however measurement protocols have been limited to date.

Although defining and measuring stewardship is difficult there has been recent progress through the development of a stewardship index by DELWP.

Although it is too early to measure trends using this index, benchmark data are starting to be collected for Port Phillip Bay programs and this should provide a model for future data collection and indicator assessment.

At a more disaggregated level, stewardship activities can also be assessed through measures provided for Indicator 76: Community connection to the coast, Indicator 77: Volunteering, and Indicator 78: Citizen science.

Indicator 75: Community connection to the coast

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		→			N/A	N/A

Data source:	Ipsos Marine and Coastal Community Attitudes and Behaviour Report, VFA Creel Surveys
Measures:	Values held in relation to marine and coastal environment; Reasons for involvement in coastal activities like fishing

Comments:

Surveys provide clear evidence that many Victorians value marine and coastal areas. This suggests a strong sense of connection with such environments.

Australia has long had coastal environments as part of its cultural heritage – both for Indigenous and non-Indigenous Australians.

One challenge this raises is how to maintain important cultural aspects of the ocean or beach experience while protecting coastal and marine environments from being 'loved to death'.

Theme 9: Stewardship and collaborative management

Indicator 76: Volunteering

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	ABS, DELWP, Parks Victoria
Measures:	Participation

Comments:

There are many committed volunteer groups that contribute to protecting, conserving and improving marine and coastal environments.

However, less than 6% of Australians who volunteer are involved in environmental activities. There is an opportunity to draw from the broader community to increase the number of environmental volunteers.

Maintaining and attracting volunteers is challenging in the modern era due to competing demands on peoples' time and changing lifestyles and expectations.

Indicator 77: Citizen science

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	DELWP, Parks Victoria, VFA, VNPA, Tangaroa Blue Foundation, Estuary Watch, RedMap, Atlas of Living Australia.
Measures:	Citizen science participation | Citizen science coastal programs.

Comments:

Citizen scientists have been involved in marine and coastal programs, even during COVID-19 lockdowns when virtual projects enabled seal counts (via webcam) and other activities to continue.

While there can be challenges in ensuring scientific rigour, there are models available such as ReefWatch (with photo identification of species required) Sea Search (with supervision from park rangers and photo identification of species) or Redmap (with expert coordinators) which provide examples of how rigour can be achieved and maintained.

Nevertheless, ensuring rigorous citizen science is not costless and funding is required to support coordination, equipment, communications and web platforms to be maintained.

Current development of a citizen science framework for Victoria is a promising development that can help address some of these requirements and challenges in order to expand citizen science activities.

Theme 9: Stewardship and collaborative management

Indicator 78: Planning and implementation

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	N	N	N	●	N/A	N/A
Data source:	VEAC, GeoScience Australia, DELWP					
Measures:	Effectiveness of marine and coastal plans and policies					

Comments:

Policy frameworks affecting marine and coastal planning may operate at international, national or state levels. Those involved in local marine and coastal management may be from local government, CMAs, not-for-profit entities and. This makes a single assessment of 'planning and implementation' unrealistic. This section therefore takes a narrative approach to explore Victoria's marine and coastal planning regimes and implementation strategies.

In the past, Victoria's marine and coastal planning and policy arrangements have been criticised for being overly complex and multi-layered, thus limiting policy coherence.

The introduction of the Marine and Coastal Act 2018 and the subsequent Marine and Coastal Policy 2020 have helped to streamline and clarify aspects of coastal policy. The identification and documentation of various legislation and policies relevant to Victoria's marine and coastal environments has provided a level of coherence.

Victoria's first Marine Spatial Planning Framework is currently being developed as part of the Marine and Coastal Policy 2020. This is intended to provide overarching guidance and a process for achieving integrated and coordinated planning and management of the marine environment.

Inventories and assessments by the Victorian Environmental Assessment Council have also contributed to valuable benchmark data from which planning and implementation can be undertaken.

However, marine and coastal planning remains a somewhat crowded and contested space suggesting that ongoing monitoring and assessment will be important to maintain the benefits of recent work. In particular, the effectiveness of recent initiatives will be important to evaluate over time so that a process of continuous improvement and sustained clarity and coherence can be achieved.

One way of assessing the effectiveness of policies is through community surveys such as those done by Parks Victoria for the system of marine parks which they manage. The parks are perceived by a majority of Victorians as successful. Importantly, this success is evident across a number of environmental, social and economic criteria, suggesting that sustainability objectives which aim to balance the interests of different users while protecting the environment are being achieved.

Theme 9: Stewardship and collaborative management

Indicator 79: Committees and councils

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	N	N	N	●	N/A	N/A
Data source:	VEAC, VAGO, DELWP					
Measures:	Area managed by coastal CoMs | Effectiveness of coastal CoMs					

Comments:

Policy frameworks affecting marine and coastal planning may operate at international, national or state levels. Those involved in local marine and coastal management may be from local government, catchment management authorities, not-for-profit entities and. This makes a single assessment of 'planning and implementation' unrealistic. This section therefore takes a narrative approach to explore Victoria's marine and coastal planning regimes and implementation strategies.

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Theme 9: Stewardship and collaborative management

Indicator 80: Institutional knowledge and capacity

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide		?			N/A	N/A

Data source:	N/A
Measures:	Number of applied scientists employed by marine and coastal management agencies Government funding for marine and coastal research or monitoring projects in Victoria

Comments:

Knowledge and capacity are acknowledged as critical for effective environmental policy.

Following findings from the State of the Bays 2016 Report, Victoria has put in place the MACKF to support the knowledge needs of planning for Victoria's marine and coastal areas. One outcome has been CoastKit – an online system for marine and coastal spatial data. While the development of data systems for marine and coastal management is welcome, analysis of what the data tell us and the degree to which such intelligence is being used in decision-making is still unclear and unable to be fully assessed yet.

At the aggregate level, a meaningful assessment of institutional knowledge and capacity is unrealistic because of the large number, variety and complexity of institutions which have responsibilities for marine and coastal management.

Measures which aim to capture educational qualifications or skill levels within organisations are not suitable for judging the qualitative aspects of how such knowledge and skills are being applied.

Although assumptions about the positive role of funding on institutional capacity make intuitive sense, there are issues in trying to measure this quantitatively. This is partly because of the complexity of unravelling public funding streams but also because of causal ambiguities in assessing capacity. Qualitative approaches may prove more reliable for future assessments.

Theme 9: Stewardship and collaborative management

Indicator 81: Engagement and inclusiveness

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide	N	N	N	●	N/A	N/A
Data source:	Engage Victoria					
Measures:	Engagement processes undertaken for marine and coastal policies | Environmental justice					

Comments:

Engagement processes are increasingly documented as part of policy development. Evaluation of engagement processes is sometimes undertaken and can provide a good basis for continuous improvement.

Different parts of government and different professions may take a different approach to engagement and this can make a single assessment of engagement processes difficult.

Because engagement processes are undertaken by different agencies for many different policies affecting marine and coastal planning, a single assessment of 'engagement and inclusiveness' is unrealistic. This section therefore takes a narrative approach to explore engagement and inclusiveness more broadly.

The impacts of environmental degradation may disproportionally affect certain groups within society (such as the elderly or the poor) and may also have varying spatial outcomes. The impacts of climate change along Victoria's coastline may be similar in terms of physical effects but coastal communities vary greatly in their capacity to respond. Environmental policies themselves may have disproportionate effects across different populations, for example, transition to a low-carbon economy can mean increased energy prices which has a greater impact on those with low incomes.

Theme 9: Stewardship and collaborative management

Indicator 82: Delivery and accountability

Region	2021 status	2021 trend	2021 data	2018 status	2018 trend	2018 data
Statewide						

Data source:	Parks Victoria, Victorian Auditor-General's Office
Measures:	Effectiveness of delivery

Comments:

Delivery and accountability are essential for any policy or program. Although delivery is often reported through corporate annual reporting processes, the evaluation of policy effectiveness is more difficult to determine.

Policy effectiveness has been assessed by Parks Victoria, based on the expert judgement of land managers. While such assessment might be criticised for being subject to subjective bias of individuals, or institutional pressures for favourable judgements, it nevertheless provides valuable insights that are generally unavailable.

Victoria has a number of systems to ensure accountability for government performance and spending. Government inquiries such as the Review of the Environmental Protection Authority are one example. The Victorian Auditor-General's Office also reviews the effectiveness of government activity and spending on behalf of the Victorian community.

The existence of these systems of accountability has led to an assessment of good for this indicator, while the improving trend reflects departments' efforts to develop monitoring and evaluation systems that also report on policy effectiveness.

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Appendix D

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Appendix D

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