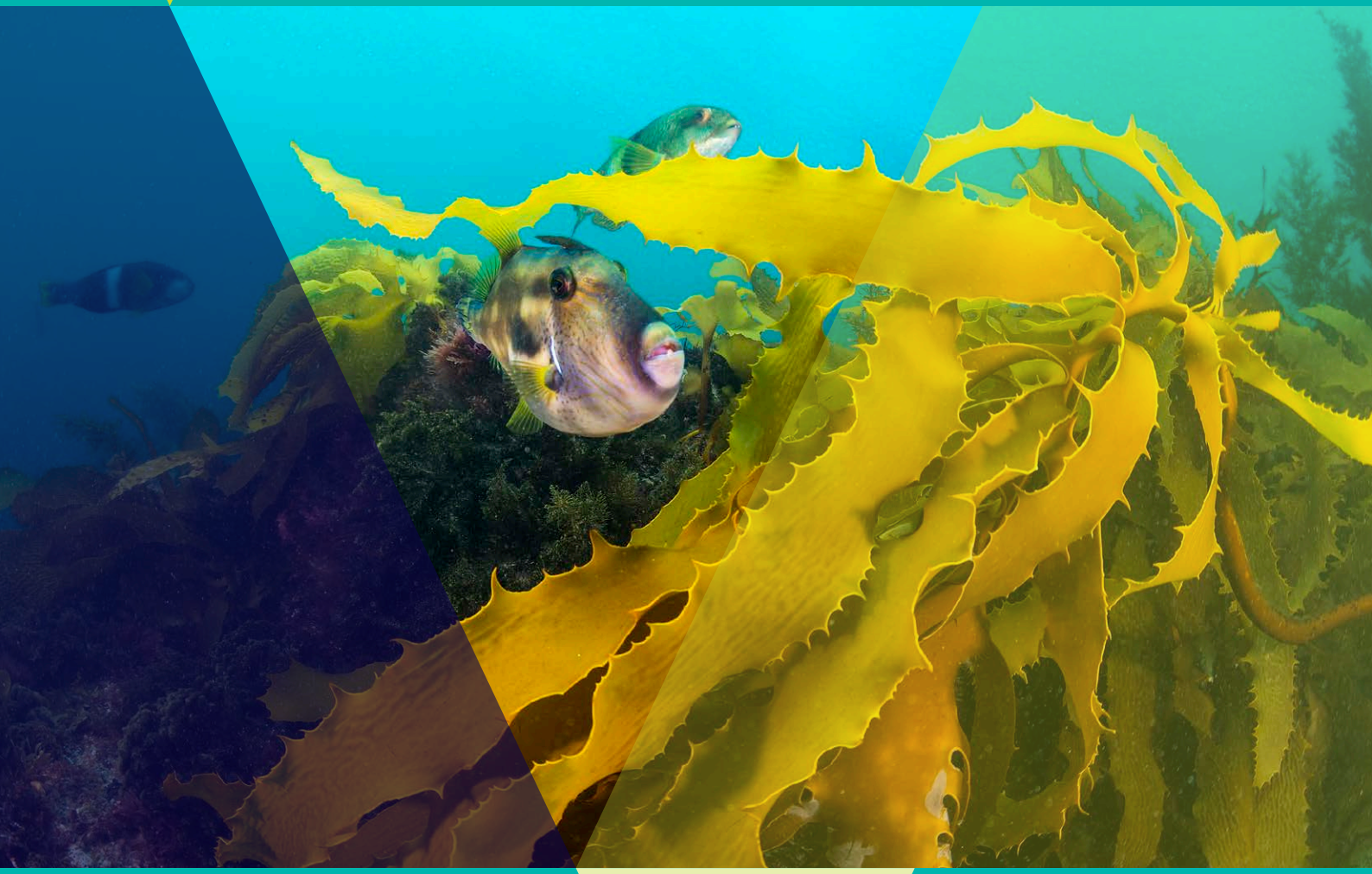
Port Phillip Bay Environmental Management Plan 2017–2027

Supporting Document



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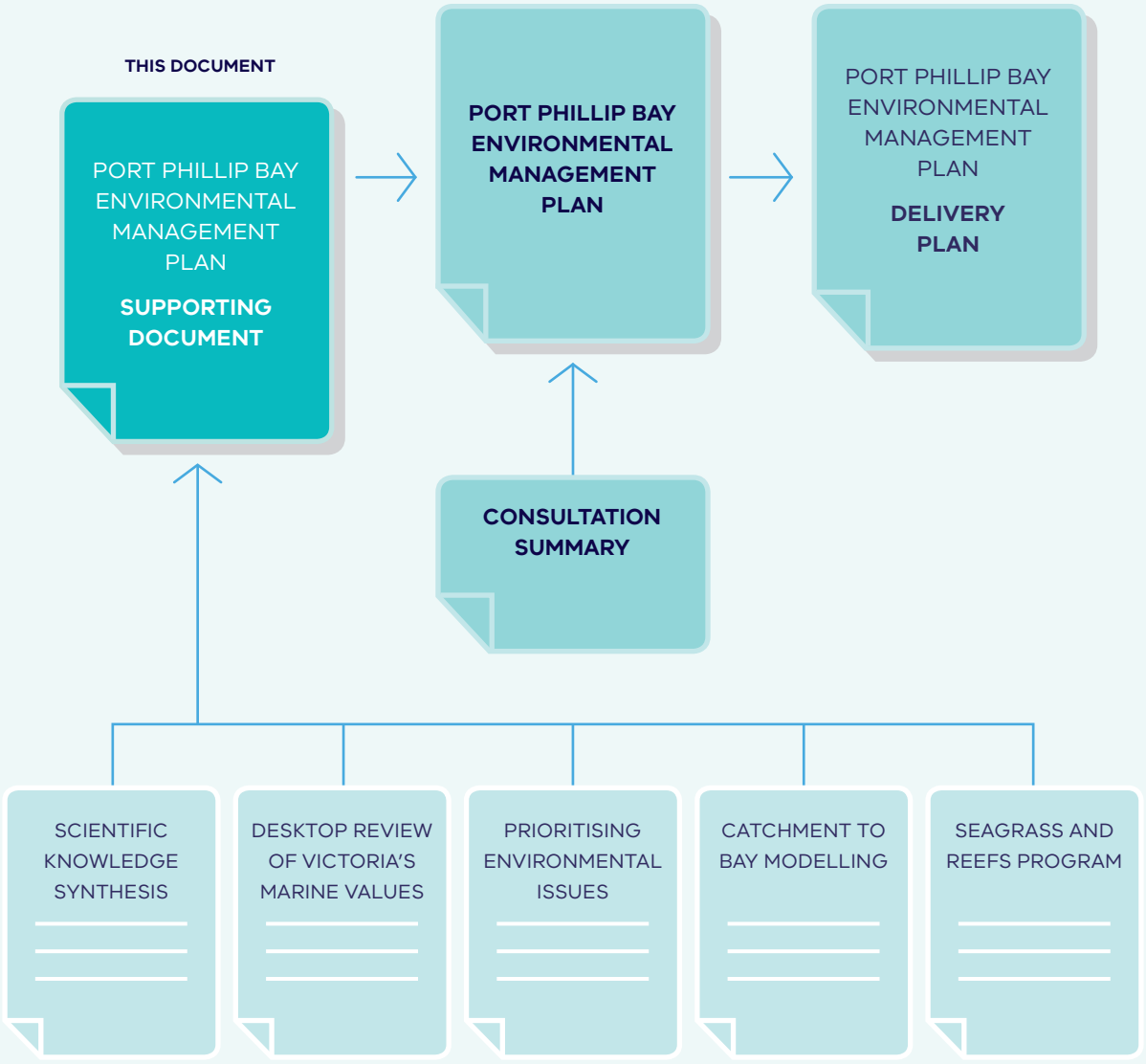

Cover: Leatherjacket (*Meuschenia freycineti*), amongst kelp at Pope's Eye, Port Phillip Bay Marine National Park. Photo – Gary Bell/OceanwideImages.com

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Giant Spider Crabs (*Leptomithrax gaimardii*) at Rye Pier. Photo – David Reinhard

1 Introduction

The Victorian Government is delivering on its commitment to protect and enhance the health of Victoria's marine and coastal environments by developing a new Environmental Management Plan for Port Phillip Bay.

The Plan, as required under the *State Environment Protection Policy (Waters of Victoria) Schedule F6 Waters of Port Phillip Bay (1997)*, presents a framework for the protection and enhancement of beneficial uses of the Bay.

The approach for developing the Plan was to establish the long-term vision for the Bay, and then use scientific knowledge and community and stakeholders' understanding of the Bay to identify a series of goals, priority areas and actions that will drive a coordinated effort over the next 10 years (Figure 1).

Development of the Plan has been informed by input and advice from government and industry through a project reference group, key stakeholders through targeted engagement, and the broader community through public consultation.

The Plan has also been informed by investigations on the values of the Bay and threats to these values. These have included targeted scientific investigations, complementary government projects and other activities such as a review of the achievements and learnings from the previous environmental management plan ('2001 Plan'), a review of policies and programs, and an assessment of the economic benefits provided by the Bay and how these may change in the future. A summary of the key documents that have informed development of the Plan are provided in Table 1.

This Supporting Document collates information from the background investigations and community and stakeholder engagement, and provides context to the management framework (the Plan). This document describes the Bay, its physical and ecological functions; the value and challenges to consider; and the current context for environmental management. It also provides details concerning the Plan's priority areas, highlighting key points from background investigations and other complementary programs and investigations.

Key principles guiding the development of the Plan

The development of the Plan has been guided by the key principles outlined in the Victorian biodiversity plan, *Protecting Victoria's Environment – Biodiversity 2037*, and those in the *Water for Victoria* plan.

In developing the Plan it is recognised that:

- The Bay is in good health and supports a range of environmental, social and economic values.
- The Bay will be affected by future pressures such as climate change and population growth, and we need to plan and manage for a resilient Bay and work towards long-term sustainability.
- We need to recognise and build on past achievements made by the community, industry and government within the catchment and Bay to enhance values.
- We need to work collectively to:
  - Address legacy and future impacts affecting the health of the Bay.
  - Engage citizens and communities in decisions that affect the health of the Bay.
  - Align outcomes.
- We need to recognise and manage for Traditional Owner values and entitlements.
- We need to demonstrate to the community that water quality management systems are effective in protecting and enhancing the values and uses of the Bay.

Table 1 Background investigations completed for the Plan

Desktop review of Victoria's Marine values (Hale and Brooks 2015)	Identified and collated information on values (particularly relating to the *State Environment Protection Policy (Waters of Victoria) (SEPP) Schedule F6 Waters of Port Phillip Bay (1997)* beneficial uses) in Victoria's marine environment including Port Phillip Bay.
Prioritising Environmental Issues (Hale and Brooks 2016)	Identified pressures and stressors that pose the greatest risk to the Bay's health and its beneficial uses, and assessed priorities for further investigation and management.
Science Knowledge Synthesis (Barbee *et al.* 2016)	Collated current scientific knowledge on the status of nitrogen cycling, marine pests and pollutants in the Bay as a basis for developing management actions.
Catchment to Bay model (Jacobs and HydroNumerics 2015a, b)	A catchment to bay model was built to assess the risk to water quality in the Bay from increased loads of nitrogen, sediments and pathogens. Scenarios were modelled to analyse outcomes for a broad range of management options under future environmental conditions (climate change and population projections out to 2030 and 2050).
Community and stakeholder consultation (DELWP 2017)	Summarises stakeholder and community consultation over the past 2½ years, showing involvement of stakeholders throughout the Plan's development, and highlighting two rounds of public consultation where the community helped to shape and refine the Plan.
Seagrass and Reefs Program (Jenkins *et al.* 2015, and Johnson *et al.* 2015)	The Seagrass and Reefs Program, completed in 2015, included research to better understand ecological processes for seagrass and temperate reef habitat in the Bay.

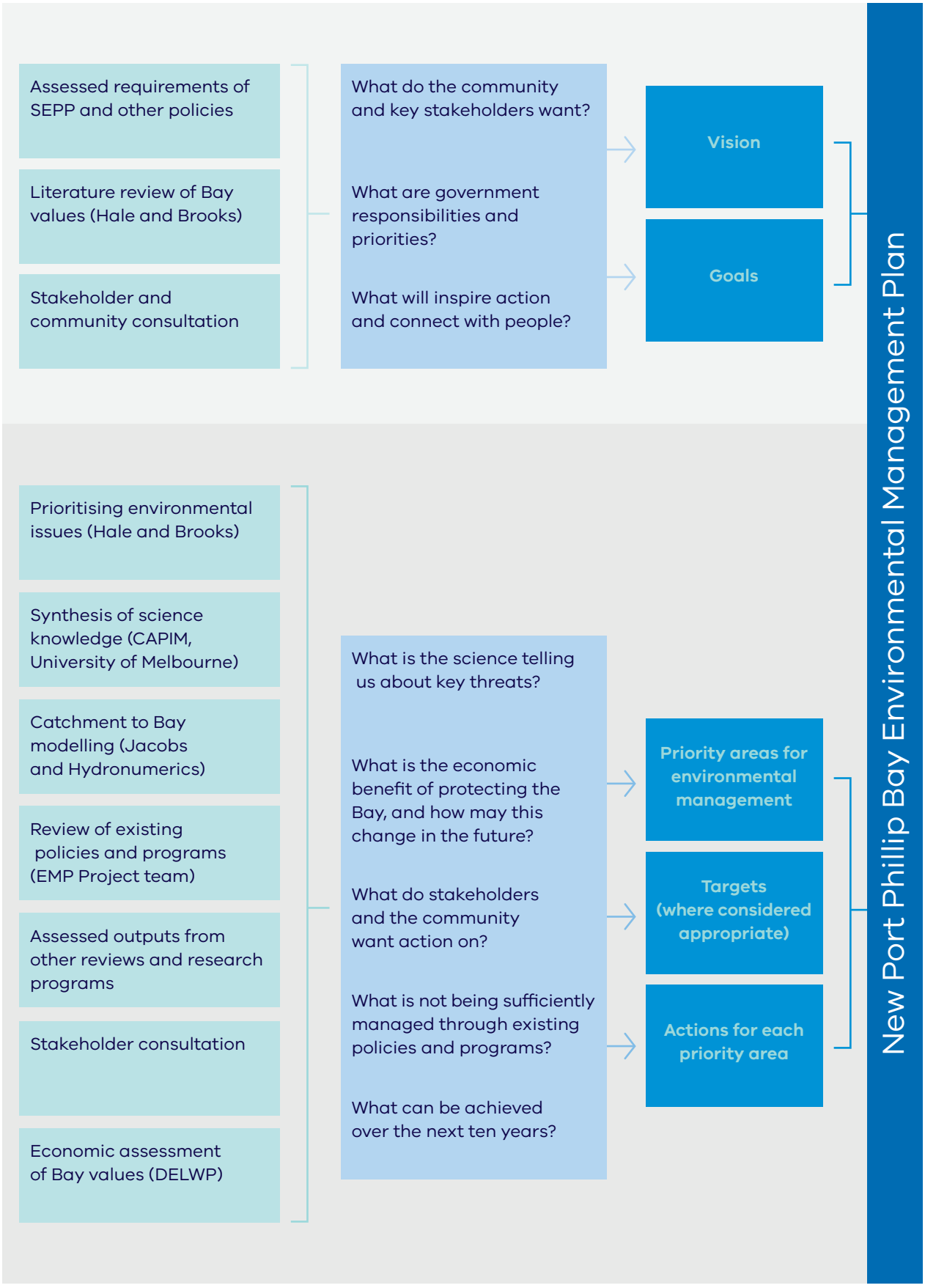


Figure 1 Process for developing the Environmental Management Plan

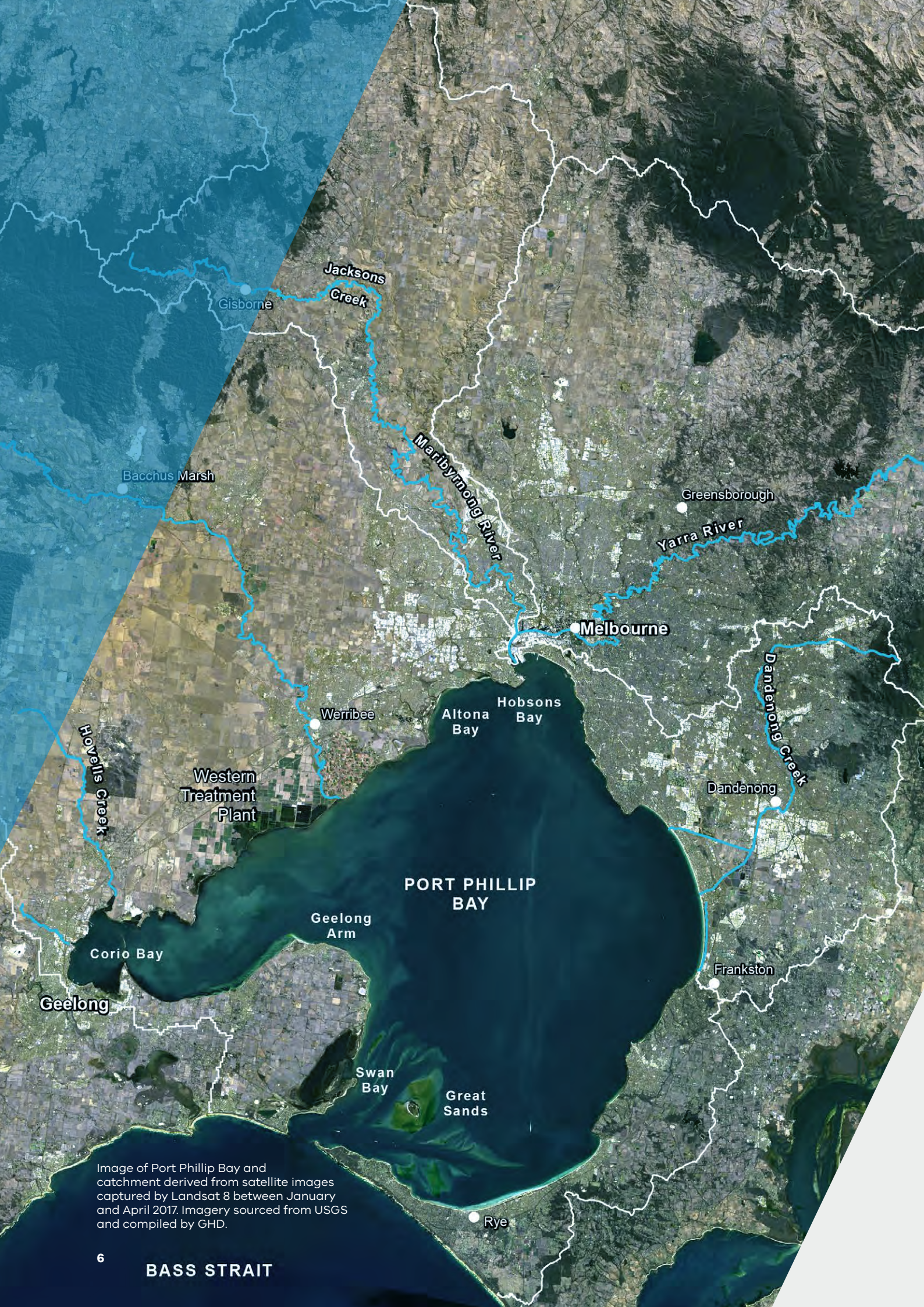


Image of Port Phillip Bay and catchment derived from satellite images captured by Landsat 8 between January and April 2017. Imagery sourced from USGS and compiled by GHD.

2

Port Phillip Bay

Port Phillip Bay, called Nairm in the language of the Traditional Owners, was formed some 8000 years ago when rising sea levels at the end of the last ice age resulted in flooding of the delta of the Yarra and Werribee rivers. Prior to flooding from the sea, the wide expanses of the plains had been inhabited by Aboriginal communities for over 30,000 years. There remain many Aboriginal cultural heritage landscapes and places of significance recorded around the Bay (Rhodes 2007). In more recent times the ecology of the Bay has been greatly modified by human activity, especially in the last 150 years following European settlement (Edmunds *et al., 2006*).

The Bay is the largest marine embayment in Victoria. It covers an area of approximately 1930 square kilometres, has a coastline of 333 kilometres and a catchment area of close to 10,000 square kilometres. The Bay's catchment is a mix of urban (32%), rural (46%) and forested (21%) land uses (Jacobs and HydroNumerics 2015a). The Bay incorporates many smaller bays, sounds, bights, coves and inlets (such as Hobsons Bay and Corio Bay), which are all considered parts of the larger Port Phillip Bay. The Bay and its catchment are shown in Figure 2.

The Bay is semi-enclosed, with a narrow entrance (approximately 3.2 kilometres wide) at Port Phillip Heads. The narrow entrance limits water exchange between the Bay and Bass Strait and is significant to the way the Bay functions. The central basin is enclosed by sandy shoals (the Great Sands), beaches and fringing reefs.

Figure 2 Port Phillip Bay and catchment

The maximum depth in the Bay is 24 metres, but average depth is just 13 metres, with more than half the Bay shallower than 8 metres. Wind-driven currents are the primary source of vertical and horizontal mixing. This, together with the shallow depth, helps to ensure the Bay is well aerated (Harris *et al.* 1996).

Movement of water within the Bay is important for dispersing inputs from the catchments, including freshwater, nutrients and sediments. However, mixing and dispersal efficiency varies across the Bay. Areas nearer to the shore and in bays, such as Hobsons Bay and Corio Bay, have limited mixing. This affects the ability to process catchment runoff and waste discharges, which results in these parts of the Bay being more impacted by poor water quality.

The Bay supports Victoria's largest commercial ports. The Port of Melbourne is Australia's busiest container port, handling approximately 36% of national container trade, and around 3000 ship visits per annum (Port of Melbourne Corporation 2015). The Port of Geelong is Victoria's largest regional port and its most important bulk commodities port.

In 2014/15 the Port of Geelong managed a gross tonnage of 14.5 million and 639 ship visits (Victorian Regional Channels Authority 2015).

A conceptual model of the Bay and its processes is shown in Figure 3. It illustrates the complexity of the Bay's features, values, threats and processes that need to be considered in developing the Plan.

VALUES

Port Phillip Bay provides a range of benefits to the community. These include:

- Recreation
- Tourism
- Aquaculture
- Wetlands
- Biodiversity
- Recreational Fishing
- Commercial Fishing
- Reef Habitat
- Seagrass Habitat
- Iconic Species
- Shipping/Navigation

THREATS/ISSUES

The functioning of the system could be compromised by a number of threats and issues:

Pollution Chemicals, pathogens, litter and nutrients from urban, industrial and agricultural sources (including stormwater and wastewater discharges) contribute to reducing water quality

Sea Level Rise Increase in sea levels due to climate change may significantly affect hydrodynamics and coastal processes

Flooding Flooding and seawater intrusion can occur due to increased intensity of rainfall and sea level rise

Algal Blooms Algal blooms in nearshore waters have serious impacts on commercial and recreation activities

Hypoxia Low oxygen in bottom waters due to consumption of oxygen by algae affects marine life

Marine Pests Invasive species may out-compete native species for resources. Pests may be introduced as a result of biofouling and ballast water discharge.

PROCESSES

The Bay environment is controlled by a number of physical, chemical and biological processes:

Catchment Runoff/River Inflows deliver nutrients, pollutants and sediment to the Bay

Tidal Saline Water Exchange Seawater enters the system from Bass Strait

Sediment Resuspension, Erosion and Deposition Sediment is resuspended by water currents, wind and waves. This leads to increased turbidity and smothering

Thermodynamics/Evaporation Heating of the water surface leads to evaporation and increased salinity

Mixing Mixing of the water column is driven by wind and tidal generated currents

Atmospheric Exchange Oxygen, nitrogen and other chemicals are exchanged across the air water interface

Denitrification Nitrate is released from the system as gas due to microbial processes in the sediment

Benthic Algae Algal growth impacts on a range of sediment processes in the Bay

Climate Change A warming climate leads to higher sea levels, more frequent and intense storm events (with accompanying storm surges and rainfall), and higher water temperatures.

Symbols courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/).

Figure 3 Conceptual model of Bay values, threats and processes (adapted from EPA)

Catchment inflows

The Bay receives freshwater inflows from two main sources: the Yarra River (with its major tributary the Maribyrnong River) and the Western Treatment Plant. There are also hundreds of stormwater drains that discharge directly to the Bay during and immediately after rainfall events. Other stormwater drains discharge into the rivers and creeks across the catchment, which then discharge to the Bay. With the exception of the Western Treatment Plant, a large proportion of the inflows to the Bay occur following rainfall events in the catchment.

The volume and quality of inflowing waters is dependent on a range of factors, but principally land use and rainfall. Across the catchment there is significant variation in average annual rainfall, with catchments to the east of Melbourne being wetter than those to the north and west (Figure 4 from Jacobs and HydroNumerics 2015a).

Stormwater runoff, particularly from urban areas, is a threat to the values in waterways and the Bay, and to public health, because it carries sediments, nutrients, toxicants, pathogens and litter into the Bay (Melbourne Water 2013).

Figure 5 shows annual flow volumes since July 1990 for the Yarra River, together with annual rainfall for the corresponding period. The graph highlights the variation in annual rainfall across the past 25 years and shows the strong correlation between the amount of rainfall and flows, including runoff. This means that loads of nutrients and other pollutants entering the Bay are highly dependent on rainfall, and will vary significantly between wet and dry years.

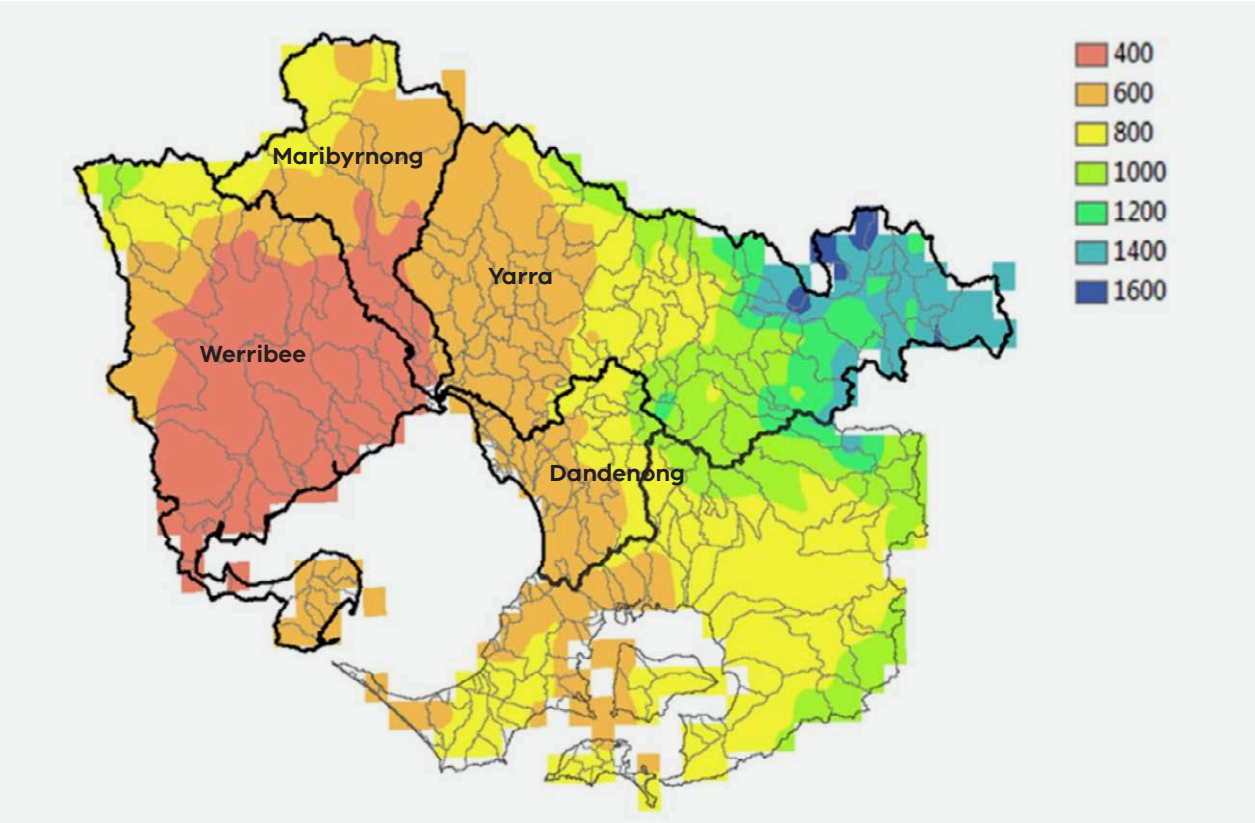


Figure 4 Mean annual rainfall (mm) (1970-2015) for Port Phillip Bay catchments

Yarra River plume after large rainfall event in February 2011. Photo – Fairfax Syndication

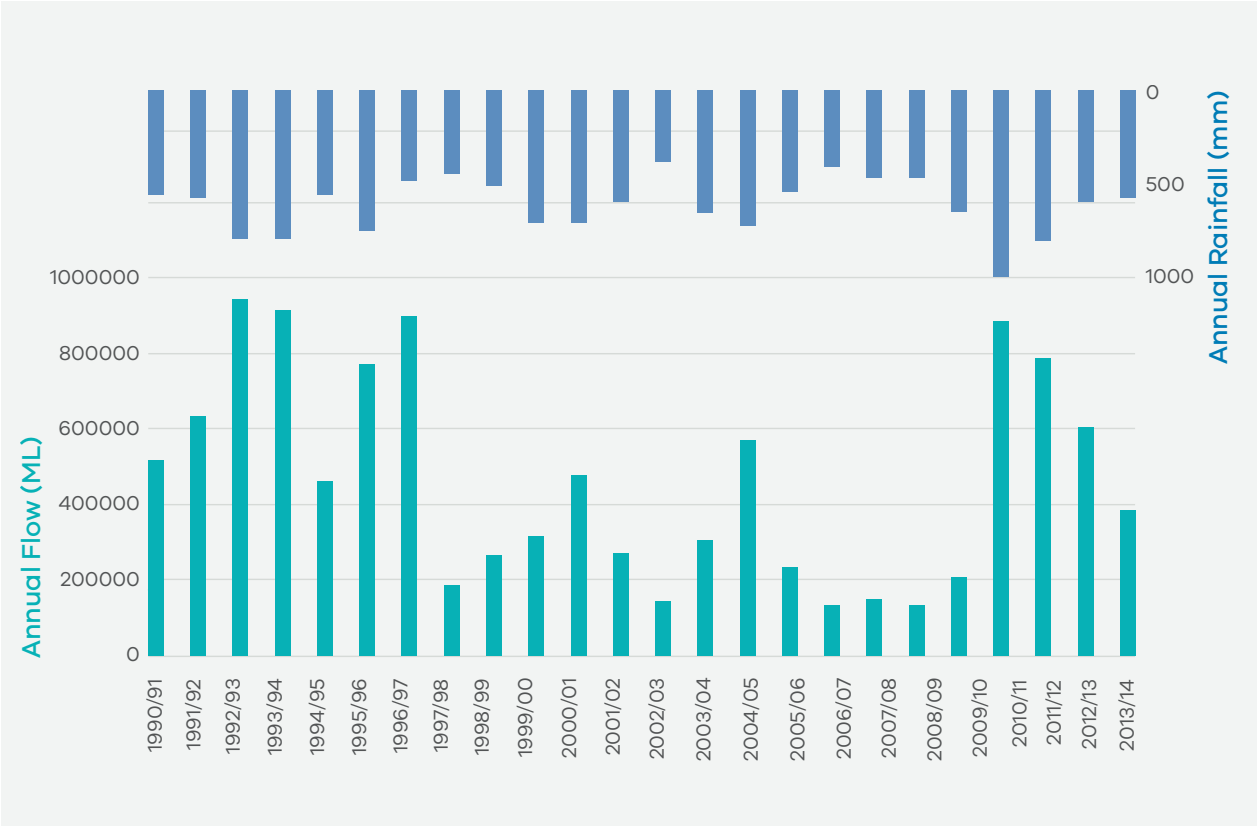


Figure 5 Annual rainfall for Melbourne (top) and annual flows (bottom) in the Yarra River measured at Chandler Highway, Kew

Nutrients, pollutants and denitrification

The nutrients nitrogen and phosphorus are essential building blocks for plant and animal growth. The amount of nitrogen that comes into the Bay controls how much plant growth can occur. The Bay is considered to be nitrogen limited because the amount of phosphorus available in the Bay is in excess of the amount needed for plant growth. When there is too much nitrogen the system is considered to be eutrophic, which results in excessive algal growth and persistent algal blooms.

Pollutants include sediments and toxicants, which are further classified to include heavy metals, pesticides, industrial chemicals and chemicals of emerging concern (such as endocrine-disrupting compounds, pharmaceuticals and personal care products). Higher loads of sediments can reduce the amount of light available for seagrass growth and may also smother nitrogen cycling bacteria living on the bottom of the Bay (which are crucial for a healthy functioning Bay). Sediments also carry toxicants into the Bay. Most toxicants are sediment-bound, and higher loads directly affect fish and invertebrates in inshore areas, as well as marine mammals and waterbirds (through the food chain).

As implied above, the Bay and its catchment are highly connected. Nutrients and pollutants can flow to the Bay from any part of the catchment via the drainage network. Up to 80% of the annual load of nutrients and sediments from the catchment is delivered via runoff during high flow storm events. Other freshwater inflows include wastewater discharges from treatment plants, and seepage of contaminated groundwater. Nutrients and pollutants are also conveyed to the Bay from atmospheric sources; however, these sources contribute only about 1% of the total loads to the Bay.

The *Port Phillip Bay Environmental Study* (Harris *et al.* 1996) found that most of the nitrogen entering the Bay is removed by a highly efficient microbial process (denitrification), which takes place on the sea bed. Maintaining the effectiveness of denitrification by limiting nitrogen loads to the Bay is important for maintaining a healthy marine ecosystem (Barbee *et al.* 2016).

Constructed wetlands are used to clean up stormwater and to reduce the discharge of nutrients, sediment and other pollutants to the Bay. Photo – Melbourne Water

The conceptual model of nutrient cycling in the Bay (Figure 6) is predicated on the following principles and observations (from Longmore 2014):

- Nutrient inputs stimulate plankton growth.
- Plankton growth is limited by the availability of nutrients, particularly nitrogen.
- Diatoms make up a significant proportion of the plankton, and settle to the seabed where they are decomposed by microbes.
- Microbial activity consumes oxygen and releases nutrients into the sediment and water column.
- Biogeochemical processes transport regenerated nitrogen between oxygen-rich and oxygen-poor zones in the sediment to facilitate sequential nitrification and denitrification.
- Denitrification is the key process limiting nitrogen availability and associated plant growth. It has high value as an ecosystem service because it leads to the net loss of nitrogen from the system, preventing long-lived algal blooms.

Key factors with the potential to affect denitrification include:

- Drivers for plankton growth (nutrient supply and physical conditions – light, temperature, salinity).
- Oxygen regime at the sediment surface.
- Mechanisms (e.g. bio-irrigation by infauna) that affect nutrient transport through the sediment.

Continued low to moderate levels of nitrogen inputs help to ensure that the marine ecosystem remains robust and able to support a diversity of plants and animals.

Estimated annual loads of total nitrogen to the Bay from 1996-97 to 2014-15 are shown in Figure 7. The largest contribution of nitrogen is from the Western Treatment Plant. The second largest contribution is from the Yarra Catchment, which carries runoff from urban and rural land. Runoff from the Werribee, Maribyrnong and Dandenong catchments also contributes significantly, but varies between years in response to flooding events (Jacobs and HydroNumerics 2015a).

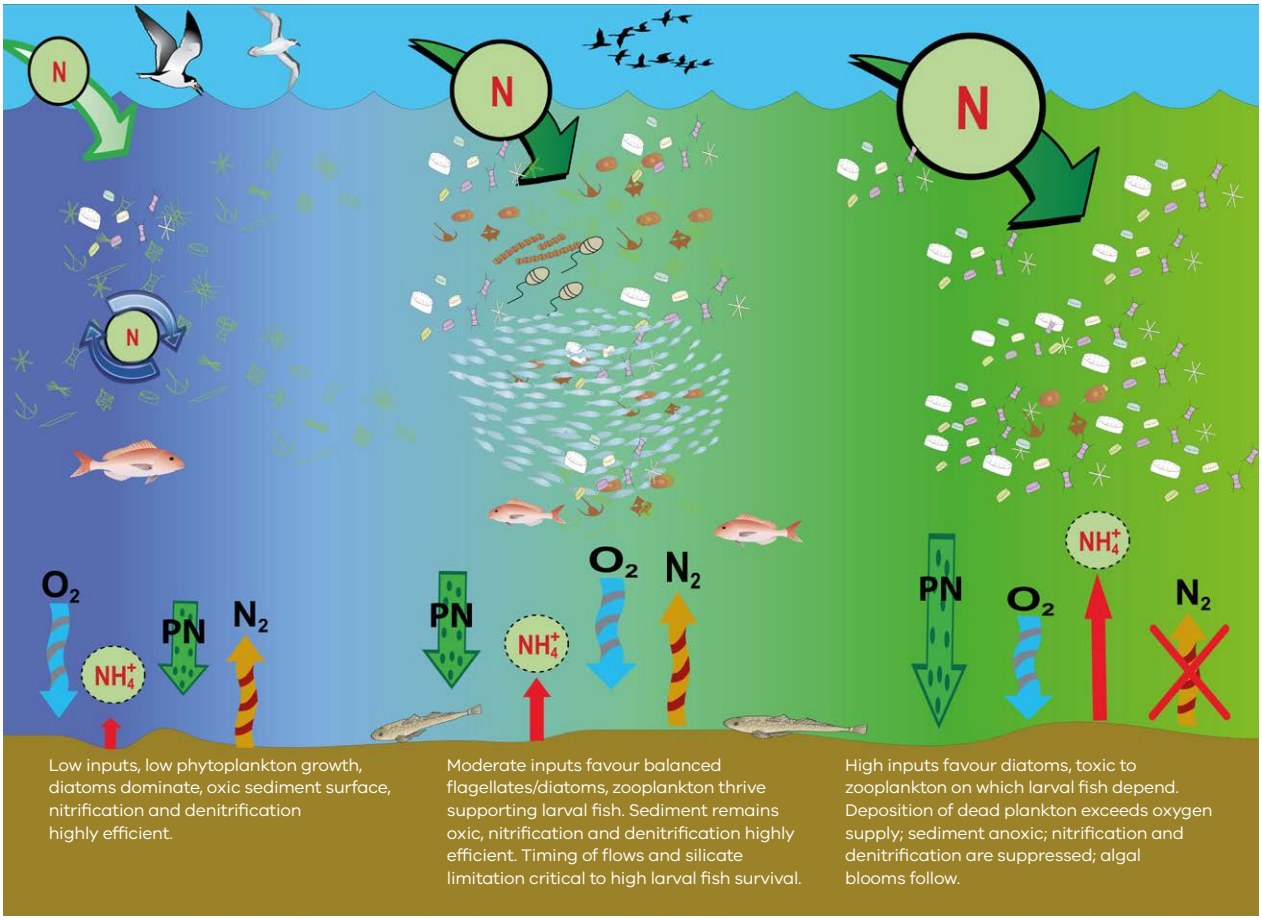


Figure 6 Conceptual model of the denitrification process in Port Phillip Bay under conditions of low, moderate and high inputs of nitrogen. Source: Andy Longmore, University of Melbourne.

In an initiative resulting from the 2001 Plan, the nitrogen cycling process has been monitored biannually at two sites in the Bay: Hobsons Bay and Bay Central (Longmore 2014). This monitoring has confirmed the continued efficiency of denitrification and the conceptual understanding of nitrogen cycling reported by Harris *et al.* (1996).

Integrated water quality modelling undertaken by Jacobs and HydroNumerics (2015a, b) verified the previous estimates for nitrogen loads to the Bay and the efficiency of the nitrogen cycling process that occurs within the Bay.

The science knowledge synthesis and modelling both found that denitrification is working well as a key process for nitrogen loss from the system across the Bay. Catchment modelling indicated that the bulk (about 60%) of the nitrogen load comes from the Western Treatment Plant, with the remainder from diffuse sources across the catchment. The Yarra catchment contributes the highest loads of all the regional catchments due to its larger area and higher rainfall. There were similar findings in the *Port Phillip Bay Environmental Study* (1996).

The science knowledge synthesis indicated that current inputs are having important localised, small-scale effects in areas close to the shore in the north and west of the Bay. However, further modelling and field work is required to confirm the scale of the threat to the Bay's health, and what role nitrogen inputs actually play in threatening that health.

The modelling identified that further upgrades to the Western Treatment Plant will offer the greatest potential to reduce nitrogen loads to the Bay, which in turn will lead to reduced algal productivity. However, there will be no significant reduction in sediments or pathogen loads, as the treatment plant has already reduced these to acceptable levels. By comparison, catchment management initiatives have significant potential to reduce nitrogen, sediments and pathogen loads, which will offer greater benefit to the health of near-shore waters.

The modelling also highlighted the need to consider management of the Bay on both a bay-wide and local scale to protect Bay values such as recreational use, visual amenity and seaweed covered reefs in near-shore waters.

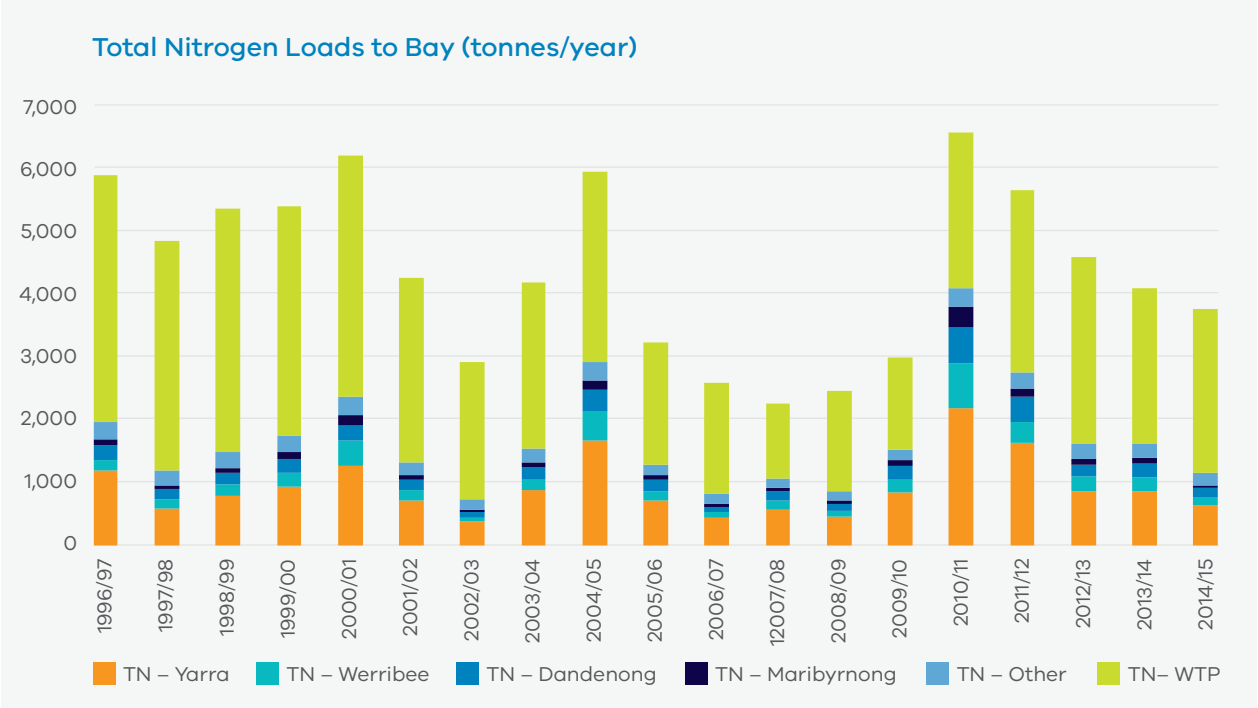


Figure 7 Estimated annual loads of total nitrogen (TN) based on catchment modelling. Loads for Werribee and Dandenong include contributions from smaller rivers and creeks that discharge directly to the Bay in those regions. 'Other', includes discharges from drains and minor waterways not included in the four major catchments/regions, direct discharge of groundwater and atmospheric deposition to the Bay.

Bay habitat

The Bay is home to a diverse array of marine plants and animals, with many of these species only found in southern Australia. More than 1300 species are documented in the Taxonomic Toolkit for Marine Life of Port Phillip (http://portphillipmarinelife.net.au).

The fauna of the Bay includes more than 300 species of fish and several hundred species of each of the following: molluscs (e.g. blue mussels, periwinkles and limpets), crustaceans (shrimp, crayfish, krill and barnacles), polychaetes (bristle worms), cnidarians (e.g. corals, jellyfish and sea anemones) and sponges (Harris *et al.* 1996). The Bay also supports populations of marine mammals including the Australian fur seal, and Common and Bottlenose dolphins. A number of whale species – including Humpback, Southern Right and Killer – are occasional visitors to the Bay, as are sea turtles. Various migratory bird species are also seasonal visitors to the Bay.

There are more than 20 plant and animal species found in the Bay that are listed as threatened under the *Victorian Flora and Fauna Guarantee Act 1988*. These include a number of birds, fish, mammals (including the Burrunan Dolphin), echinoderms, as well as one crustacean (Southern hooded shrimp, *Athanopsis australis*), one reptile (Leatherback turtle, *Dermochelys coriacea*), one mollusc (Chiton, *Bassethullia glypta*) and one plant (Sea water-mat, *Lepilaena marina*). These species are a mix of resident and transient species.

The generalised habitat map presented in Figure 8 draws together information from various datasets being compiled by Deakin University for the Department of Environment, Land, Water and Planning (DELWP).

Habitats include seagrass meadows, rocky intertidal and subtidal reefs, sponge gardens and unvegetated soft sediments. Plants found in the Bay include phytoplankton (single-celled algae that live in the water column and move with the currents), microphytobenthos (microscopic algae that live and form mats on the sea floor), seaweeds and seagrasses.

The marine community of the Port Phillip Bay Entrance Deep Canyon is located in a 100-metre deep canyon reef complex at the entrance of the Bay. It includes a diversity of sessile invertebrates, including more than 271 species of sponges, 115 of which are known only from the Port Phillip Heads (Edmunds *et al.* 2006). The Deep Canyon community is listed as threatened under the *Flora and Fauna Guarantee Act 1988*.

The Bay has four marine protected areas that were established as 'no take' areas in 2002. Port Phillip Heads Marine National Park comprises six separate sections (Point Lonsdale, Point Nepean, Popes Eye, Mud Island, Portsea Hole and Swan Bay) and covers an area of 3475 hectares.

Stingray at Ricketts Point Marine Sanctuary. Photo – Parks Victoria

There are also three marine sanctuaries in the Bay: Point Cooke (290 hectares), Jawbone (30 hectares) and Ricketts Point (115 hectares). These marine parks and sanctuaries have been established to protect representative examples of Victoria's unique and diverse marine environments, and the plants and animals they support.

There are two Ramsar-listed wetland sites in the Bay. The Port Phillip Bay (western shoreline) and Bellarine Peninsula Ramsar site is recognised for the quality of its natural wetlands and the large numbers of waterbirds that utilise its natural and constructed wetlands, particularly migratory shorebirds. Up to 50% of the critically endangered Orange-bellied parrot (*Neophema chrysogaster*) population utilises the site for winter feeding habitat, and it also provides an important drought refuge for waterbirds.

The other Ramsar site, the Edithvale-Seaford Wetlands on the east coast of the Bay, supports a rich diversity of Australian and migratory birds. These wetlands are the last remnants of the Carrum Carrum Swamp and assist with flood protection in the Dandenong catchment.

Artificial structures in the Bay are important for a number of species. Shipwrecks provide important habitat, and artificial reefs (located at Portarlington, Altona, Aspendale, Carrum, Seaford and Frankston) support recreational fishing. Rock walls and breakwaters provide homes for a variety of wildlife. For example, the St Kilda Breakwater is home to a colony of Little Penguins and Rakali (native water rats), and some of the old channel marker structures are used as haul-out sites for Australian fur seals.

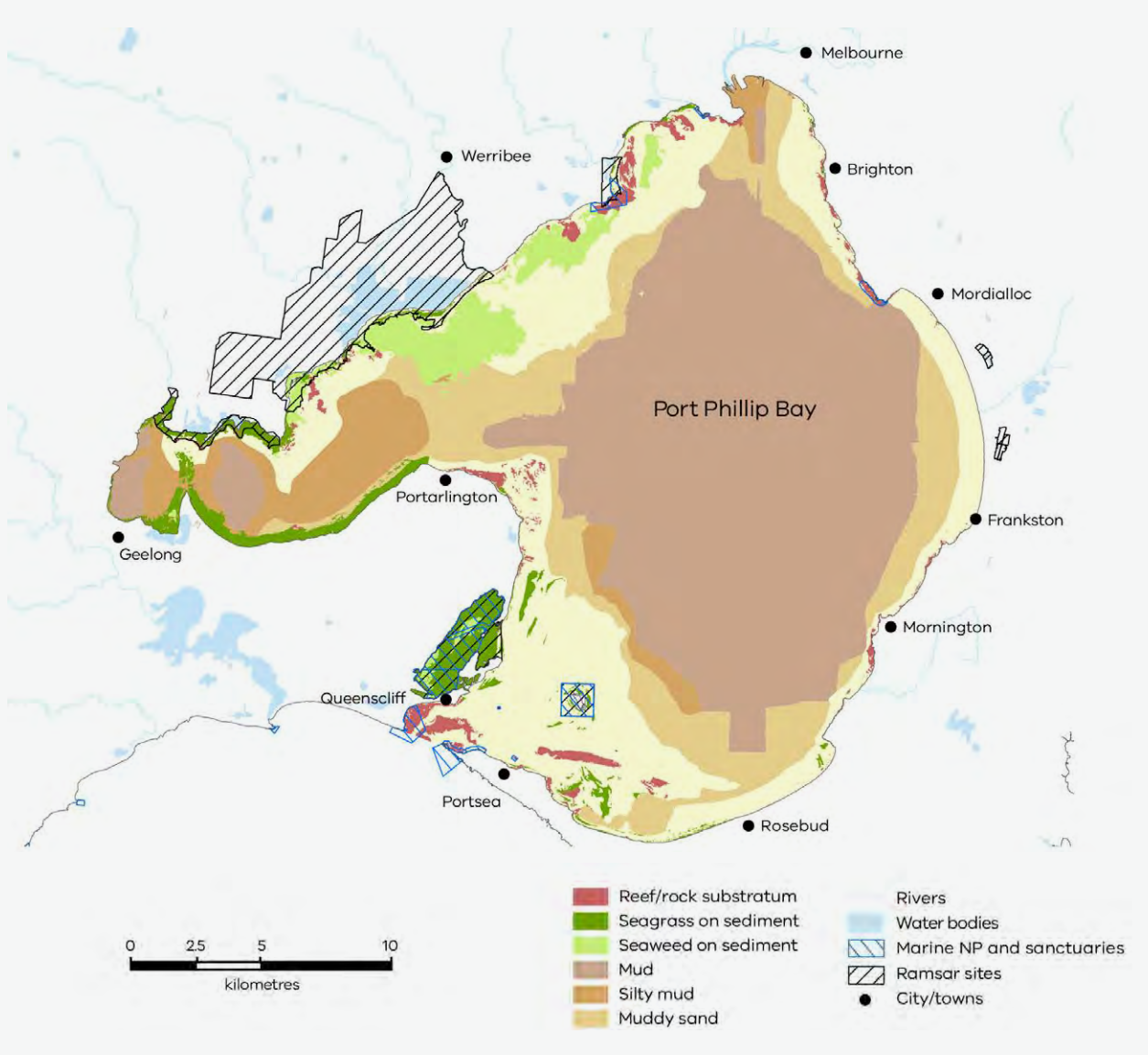


Figure 8 Port Phillip Bay habitat map

One of the Bay's resident Burrunan Dolphins, near Portsea. Photo – Troy Muir, Polperro Dolphin Swims

Current health of the Bay

Environmental monitoring indicates that the Bay continues to show good water quality that is safe for swimming and fishing, and supports a diverse range of marine life (DSE 2012, EPA 2012a, Hirst *et al* 2011, Hirst *et al.* 2012, Longmore 2014, Woods and Edmunds 2014).

The EPA has undertaken water quality monitoring monthly at eight sites across the Bay for the past 30 years. Standard parameters monitored include nutrients, water clarity, dissolved oxygen, salinity, algae (chlorophyll-a) and some monitoring of metals. Using this data, a Water Quality Index score is calculated for each site based on the level of attainment against the water quality objective.

The Water Quality Index scores show that average water quality in the Bay is good, with a general but small improvement since 2001. However, there are localised variations that reflect proximity to catchment inflows. Sites remote from these inflows and closer to The Heads have better water quality. While water quality in the western part of the Bay (Geelong Arm) is less frequently affected by stormwater, these areas can be impacted by wastewater discharge from the Western Treatment Plant.

Hobsons Bay, at the northern end of the Bay, is frequently affected by stormwater. Water quality there has varied between fair and good since 2001, with better water quality generally corresponding with periods of lower rainfall and stormwater runoff.

Pathogens are not included in the Water Quality Index. However, pathogen levels that indicate the potential risk of sickness are measured by the EPA at 36 beaches around the Bay throughout summer. During the 2016-17 summer, 97% of beaches around the Bay met end-of-season water quality objectives (as specified in *Schedule F6*) for swimming, with just one beach (Mordialloc) experiencing a higher number of days of poor water quality due to stormwater pollution issues. Similar patterns were observed in the 2015–16, 2014–15 and 2013–14 summers, with more than 90% of beaches meeting end-of-season objectives.

In previous summers (2011–12 and 2012–13), when higher rainfall events washed greater quantities of pollutants into the Bay, the number of beaches that met these objectives dropped below 60%.

It is important to note that monitoring and reporting on the Bay's health to date have been focused on understanding traditional water quality issues. There are other aspects of Bay health that have received less attention, such as assessments of litter and the condition of marine life and habitat. The Plan and the *State of the Bays* report will address these gaps in understanding.

Australasian Snapper (*Pagrus auratus*) at Ricketts Point. Photo – David Reinhard

Values and challenges

3

The Bay provides and supports a wide range of uses, functions and features that have great social, economic and environmental importance. For the purposes of the Plan, we refer to these collectively as values.

During development of the Plan, a list of marine values for the Bay was identified through a *Desktop Review of Victoria's Marine Values* (Hale and Brooks 2015). These marine values were adjusted to align with beneficial uses as defined in the *SEPP* (*Waters of Victoria*). The resulting list of values, along with the broader benefits to which they contribute, are shown in Table 2.

Female Pot Belly Seahorse *(Hippocampus abdominalis)* at Rye. Photo – Josie Jones

Table 2 Marine values considered in developing the Plan

Value	Description
Primary contact recreation	This relates to people being in direct contact with, or immersed in, the water. This includes activities such as swimming, water-play and diving. Primary contact rates are significantly higher over the summer period.
Secondary contact recreation	This relates to people being in close contact with the water or water spray. This includes activities such as boating, kayaking and sailing. Boat ramps, marinas and jetties, which provide access to the Bay for fishing and sight-seeing, facilitate secondary contact.
Aesthetic enjoyment	Aesthetic enjoyment of the Bay is associated with the emotional enjoyment derived from vistas of the open water and coastal habitats. Beneficiaries include people who view the Bay from their offices, apartments and houses, as well as from cafes, restaurants and other locations around the Bay.
Aquaculture	There are seven aquaculture fisheries reserves in the Bay that produce around 800–900 tonnes of mussels a year (DPI 2012). In addition there are onshore abalone farms that circulate water to and from the Bay.
Commercial fishing	Commercial fishing in the Bay includes the use of longlines, nets and other authorised gear types, with target species including snapper, King George whiting, flathead, squid and pilchards. The Bay also supports commercial diving for abalone, scallops and sea urchins.
Recreational fishing	Recreational fishing is popular and includes fishing from the shore, jetties and boats. Popular species for anglers include: Australian salmon, bream, flathead, garfish, King George whiting, leatherjacket, silver trevally, snapper, squid and yellow-eye mullet.
Seagrass	Seagrass in the Bay is predominantly *Zostera nigricaulis* and *Zostera muelleri* with smaller areas of *Halophila australis* and *Amphibolis antarctica*. Most of the seagrass (*Zostera spp.*) is located in the south and west of the Bay (Corio, Bay, Swan Bay, Mud Islands and Mornington Peninsula) in waters less than seven metres deep (Ball *et al.* 2014).
Intertidal and subtidal flats	This habitat includes the non-vegetated sands, silts and mudflats that occur in the shallow areas of the Bay. It supports productive microphytobenthos and benthic invertebrate communities (Poore and Rainer 1979, Beardall and Light 1997).
Intertidal and subtidal reefs	The Bay contains diverse intertidal and subtidal rocky reef habitats. These include shallow habitats in the north and south of the Bay as well as the deep reef habitats at the entrance. They support a diversity of macro-algae, sponges, invertebrates and fish (Hart *et al.* 2005, Woods *et al.* 2013, Woods and Edmunds 2014).
Saltmarsh and mangroves	There is more than 1800 hectares of saltmarsh and about six hectares of mangrove around the Bay, which provides important habitat for marine invertebrates and waterbirds. Key locations include Swan Bay and the Geelong Arm and Werribee coastal regions (Boon *et al.* 2011).
Fish	The Bay supports a diverse range of fish apart from those sought by anglers, including the Weedy Seadragon.
Waterbirds	More than 130 species of waterbirds – including seabirds, shorebirds and Little penguins, as well as ducks and large waders – have been recorded within the Bay (Hale 2012). Forty-seven species are listed under international migratory agreements. Important shorebird habitats exist in the north and west of the Bay. Mud islands in the southern part of the Bay are an important breeding ground for ibis, terns and gulls. The St Kilda breakwater is home to a Little Penguin colony.

Marine mammals	There are two species of resident dolphins in the Bay: Bottlenose and Common. The Common Dolphins (*Delphinus delphis*) are unusual in that they are an isolated population of about 30 resident in the Bay (Charlton-Robb *et al*. 2014, Mason *et al*. 2016). There are several haul-out sites for Australian fur seal located in the south of the Bay, but the species does not breed in the Bay (Kirkwood *et al*. 2010). Several species of whales, including Humpback, Southern Right and Killer, visit the Bay.
Denitrification	Denitrification (the process of converting bioavailable nitrogen to nitrogen gas and subsequent loss to the atmosphere) is critical in maintaining water quality in the Bay (Harris *et al*. 1996; Longmore 2014).

Saltmarsh within the Jawbone Marine Sanctuary provides critical habitat for many waterbirds. Saltmarsh is also very effective at carbon sequestration.
Photo – Parks Victoria

Environmental values

Across the community, there is broad agreement that a healthy environment, and by extension, a healthy Bay, is something to value and protect. Most of us respond to nature's beauty, admire its complexity, and experience pleasure in our interactions with nature. At another level, a healthy environment is essential for our survival; it provides life-sustaining resources and other raw materials for our use.

The *SEPP (Waters of Victoria)* recognises many of the things we value about the Bay, and incorporates them into a list of 'beneficial uses'. Some of the SEPP's beneficial uses are obvious, such as recreation and fishing. But there is another less obvious category of benefits that we receive constantly from Port Phillip Bay. Known as 'ecosystem services', these are natural features and processes that protect the environmental condition of the Bay, and in doing so, enhance our way of life. Ecosystem services include things such as bacteria that remove the nutrients from waste and prevent the waters from becoming putrid; seagrass beds that store carbon, produce oxygen and create safe places for juvenile fish to grow; and subtidal rocky reefs that reduce wave impact on the coast and provide a habitat for invertebrates.

These ecosystem services are critically important to the community's wellbeing, and reproducing them may be extremely costly or even impossible. It is clear that the water, habitats and marine life in the Bay create a complex natural system that greatly benefits the community and underpins many social, cultural and economic values.

Social and cultural values

The Bay is one of Victoria's most popular recreational destinations, and contributes significantly to Melbourne's liveability. It is popular with local, regional, national and international visitors. Parks Victoria (2015) estimates there are nearly 60 million visits per year to various locations around the Bay shoreline. The Bay is also appreciated from afar, providing visual and other benefits to visitors and nearby residents.

The Bay and its beaches support a range of recreational activities including swimming, snorkelling, kite-surfing, scuba diving, fishing, sailing and boating as well as sand-play, walking, relaxing and socialising. There are 135 beaches around the Bay, of those, 27 are patrolled by lifesaving clubs.

There are many great locations for viewing the Bay's unique marine life by diving and snorkeling, including within the Marine National Park and the three marine sanctuaries.

Recreational fishing and boating are important values of the Bay, which deliver social and economic benefits to coastal communities through visitation and tourism. There are more than 40 boating and sailing clubs around the Bay, and more than 50 boat ramps. Recreational fishing and boating participation is projected to increase with population growth.

The opportunities for recreation and socialising provided by the Bay contribute significantly to the health and wellbeing of Victorians. There is growing evidence that time spent in natural places, including the Bay, is associated with positive long-term health outcomes. The large number of community groups and individuals that actively contribute to management of the Bay and its foreshore, including 'Friends of' groups, Coastcare Victoria and Beach Patrol groups, reflects the strong connection that many people have to the Bay.

The Bay provides important cultural values that contribute to our sense of place and identity, including landscapes and sites of historical and cultural significance. Aboriginal tribes that have lived on and around the Bay for millennia include the Wathaurung, the Bunurong/Boon Wurrung and the Wurundjeri. These tribes are all part of the Kulin nation. Through their cultural traditions, Aboriginal people maintain their connection to their ancestral lands and waters. It is important that this connection to Country is strengthened and that the Aboriginal values and interests in the Bay are recognised.

Victoria's first European settlement in the Bay was established at Sullivan Bay, near Sorrento, in 1803 – 32 years before Melbourne was founded. There are also many shipwrecks and other heritage sites in the Bay associated with early seafaring days.

Economic values

Commercial fishing has operated in the Bay for more than 170 years. Annual production of finfish between 1978 and 2012 averaged around 1200 tonnes, and for 2009-10 the fish catch had a market value of about $3.5 million (DPI 2012). The value of the commercial catch will decline in future due to the phasing out of netting and a buy-back of commercial licences. Aquaculture and commercial diving for abalone, scallops and sea urchins also take place in the Bay. Farming of blue mussels is the predominant aquaculture activity, with seven aquaculture fisheries reserves located in the Bay. Production of mussels is around 900 tonnes per year (DPI 2012). Recreational fishing in the Bay is also an important contributor to the Victorian economy, with an estimated economic worth upwards of $420 million per year (derived from economic analysis by Ernst and Young 2015).

The Bay's natural features and recreational opportunities make it an important tourist destination. Bay tourism and recreation, along with associated industries, are estimated to contribute more than $320 million per year to the Victorian economy. Among the activities generating economic benefits are commercially operated boat tourism offering wildlife watching experiences (dolphins, seals and penguins) and recreational diving. Many bayside businesses such as restaurants and cafes also rely on the amenity of the Bay.

The Bay provides important natural 'goods and services' (collectively referred to as 'ecosystem services') that have economic value for our community. These include nitrogen cycling, receipt of wastewater, coastal protection, amenity and food (e.g. fish). The estimated values (non-additive) of some of these services include:

- **Nitrogen cycling:** the Bay naturally processes more than 5000 tonnes of nitrogen per year from catchment runoff and treated wastewater discharge, thus preventing eutrophication (which leads to algal blooms, anoxia and other negative effects). This service is potentially worth $11 billion, based on a replacement cost of $2250 per tonne (Marsden Jacob Associates 2014), when compared to managing the nitrogen in the catchment through the construction of wetlands or new wastewater treatment plants.
- **Coastal protection:** saltmarshes, mangroves and wetlands provide in the order of $3 million per kilometre of coastal protection benefits, when compared to the alternative of having to construct seawall protection for communities (Parks Victoria 2015).
- **Carbon storage:** each year the Bay stores around 8500 tonnes of carbon (PP&W CMA 2015). The economic value of this carbon capture is about $1 million each year. If all carbon stored in the saltmarsh, mangrove and seagrass habitats was released, the one-off cost to offset these emissions would be between $6 million and $25 million.

Economic analysis undertaken by DELWP to inform the Plan found that modelled increases in nitrogen, sediments and pathogen loads would have significant economic impacts. Projected increases in loads could result in more persistent algal blooms and poor water quality at beaches, which would have the potential to reduce tourism contribution to the economy by at least $68 million per year and reduce the value of enjoyment derived by locals and tourists from visiting the Bay by $39 million per year.

Beach goers enjoy the Bay's tourism and recreation facilities at West Beach, St. Kilda. Photo – Ross Kilborn

Challenges, pressures and stressors

An environmental risk assessment was used as a screening tool to identify pressures (threatening activities) and stressors (the physical and chemical changes due to an activity) that pose the greatest risk to Bay values (Hale and Brooks 2016).

Impacts from forecast population growth and climate change underpin many of the pressures and stressors identified for the Bay.

Melbourne's population (currently around 4.5 million) is predicted to almost double over the next 35 years, with significant growth also forecast for regional centres around the Bay (DTPLI 2014). This increase in population presents both challenges and opportunities. Drainage and sewerage systems will need augmenting to manage the increased inflow associated with an increase in urbanisation and intensification of agriculture in the Bay's catchment. With more people there will be a need for more services and facilities to support community use and enjoyment of the Bay.

Climate change is likely to exacerbate some existing problems and create new ones. Water temperatures will increase, leading to a change in species composition, and changing patterns of underwater and coastal plant and animal communities.

Sea levels will rise and storm surges will become more frequent, exposing the coastline to erosion and inundation, and squeezing coastal habitat between the sea and urban areas.

The most significant pressures and stressors identified in the environmental risk assessment are described below.

Catchment inflows (stormwater and the Western Treatment Plant)

Population growth and climate change will increase nutrient, sediment and pollutant loads to the Bay. Under a changing climate there will be more years with less rainfall, but more intense rainfall events over summer. This will result in higher event-related flows to the Bay containing nutrients, sediments and other pollutants.

Catchment modelling has indicated that the bulk (about 60%) of the nitrogen load comes from the Western Treatment Plant, with the remainder from diffuse sources across the catchment.

Fletcher and Deletic (2006) undertook a review of water quality knowledge for the major catchments that drain to the Bay.

They stated that urban areas within the Yarra catchment contribute 43% of total nitrogen, with rural pasture contributing 42%, and horticulture/cropping contributing 8% of total nitrogen respectively. Contributions from forested areas were only 8%. On a per-hectare basis, the contribution from urban is greater. Results from modelling undertaken by Jacobs and HydroNumerics (2015a) aligned with the earlier analysis.

Based on catchment modelling, it is estimated that nitrogen loads to the Bay will increase by about half by 2050 (to 8300 tonnes per year, depending on whether annual rainfall is below or above average) unless actively managed. The model showed that if nitrogen loads increased to this level, 75th percentile for chlorophyll 'a' at the EPA's Hobsons Bay monitoring site could range between 6 and 8 µg/L. This level of chlorophyll 'a' exceeds the 4 µg/L water quality objective derived from the EPA's fixed site monitoring over the past 25 years. With nitrogen loads this high, beaches along the north-eastern shore would experience more frequent algal blooms.

Scenario modelling indicates the Yarra catchment will contribute the largest load of sediment to the Bay, while the Werribee and Dandenong catchments are predicted to have the greatest proportional increase in nutrient and sediment loads due to future urban development. Other pollutants will also increase as a result of greater stormwater runoff (and increased production and use of toxicants in the catchment).

Based on population forecasts and urban growth, inflows to the Western Treatment Plant are expected to increase 45% by 2050. Nitrogen loads discharged from the plant have varied greatly over the past 50 years. During the early 1970s, discharge loads were estimated to be in the order of 6000 tonnes of nitrogen per year. However, with the commissioning of the Eastern Treatment Plant in the mid-1970s, nitrogen loads were reduced significantly. Discharges from the Western Treatment Plant are affected by the volume of sewage flowing to the plant (inflows), weather impacts on processes within the plant (including capacity to contain storm flows), and the amount of water recycled for other uses.

Invasive species

Elevated sea urchin densities are a threat to the integrity of kelp beds on rocky reefs. Grazing by large populations of the native sea urchin, *Heliocidaris erythrogramma*, has been implicated in the loss of macroalgal cover on reefs (particularly the once-dominant canopy-forming macroalga, *Eklonia radiata*) (Carnell and Keough 2014). Urchin barrens have been formed on more than 90% of the reefs in the western and northern parts of the Bay. This is thought to have negatively affected reef-associated fish that depend on the macroalgae for food and shelter (Johnson *et al.* 2015).

Toxicants and sediment

Based on our current knowledge, many gaps still exist regarding the presence of different toxicants and their effects on marine life in the Bay (Barbee *et al.* 2016). The science knowledge synthesis conducted for this report concluded that toxicants such as metals and organochlorine pesticides are generally below guideline levels. However, increased levels are found in a few localised areas, including Hobsons and Corio Bays and where the Mordialloc and Kananook Creeks discharge into the Bay.

While the presence and sources of phosphorus and sediments are well described, and the impacts of litter on key Bay values have been identified, there are a number of contaminants of emerging concern. These include endocrine-disrupting compounds (EDCs), pharmaceuticals, flame retardants, pesticides (other than organochlorines) and microplastics. These pollutants have not been monitored in the Bay in a systematic way, and in many instances their impacts on marine life have not been well characterised.

Sediments can have a significant impact on aesthetic, recreational and ecological values, and are vectors for transporting toxicants. Modelling by Jacobs and HydroNumerics (2015a) showed that the Yarra Catchment is a major source of sediments, with annual loads closely correlated to rainfall (i.e. loads are higher in wetter years – see Figure 9). The split between urban and rural sources is about 50/50 despite the area of rural land being twice that of urban land (Figure 2). Figure 9 also highlights the efficiency of the Western Treatment Plant in removing sediments. Modelling results have identified the need for improved management within catchments (urban and rural) to reduce sediment loads and their associated toxicants from entering the Bay, especially in periods of high rainfall.

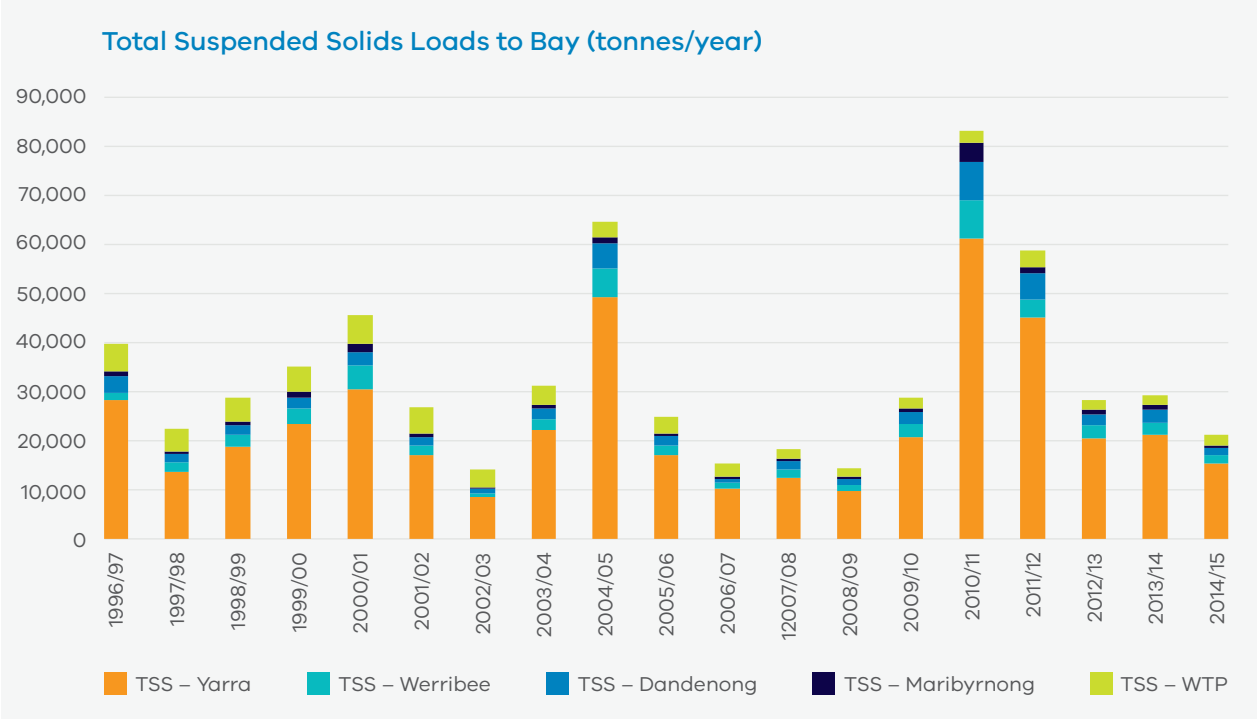


Figure 9 Estimated annual loads of sediment (total suspended solids, TSS) based on catchment modelling. Loads for Werribee and Dandenong include contributions from smaller rivers and creeks that discharge directly to the Bay in those regions.

Litter

Litter constitutes any solid or liquid domestic or commercial waste that is deposited inappropriately. In the general community, litter is variously perceived as harmful (non-biodegradable and/or hazardous) and less harmful (biodegradable) (VLAA 2014a). Harmful litter includes cigarette butts, plastics, nappies, broken glass, dog faeces and fast-food wrappers. Non-harmful litter includes paper, cardboard and fruit scraps. Plastics, particularly microplastics and nurdles, are a concern to the community (VLAA 2015).

Litter is a significant challenge. It has a negative impact on visual amenity, reduces water quality and can kill or harm marine animals. According to previous estimates, about 95% of litter found on our beaches had been transported from suburban streets through the stormwater system (Melbourne Water 1993). However, concern has been raised that with more people using the Bay for recreation, there is likely to be an increase in direct littering within the Bay and on its beaches.

Microplastics are an emerging issue of concern. These are small (< 5mm) pieces of plastic that come from broken-down plastic litter or from raw plastic manufacturing materials being washed off properties into the drains and waterways. They can be eaten by marine animals, with impacts on their health (Duckett and Repaci 2015, Maillard *et al.* 2013). Microplastics also include small synthetic fibres from the breakdown of woven cloth, which result from washing clothes.

Marine pests

Marine pests are non-native plants or animals that can establish themselves in a new environment by producing large numbers of spore or offspring. They are 'ecosystem engineers' as they change the dynamics of the ecosystem. Marine pests can seriously affect habitats, food chains, the ecosystem and our enjoyment of the marine environment. Some marine pests may pose a risk to human health and have potential to affect the social and economic benefits provided by the marine environment including aquaculture, recreational and commercial fishing and domestic and international shipping.

Overlooking the Bay from Point Ormond. Photo – Robert Molloy

The last systematic survey of the Bay for introduced marine species was completed in 2003 (Hewitt *et al.* 2004). The authors suggested that the Bay, with more than 160 introduced species, was the most invaded ecosystem in the southern hemisphere. The species that have received the most attention are the Northern Pacific seastar (*Asterias amurensis*), Japanese kelp (or Wakame) (*Undaria pinnatifida*), European fan worm (*Sabella spallanzanii*), European clam (*Corbula gibba*) and European green shore crab (*Carcinus maenas*). A more recent species to be identified is the red algae *Grateloupia turuturu*, which has been recorded in the Point Cooke Marine Sanctuary.

Marine pests have a ubiquitous and permanent presence in the Bay (Barbee *et al.* 2016). While there is limited knowledge of the current status of most pest species, the available evidence suggests that their impacts on nutrient cycling and biodiversity have been negligible and localised. However, marine pests still pose considerable risks to biodiversity, aquaculture, ecosystem function and recreational amenity.

They have the potential to have significant impacts on the Bay and these values, particularly if there are changes to environmental conditions that are favourable for these species; for example, warmer water, increased availability of nutrients, or reduced predation by other species. The prospect of marine pests being introduced to and spreading from the Bay, particularly via small (commercial and recreational) vessels, was also identified as a high-priority risk. All of this suggests that marine pests should be considered a long-term and ongoing threat to the Bay.

Pathogens

Pathogens were rated as a medium-level concern, as impacts for recreational use and aquaculture are generally localised and short-term in nature. However, the potential public health implications of pathogens and public expectations for swimming and collecting shellfish in the Bay mean that this is a significant issue that requires ongoing management and consideration.

EPA advises against swimming near stormwater outlets for up to 48 hours after heavy rain, as there could be a higher risk of illness to swimmers from increased bacterial levels. Photo - Robert Molloy

Geelong. Photo - Parks Victoria

4 Responsibilities and management

Management responsibilities

Appropriate and coordinated management of the Bay is crucial to ensure its ongoing health and capacity to support a diverse range of values and activities.

Most of the marine areas of the Bay are classified as unreserved Crown land under the *Land Act 1958*, and are under the administrative control of DELWP. DELWP is also responsible for leading and coordinating environmental management of the Bay, along with other roles including wildlife protection, incident response, planning and issuing permits for works.

Environmental regulation

The Environment Protection Authority (EPA) Victoria is the environmental regulator and has responsibility for independent assessment, licensing, reporting and advice regarding environmental health issues affecting waterways and the Bay. The EPA is also responsible for administering and enforcing the *Environment Protection Act 1970* and the *SEPP (Waters of Victoria)*. Wastewater treatment plants have operating licences issued by the EPA that set the allowable discharge quality and quantity to receiving environments. Onsite wastewater systems (e.g. septic tanks) are regulated by councils.

Coastal and foreshore management

Under the *Coastal Management Act 1995*, there is a hierarchy of agencies responsible for managing coastal issues such as inundation, erosion and development. The Victorian Coastal Council has responsibility to prepare a framework to guide planning, management and sustainable use of the Victorian coast. At a regional level, the Central Coastal Board has developed the *Central Regional Coastal Plan*, incorporating Port Phillip Bay. At a local level, a range of public land managers (including local government and DELWP) are responsible for preparing coastal management plans and climate change adaptation plans.

Ten councils in partnership with the Association of Bayside Municipalities have prepared the 'Bay Blueprint', to provide a consistent, bay-wide response to coastal adaptation.

Overarching adaptation to climate change is a whole-of-government priority, which will be guided by the *Climate Change Act 2017*, and *Victoria's Climate Change Adaptation Plan 2017-2020*. There may be some change to coastal management responsibilities with the introduction of the new *Marine and Coastal Act* (in preparation).

Waterways and catchment health

Melbourne Water and the Corangamite Catchment Management Authority (CMA) have waterway management functions under the *Water Act 1989* for designated waterways within their respective areas. They have enabling functions within the Act to develop and implement plans, and to carry out works and activities to improve environmental values, typically in priority areas. The Port Phillip and Westernport CMA also plays an important role in catchment management, improving biodiversity, reducing erosion, improving river health and supporting community action.

Marine protected areas, local ports and navigable waterways

Parks Victoria manages the Bay's marine national parks and marine sanctuaries, which form part of Victoria's park and reserve system. Parks Victoria is also the manager for local ports within the Bay under the *Port Management Act 1995* and is responsible for ensuring that local port operations are safe, efficient and effective. It is also responsible for managing port infrastructure (including piers and jetties, navigational aids, moorings and berths), and preparing and implementing safety and environment management plans. Parks Victoria is also the waterway manager for the Yarra, Maribyrnong and Patterson Rivers under the *Marine Safety Act 2010*. This role covers management of vessel activities including control of navigation and vessel movement, removing and marking in-water obstructions, and channel maintenance within the local port area.

Commercial ports, shipping and navigation

The Bay's commercial shipping is managed by the Victorian Ports Corporation (Melbourne) for Port Phillip Bay and Melbourne, and the Victorian Regional Channels Authority for the approaches to the Port of Geelong. Responsibilities for the commercial operations within the port lie with Port of Melbourne Operations Pty Ltd and Geelong Port respectively. Victorian Ports Corporation and Victorian Regional Channels Authority both provide the Harbour Master function, which includes shipping control, oversight of channel management and the provision of navigation aids. Both organisations are responsible for the development and implementation of safety and environment management plans (SEMPs).

Commercial and recreational fishing

The Department of Economic Development, Jobs, Transport and Resources (DEDJTR), which includes Victorian Fisheries Authority, manages and regulates commercial and recreational fishing and aquaculture in the Bay under the *Fisheries Act 1995*. Victorian Fisheries Authority prepares and reviews management plans for the recreational, commercial and aquaculture sectors. These plans identify policies and strategies for the ecologically sustainable management of Victoria's fisheries.

Boating and marine safety

Maritime Safety Victoria, which is a branch of Transport Safety Victoria, regulates the safe operation of vessels (sailing, human-powered and motor craft) in the Bay, under the *Marine Safety Act 2010*. Maritime Safety Victoria works closely with vessel operators and waterway and port managers to provide expert knowledge, education, support and direction, and is committed to safe vessel operations and safe waterways for the benefit of all Victorians.

Other organisations

Other agencies with a role in conserving and caring for the Bay and its catchment include:

- Committees of management for Crown Land Reserves
- Department of Economic Development, Jobs, Transport and Resources (which includes Agriculture, Biosecurity, Fisheries, Ports and Tourism)
- Department of Health and Human Services
- Local government (including local councils, the Municipal Association of Victoria, and the Association of Bayside Municipalities)
- Office of the Commissioner for Environmental Sustainability
- Sustainability Victoria
- Victorian Planning Authority
- Water corporations (Barwon Water, Central Highlands Water, City West Water, South East Water, Southern Rural Water, Western Water and Yarra Valley Water)
- Zoos Victoria.

Aboriginal groups from the Kulin nation represent the views and understanding of Traditional Owners, and can bring valuable heritage and ecological knowledge to Bay management.

There are also a large number of non-government conservation and community based organisations that play a significant role in managing the health of the Bay through on-ground activities and research.

Capacity building and community based programs

Capacity building typically includes access to:

- Technical advice
- Training
- Resources and tools on best-practice science and management techniques
- Strategic advice on group administrative matters, governance and funding sources
- Fostering of peer-to-peer learning across groups.

Many capacity-building programs exist to support community groups and individual volunteers. Examples include Coastcare, Waterwatch, Landcare, Port Phillip EcoCentre, Baykeeper, Riverkeepers, ReefWatch, and programs run by other management organisations such as the CMAs and water corporations. These programs have built a high degree of trust with their target audiences over many years, which is vital for successful community capacity building.

There are a number of government, community and citizen science programs that promote healthy Bay habitats and marine life. Current programs include:

- *ReefWatch*, a citizen science program run by the Victorian National Parks Association (VNPA) in partnership with Museums Victoria. The program encourages divers and snorkellers to monitor marine life at their favourite dive sites. Current ReefWatch projects include the Great Victorian Fish Count, Dive In, Buddy up with a Blue Devil and Feral or in Peril. ReefWatch is also assisting with The Nature Conservancy's shellfish reef restoration projects.
- *Sea Search,* a Parks Victoria program that encourages and provides opportunities for community participation in marine data collection and surveillance within Victoria's marine national parks and marine sanctuaries. Sea Search assists in improving understanding of natural assets and processes, and in the early detection of change and identification of threats. It also provides meaningful opportunities for citizens to make active and welcome contributions to the management of marine parks and sanctuaries.
- *'i Sea, i Care'*, a marine ambassador program run by the Dolphin Research Institute. The program has focused on primary school-aged students (grades 5 and 6) and currently has more than 450 ambassadors in more than 100 schools.

The key messages of the program are that our marine life is too precious to lose and that diffuse pollution from the catchment is one of the biggest issues for the marine environment. i Sea, i Care focuses on peer learning to increase marine stewardship and leadership. The program also includes partnerships with local councils. These partnerships have assisted with local government decision making on stormwater issues. The Dolphin Research Institute is currently expanding the program to work with secondary school students, community groups and businesses.

- *Port Phillip EcoCentre*. This organisation facilitates events that build community awareness on key habitat values of the Bay, and highlights issues that are impacting on these habitats. The EcoCentre runs activities including snorkelling, cycling and twilight walking tours that showcase the diversity of plants and animals in the Bay. These activities facilitate the sharing of information about conservation and management issues, and inform people of what they can do to help care for the Bay. The Port Phillip Baykeeper, a community program run by the EcoCentre, brings together stakeholders from across the government, research and business sectors as well as schools and the community to undertake projects that help to conserve and improve the health of the Bay. Activities facilitated by the Baykeeper include shoreline shell surveys, beach profiling activities and live mollusc surveys.
- Marine Care Ricketts Point, a community group that supports the wellbeing of the Ricketts Point Marine Sanctuary. The group has approximately 250 members and works closely with Parks Victoria (as the sanctuary manager), Bayside City Council and other interested groups. Marine Care Ricketts Point runs a Marine Education Centre and a range of activities that help to conserve and preserve the natural environment, and to educate the community about the role and values of the sanctuary. Activities include mapping, monitoring and recording of marine life.
- *Coastcare Victoria*, a government program that supports thousands of community volunteer groups working to protect and enhance Victoria's coastline. Volunteer groups help to maintain marine and coastal environments through activities such as revegetating coastal areas, building tracks and boardwalks, fencing, monitoring native shorebirds and animals, presenting education and awareness raising sessions and protecting cultural sites.

- *Summer by the Sea*, an annual program that provides a great opportunity for the community to connect with the rich and diverse natural and cultural values of Victoria's marine and coastal environments. This is a Coastcare Victoria program delivered as a partnership between DELWP and Parks Victoria with support from local volunteers and experts. Activities range from coastal discovery walks, rockpool rambles and snorkelling to junior ranger and responsible fishing activities. Through these activities, the program promotes respect for coastal and marine environments and builds understanding of the impacts our actions can have on these environments.

Citizen science groups and other community groups are also conducting research and monitoring on issues affecting Bay values. For example, citizen science projects have sampled sediment for microplastics (Two Bays and the Clean Bay Coalition project). The Nature Conservancy's Shellfish Reef Restoration Project aims to re-establish the Bay's shellfish reefs. Restoration work for two reefs (Geelong Arm and Hobsons Bay) has commenced, with results showing an average oyster survival rate greater than 50% (The Nature Conservancy Australia 2016).

Policy setting for the Plan

Management of the Bay occurs within a network of state, regional and local strategies, plans and policies. Most of these relate indirectly to the Bay through activities that focus on stormwater, waterways, catchments and coastal areas, but which have an impact on Bay conditions. The key documents are set out in Figure 10. Further detail regarding key legislation and policies that directly influence the management of the Bay are outlined below, along with a number of current Victorian Government initiatives.

Current legislation and policy

Management of the Bay is guided by a number of pieces of legislation and government policy that directly relate to marine and coastal environments. Among the main pieces of legislation and policy are:

Environment Protection Act 1970 and State Environment Protection Policy (Waters of Victoria)

- *State Environment Protection Policies (SEPPs).* These are subordinate legislation made under the provisions of the *Environment Protection Act 1970*. They aim to safeguard the environment and humans from the effects of pollution and waste. *SEPP (Waters of Victoria)* sets out Victoria's water quality expectations. It establishes the pathway for protecting and improving the quality of surface water environments in a context that supports economic and social development. *Schedule F6 Waters of Port Phillip Bay* of the *SEPP (Waters of Victoria)* provides the directive for the Plan. *Schedule F6* identifies values present in various parts of the Bay that need to be protected, and sets water quality objectives for various environmental quality indicators. The Victorian Government is currently reviewing the *SEPP (Waters of Victoria)* and the *SEPP (Groundwaters of Victoria)* to ensure clear and relevant standards and legal obligations to protect and improve the health of our aquatic environments are in place.

Land Act 1958, National Parks Act 1975, and Crown Land Reserves Act 1978.

- *Land Act 1958.* The majority of the floor and overlying waters of the Bay are classified as unreserved Crown land under the *Land Act 1958*, and DELWP is the designated land manager for these areas.
- *National Parks Act 1975.* The Port Phillip Heads Marine National Park and three marine sanctuaries (Point Cooke, Jawbone and Ricketts Point) located in the Bay are established and managed under this Act, and the area within 200 metres of South Channel Fort is reserved under it. The Act establishes the statutory basis for the protection, use and management of these parks and reserves. Parks Victoria is responsible for the management of marine protected areas.
- *Crown Land (Reserves) Act 1978.* Most of the Bay foreshore, which includes the intertidal zone and the area immediately landward of it, is classified as reserved Crown land under this Act for a variety of purposes including protection of the coastline, preservation of species of native plants, and areas for public recreation. Management of this land is often delegated to committees of management, which are appointed by the Minister for Energy, Environment and Climate Change. Committees of management can be government agencies such as Parks Victoria, local councils, or voluntary community groups.

Catchment and Land Protection Act 1994

- *The Port Phillip and Western Port Regional Catchment Strategy and the Corangamite Regional Catchment Strategy.* These strategies are required under the *Catchment and Land Protection Act 1994* (section 24). They are integrated catchment management strategies that together cover the entire area that drains into Port Phillip Bay. The health of the Bay is significantly impacted by the condition of the catchment and the inputs that flow from it. The roles of the regional strategies in coastal, bay and marine management are expected to be strengthened with the development of the new *Marine and Coastal Act*.

Planning and Environment Act 1987 and Coastal Management Act 1995

- *Victoria Planning Provisions (Clause 56.07).* This is the main mechanism for managing the impact of stormwater in new residential developments (but it is not applied to development in areas that connect to existing drainage systems). Clause 56 requires the implementation of best practice environmental management (BPEM) guidelines for stormwater quality management. This includes retention of typical urban loads of total nitrogen (45%), total phosphorus (45%), total suspended solid (80%) and litter (100%).
- *Coastal Management Act 1995.* This Act establishes the legislative framework for planning and managing the Victorian coast. The Act establishes the Victorian Coastal Council and Regional Coastal Boards, provides for the preparation and implementation of management plans for coastal Crown land, and provides a coordinated approach to approvals for the use and development of coastal Crown land. Coastal Crown land is generally all Crown land within 200 metres of the high tide mark and the seabed of Victorian coastal waters, including the Bay. All use or development of coastal Crown land by any party, including committees of management and local councils, requires consent under the Act. The Victorian Coastal Council is established under the Act. Its responsibilities include statewide strategic planning and preparation of the *Victorian Coastal Strategy*. *The Victorian Coastal Strategy 2014* provides a long-term vision for the planning, management and sustainable use of the coast and identifies high-level policies and actions to help achieve the vision, which is: 'a healthy coast, appreciated by all, now and in the future'.
- The *Central Regional Coastal Plan 2015–2020* is a statutory document endorsed under the *Coastal Management Act 1995* and prepared by the Central Coastal Board. It identifies eight regional priorities:
    1. Population growth – balancing access and valuing the natural environment
    2. Adapting to climate change and increased coastal hazards
    3. Integrating coastal planning and management
    4. Sustainable and equitable funding mechanisms for coastal infrastructure and management
    5. Implementing the Recreational Boating Facilities Framework
    6. Sustainable visitation and tourism infrastructure service through the development of a multi-level hierarchy
    7. Protecting significant coastal and marine ecosystems and habitats
    8. Promoting leadership, co-ordination and capacity building.

Commonwealth and state marine pest policy and legislation

- *Anti-fouling and in-water cleaning guidelines (2013).* This Commonwealth guideline describes 'best practice approaches for the application, maintenance, removal and disposal of anti-fouling coatings and the management of biofouling and invasive aquatic species on vessels' (described as any craft that operates in an aquatic environment) (Department of the Environment and New Zealand Ministry for Primary Industries 2015).
- *Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria (2009).* Protocols developed under the guidelines include the *Victorian Protocol for the Translocation of Blue Mussels (2006*), the *Victorian Abalone Aquaculture Translocation Protocol (2007)* and Management Plans for aquaculture reserves declared under the *Fisheries Act 1995*.
- *Environment Protection (Ships Ballast Water) Regulations 2006*, the *Waste Management Policy (Ships Ballast Water),* and the protocol for environmental management '*Domestic ballast water management in Victorian state waters*'. Currently, the protection of Victorian waters from the introduction of marine pests is supported by these three key items of subordinate legislation. The *Waste Management Policy (Ships Ballast Water)* and *Protocol for Environmental Management* sets out responsibilities for ship owners to manage domestic ballast water to reduce environmental risk in Victorian waters. Vessels are required to complete a risk assessment of ballast water contained onboard. High-risk ballast water cannot be discharged within Victorian state waters (Department of Agriculture and Water Resources 2016). The ballast water regulations establish offences for discharging ballast water without written authorisation and for failing to complete reporting requirements. They also set fees and the process for collection. The EPA conducts random inspections of boats entering the Bay for compliance with these regulations. As at 2012, the EPA had not found a ship to be non-compliant (EPA 2012b).

- *Emergency Management Act (1986 and 2013).* This Act provides the legislative framework for emergency management in Victoria. Under this sits the *Emergency Management Manual Victoria (EMMV),* which contains policy and planning documents for emergency management and provides details about the roles different organisations play. Marine pest incursions are listed as a declared emergency in the *EMMV.*
- *Australian marine pest monitoring guidelines (2010).* These guidelines and an accompanying Australian marine pest monitoring manual were developed in 2010 as part of the *National System for the Prevention and Management of Introduced Marine Pest Incursions*. The guidelines established a National Monitoring Network of 18 locations around Australia, including the Port of Melbourne, and outline the nationally agreed processes, procedures and standards for marine pest monitoring programs.

New legislation and policy

The Plan will be complemented by a number of new policies or revisions of existing ones. These include development of the *SEPP (Waters)*, a new *Marine and Coastal Act*, *Water for Victoria (2016)* plan and the first *State of the Bays* report. Further detail on these initiatives and how they relate to or may impact on the Plan is provided below.

- *State Environment Protection Policy (Waters of Victoria) review*

  As part of the *State Environment Protection Policy (Waters of Victoria)* review, consideration is being given to setting load targets for catchment inputs to marine receiving waters. Water quality modelling and load projections undertaken by Jacobs and HydroNumerics (2015a, b) for the Plan are helping to inform government decisions on water quality objectives and policy targets. The new *SEPP (Waters)* is planned to be released by the government in 2018.

- *Marine and Coastal Act*

  The Victorian Government is developing a new *Marine and Coastal Act*, which will see coastal and marine management better integrated within the same system for the first time. The new Act will provide the legislative framework to support the vision of a healthy coast and marine environment in the face of future long-term challenges. It will guide marine and coastal strategies and the reports that sit beneath it. The government is also looking to develop better management and oversight arrangements for coastal and marine environments in the course of developing the new Act, including consideration of a marine spatial planning framework.

- *State of the Bays* reporting

  The Victorian Commissioner for Environmental Sustainability delivered the first *State of the Bays* report in late 2016. This report provides a scientifically rigorous baseline report on the health of Port Phillip Bay and Western Port against which future reporting can be compared. The *State of the Bays* report considers existing research and data, identifies knowledge gaps, proposes new data collection and monitoring priorities, and develops indicators for future reporting on the *State of the Bays*. Having an updated condition status for the Bay will provide a baseline for evaluating the effectiveness of the Plan. State of the Bays will also be an important part of the monitoring and reporting framework of the Plan.

- *Port Phillip Bay Fund*

  Some of the proceeds from the Port of Melbourne 50-year lease will support the new Port Phillip Bay Fund over the next four years. The fund, announced in March 2016, will support projects to protect and preserve the Bay, including water quality improvement, dune stability, amenity upgrades and wetlands improvements.

- *Water for Victoria*

  Water for Victoria was released in October 2016, and includes plans for a future with less water as Victoria responds to the impacts of climate change and a growing population. Strategic directions in the *Water for Victoria* plan will strengthen management of the Bay's health by:

  – Improving protection arrangements for urban waterways through improved land-use planning controls, and more comprehensive place-based integrated water management planning

  – Improving stormwater management through changes to planning and building regulations, use of catchment-based stormwater offsets, setting of water quality indicators that protect beneficial uses, and establishment of a risk-based framework to manage unlicensed pollution sources

  – Increasing community involvement in land, water and biodiversity management through greater recognition of Aboriginal values and ecological knowledge, and investment in citizen science programs for local waterways

  – Improving waterway management through aligned monitoring and reporting of waterway health, sharing of knowledge, and the use of scientific research to underpin evidence-based decision making and adaptive management.

- *Yarra River Action Plan (Wilip-gin Birrarung murron)*

  The Victorian Government released the *Yarra River Action Plan (Wilip-gin Birrarung murron)* in February 2017. It contains 30 actions to ensure the long-term protection of the Yarra River and its parklands. The Plan reflects the government's response to the recommendations made by the Yarra River Protection Ministerial Advisory Committee and community feedback on the *Protecting the Yarra River (Birrarung) Discussion Paper*.

- *Biodiversity Plan, Protecting Victoria's Environment – Biodiversity 2037*

  The Victorian Government's *Biodiversity Plan, Protecting Victoria's Environment – Biodiversity 2037*, is a long-term strategy that proposes a new direction for the management of biodiversity in Victoria. A key component of the plan is to encourage people to value and protect our natural environment.

- *Review of the Flora and Fauna Guarantee Act 1988*

  The government is reviewing the *Flora and Fauna Guarantee Act 1988*. The aim of the review is to improve the effectiveness and efficiency of the design and implementation of the Act in protecting Victoria's biodiversity, including threatened species and their habitats. The review will also consider how the Act can support implementation of the Biodiversity Plan and interact more effectively with other legislation relevant to biodiversity conservation.

- *Climate Change Framework and Adaptation Plan*

  The *Climate Change Framework* articulates the government's long-term vision and approach to climate change in one policy document. It draws together all of the work happening across government on climate change. This includes building on projects such as the *Our Coast* project, which is using the latest data on projected sea level rises and storm surges to help coastal communities and government agencies plan and respond to the impact of climate change.

- *Plan Melbourne*

  Plan Melbourne is the long-term plan for statutory planning for Greater Melbourne. It builds on key concepts and commitments, with a strengthened focus on housing affordability and diversity, climate change and energy efficiency, and updating transport priorities. The Plan recognises that in order for Melbourne to remain a sustainable and resilient city, we must protect the coastline and waters of Port Phillip Bay, restore natural habitats, enhance the health of waterways, reduce waste and improve waste management.

- *Victorian Government Aboriginal Inclusion Framework*

  The *Aboriginal Inclusion Framework* helps ensure services are accessible and inclusive for Aboriginal Victorians and provides for increased employment opportunities. The framework provides policy makers, program managers and service providers with a structure for reviewing their practices and reforming the way they engage with and address the needs of Aboriginal people in Victoria.

St. Kilda marina.
Photo – Anna Kilborn

LEGISLATION

Requirements, measures and guidelines for protection

- *Environment Protection Act 1970*
- *Land Act 1958*
- *Coastal Management Act 1995* ✻
- *Marine and Coastal Act* ✻
- *Flora and Fauna Guarantee Act 1988* ✻
- *Wildlife Act 1975*
- *Water Act 1989*
- *Fisheries Act 1995*
- *Climate Change Act 2017* ✻
- *Catchment and Land Protection Act 1994*

Other legislation (use and objectives for land):
Crown Land (Reserves) Act 1978, National Parks Act 1975, Planning and Environment Act 1987

POLICY SETTING

Defining policy, setting values and determining environmental quality indicators

- *Victorian Coastal Strategy*
  Lead: DELWP
- *State Environment Protection Policy (Waters of Victoria)*
  (Schedule F6 Waters of Port Phillip Bay)
  Lead: DELWP ✻
- *Water for Victoria*
  Lead: DELWP
- *Protecting Victoria's Environment – Biodiversity 2037*
  Lead: DELWP
- *Victorian Waterway Management Strategy*
  Lead: DELWP
- *Plan Melbourne*
  Lead: DELWP
- *Yarra River Action Plan (Wilip-gin Birrarung murron)*
  Lead: DELWP

STRATEGIC POLICY IMPLEMENTATION

Outlining actions and targets to manage risks and protect values

- *Central Regional Coastal Plan*
  Lead: Central Coastal Board
- *Port Phillip Bay Environmental Management Plan*
  Lead: DELWP
- *Regional Catchment & Waterway Strategies*
  Lead: Corangamite CMA, Port Phillip & Westernport CMA, Melbourne Water
- *Corangamite Marine & Coastal Biodiversity Strategy*
  Lead: Corangamite CMA
- *Regional Riparian Action Plan*
  Lead: DELWP
- *Climate Change Framework*
  Climate Change Adaptation Plan
  Lead: DELWP ✻

OPERATIONAL & INVESTMENT PLANS

Specific tasks and on-ground programs for achieving actions and targets

- *Local Coastal Management Plans*
  Lead: coastal public land managers (e.g. local council & committees of management)
- *Catchment Waterway & Drainage Investment Plans*
  Lead: Melbourne Water, Corangamite CMA, Port Phillip & Westernport CMA
- *Discharge licenses*
  Lead: EPA Victoria
- *Marine Protected Area Management Plans*
  Lead: Parks Victoria
- *Local Operational Plans*
  Lead: Water corporations and local councils

MONITORING, EVALUATION & REPORTING

Assessing the effectiveness of policies and actions

- *State of the Bays report*
  Lead: Commissioner for Environmental Sustainability
- *State of the Environment Reporting*
  Lead: Commissioner for Environmental Sustainabilty
- *Beach Report*
  Lead: EPA Victoria
- *Catchment Condition and Management Reports*
  Lead: Victorian Catchment Management Council
- *There are also project-specific monitoring and reporting programs that report on both actions and environmental conditions*

New marine, coastal and Bay environment initiatives ✻ Currently under review, in draft or in development

Figure 10 Policy context for environmental management of Port Phillip Bay

Out of scope management issues

As a result of evaluation and prioritisation, there are many issues and activities that are not featured in the Plan. These issues are nevertheless acknowledged to be significant in the eyes of the government and the community. Table 3 highlights some of the relevant mechanisms that provide environmental management for some of these out-of-scope issues.

Table 3 Out-of-scope issues and their management

Issue	Rationale
Coastal foreshore issues, including erosion and inundation	Managed through the *Victorian Coastal Strategy*, the *Central Regional Coastal Plan*, local coastal management plans, and regional and local climate change adaptation plans. In addition, the ten councils within the Association of Bayside Municipalities are undertaking the *Bay Blueprint*, a regional coastal adaptation framework for Port Phillip Bay.
Commercial and recreational fishing	DEDJTR (Fisheries) manages and regulates commercial and recreational fishing in the Bay under the *Fisheries Act 1995*. Commercial netting in the Bay is being phased out by 2022 and participation in recreational fishing will be encouraged with enhanced fishing opportunities and facilities.
Dredging	The creation and maintenance of shipping and boating channels for safe navigation requires dredging. Dredging is regulated via consents under the *Coastal Management Act 1995*. Major dredging operations may require additional approvals under the *Environment Effects Act 1978*. Those involved in dredging activities have a responsibility under the *Environment Protection Act 1970* to minimise environmental impacts. The *SEPP (Waters of Victoria)* and accompanying *Schedule F6* also contain specific provisions regarding dredging. Parks Victoria (as the designated local port manager under the *Port Services Act 1995*) is responsible for permitting and/or undertaking maintenance dredging for small boating facilities, including those at Queenscliff, Patterson River, Werribee River, St Kilda Pier and Mordialloc Creek. Victorian Ports Corporation (Melbourne) and Victorian Regional Channels Authority are responsible for dredging of commercial shipping channels and fairways in the Bay and port areas.
Marine vessels	Under the *Port Management Act 1995* and the *Port Management Amendment Act 2012*, managers of local and commercial ports are responsible for safety and environment management plans (SEMPs). Discharge of oil and other pollution to Victoria's waters is prohibited under the *Environment Protection Act 1970*. Spill management is overseen by DEDJTR, and occurs under the *National Plan for Maritime Environmental Emergencies*, the *Victorian Marine Pollution Contingency Plan* and any other relevant state or regional marine pollution contingency plans. DELWP is responsible for coordinating the response to wildlife impacted by maritime pollution under the *Wildlife Response Plan for Marine Pollution Emergencies*. EPA provides enforcement under the *Environment Protection Act 1970* and the *Pollution of Waters by Oil and Noxious Substances Act 1986*. Discharge of ballast water is also regulated through the *Environment Protection (Ships Ballast Water) Regulation 2006*. Maritime Safety Victoria (formerly Marine Safety Victoria) regulates the safe operation of vessels (sailing, human-powered, and motor craft) on all state waters, under the *Marine Safety Act 2010*.

Achievements to date

The 2001 Plan was a major driver for new approaches and associated on-ground works to manage nutrients and marine pests. Further investment in major infrastructure was undertaken through implementation of the *Better Bays and Waterways water quality improvement plan 2009–2013* (Melbourne Water 2009). The *Victorian Coastal Strategy* and *Central Regional Coastal Plan* have also contributed to more informed outcomes for Bay health. Highlights of achievements of the 2001 Plan and other initiatives are summarised in Figure 11, and under the following sub-headlines:

Nutrients

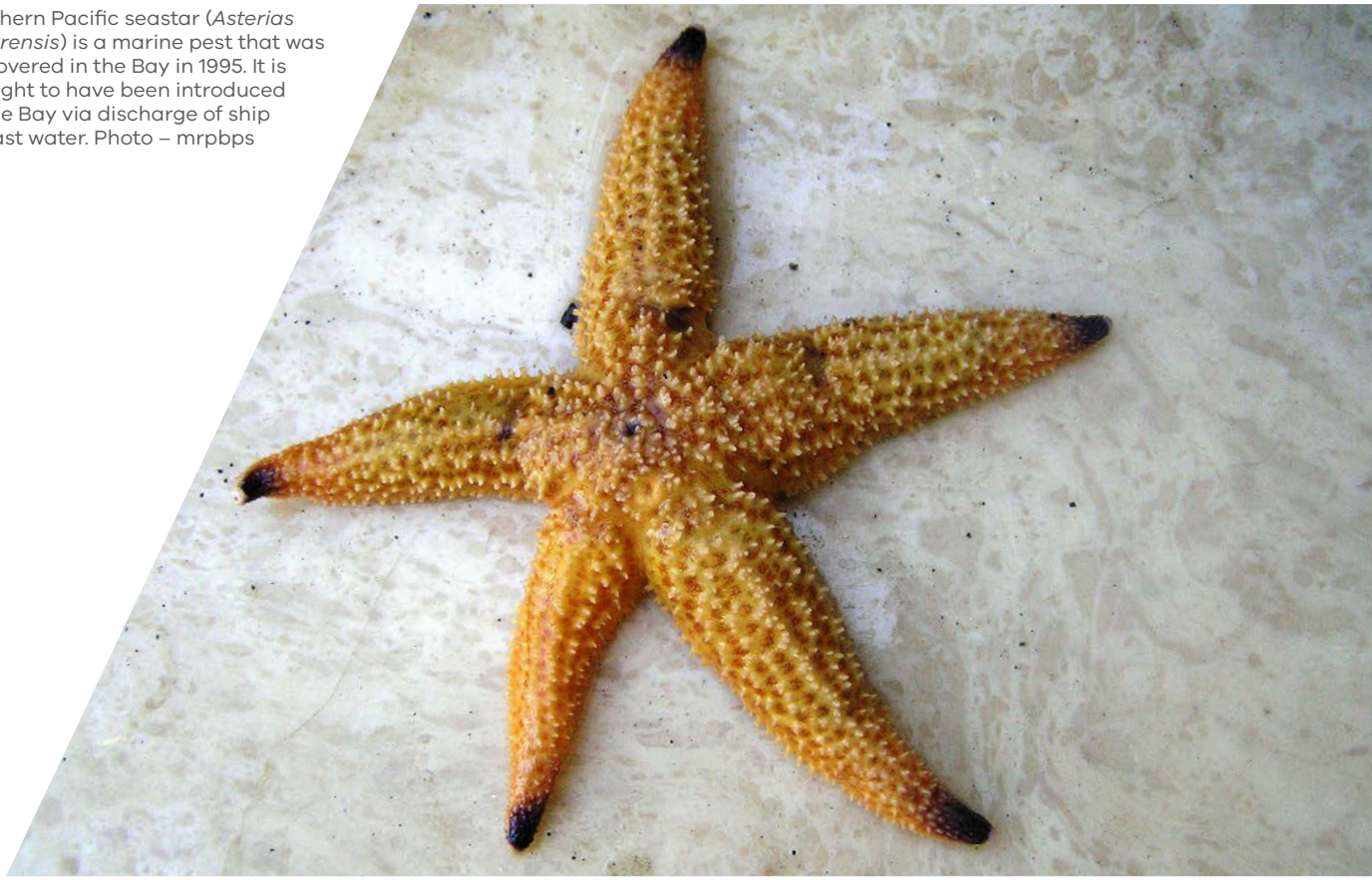
Objectives identified in the nutrients program of the 2001 Plan included a 500-tonne annual reduction in nitrogen load from the Western Treatment Plant and a 500-tonne annual reduction in load from catchment waterways.

Management actions implemented since the 2001 Plan have stabilised trends for increases in discharges of nutrient and sediment loads to the Bay (Jacobs and HydroNumerics 2015a, b). The nitrogen load reduction target of 1000 tonnes per year was met through a combination of upgrades to the Western Treatment Plant, implementation of water sensitive urban design to manage urban stormwater, and improved rural land management (Jacobs and HydroNumerics 2015a, b). Among the specific achievements:

- The 500-tonne nitrogen reduction target for Western Treatment Plant inputs was met as a result of significant upgrades to the plant completed in 2004–05.
- Fifty-two wetlands were constructed in urban areas to prevent up to 109 tonnes of nitrogen from entering waterways.
- Programs to improve rural land management practices in the cropping, grazing and horticulture industries were developed and implemented. These programs focused on raising awareness and building capacity, encouraged landholders to adopt best practice land management approaches and provided assistance to landholders to restore degraded land and reduce nutrient runoff.
- Water sensitive urban design (WSUD) has been promoted heavily since 2001. Actions include the introduction of mandatory stormwater quality performance standards for new developments, revision of Clause 56 of the *Victoria Planning Provisions* to include stormwater quality objectives for sub-divisions, implementation of a development stormwater offset scheme, and preparation and implementation of Municipal Stormwater Management Plans.
- Measures were introduced to reduce nitrogen discharge from industrial, sewerage and aquaculture sources. These included upgrades to local sewage treatment plants, connection of small wastewater treatment plants to larger sewerage systems and increased reuse of wastewater.
- Water quality monitoring programs were established, including the nutrient cycling monitoring program and storm event monitoring program. The EPA's fixed site water quality monitoring program has also continued.

Western Treatment Plant – activated sludge plants within the treatment lagoons have enhanced nitrogen removal. Photo – Melbourne Water

Northern Pacific seastar (*Asterias amurensis*) is a marine pest that was discovered in the Bay in 1995. It is thought to have been introduced to the Bay via discharge of ship ballast water. Photo – mrpbps



Marine pests

The 2001 Plan acknowledged that risks associated with marine pests are most effectively addressed by nationally agreed arrangements and, in their absence, statewide programs. The 2001 Plan's marine pest program therefore aimed to address key Bay-focused tasks and form an additional layer to the relevant statewide and national programs. Specifically, the objective of the 2001 Plan was, 'Continue to improve the management of vectors that lead to the introduction of marine pests to the Bay, reduce the impact from introductions through early detection and rapid response action where possible, and reduce the impact on the Bay from established pest populations where technically feasible'.

Achievements of the marine pest program included:

- The EPA released the W*aste Management Policy (Ships Ballast Water)* in 2004 and in 2006 published *Environment Protection (Ships Ballast Water) Regulations* to ensure that high-risk ballast water was not discharged into Victorian ports or waters.
- Engagement and communications programs were undertaken to educate small boat operators on simple steps to avoid translocating marine pests. The Boating Industry Association of Victoria implemented a communication program to reduce the risk of pest relocation by small vessel operators.
- *Victorian Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria* were completed to help control the risk of introduction and spread through aquaculture. Protocols developed under the guidelines included the Victorian Protocol for the *Translocation of Blue Mussels; the Victorian Abalone Aquaculture Translocation Protocol* and Management Plans for aquaculture reserves declared under the *Fisheries Act 1995*.

Other relevant achievements for the management of marine pests at the national level included:

- Introduction in 2001 of mandatory *Australian Ballast Water Management Requirements* for internationally sourced ballast water and trial of a national approach for ballast water management at the Port of Hastings.
- The *National System for the Prevention and Management of Introduced Marine Pest Incursions* (the National System) was introduced in 2009.
- A series of national biofouling management guidelines were published under the National System between 2009 and 2013 for recreational vessels, non-trading vessels, commercial fishing vessels, the petroleum production and exploration industry, commercial vessels and the aquaculture industry.
- Australian marine pest monitoring guidelines and an accompanying *Australian marine pest monitoring manual* were published in 2010 as part of the National System.
- National Control Plans were developed under the National System and published in 2009 for control of the Northern Pacific seastar (*Asterias amurensis*), Asian bag or Date mussel (*Musculista senhousia*), European green shore crab (*Carcinus maenus*), Japanese seaweed or wakame (*Undaria pinnatifolia*), European or basket shell clam (*Varicorbula gibba*) and European fan worm (*Sabella spallanzani*).
- The *Commonwealth Biosecurity Act 2015* replaced the *Quarantine Act 1908* and provides a framework for consistent national regulation of ballast water management. The timing for transition from state-based to national regulation of domestic ballast water is yet to be confirmed.

Research programs

Following the 2001 Plan, investment in research has continued to improve our knowledge and understanding of the Bay. The Seagrass and Reefs Program was a $5.5 million investment in research and management of seagrass and temperate reefs. Key outcomes include better understanding of ecological processes for seagrass and temperate reef habitat. The program also provided funding to Museums Victoria for development of a *Marine Taxonomic Reference Toolkit*. The toolkit includes images and taxonomic and habitat information for more than 1000 animal species that inhabit or have been recorded in the Bay.

While a lot of work and research has been done to help protect and enhance the health of the Bay since the 2001 Plan, there is still more to do to ensure the Bay remains healthy and resilient, and responds to the pressures of a growing population and the challenges associated with climate change.

Subtidal rocky reef at Jawbone Marine Sanctuary, with native eleven-armed seastar *(Coscinasterias muricata)* and sea urchins *(Helliocidaris erythrogramma)*, over a bed of blue mussels *(Mytilus edulis)*. Photo – Parks Victoria

Infrastructure

Achievement of the **500 tonne reduction target** in annual nitrogen loads to the Bay through investment of $160 million in upgrades to the Western Treatment Plant

$60 million invested to **remove 109 tonnes of nitrogen from waterways** through construction of 52 wetlands and other water sensitive urban design initiatives

Local planning

Introduction of **mandatory stormwater quality performance standards for new developments** through Clause 56 of the planning scheme

Implementation of a **stormwater offset service** for new developments that cannot meet best practice stormwater management under Clause 56

$20 million provided to councils in the Bay catchment to prepare and implement their **Municipal Stormwater Strategies**, including construction of raingardens, wetlands and other strategic water sensitive urban design projects

Education and incentives

More than **10 capacity building programs** in partnership with local government, community groups and landholders to develop and implement best management practices for reducing nitrogen inputs to waterways from rural areas

Incentives for landholders to **restore degraded land and reduce sediment and nutrient loads** to waterways and the Bay through fencing of stream frontages and revegetation

Engagement and communications programs with small boat operators to raise awareness and encourage adoption of simple steps to avoid translocating marine pests

Monitoring and research

A **Bay nutrient cycling monitoring program,** established in 2001/02

A **storm event monitoring program**, established in 2001/02

Undertook **research to improve understanding of existing marine pest populations** and impacts on nutrient cycling processes in the Bay's sediments

Invested $5.5 million in **research on seagrass and temperate reefs**

Policy and guidelines

Publication of the **Waste Management Policy (Ships Ballast water)** and **Environment Protection (Ships Ballast water)** Regulations to reduce the risk of spreading marine pests through domestic ballast water

Contribution to the **National System for the Prevention and Management of Marine Pest Incursions** in collaboration with other governments

Figure 11 Highlights of environmental management for the Bay since 2001

PRIORITY AREA 1

Connect and inspire

The aim of this priority area is to **improve the community's appreciation and understanding of Bay values** – environmental, economic and social. This includes improving awareness of Aboriginal cultural values, and understanding how to strengthen them through environmental management of the Bay.

Improved awareness of Bay values and of management agencies' roles and responsibilities (Priority area 2) will be an important step towards fostering a deeper connection between the Bay and its residents and broader community stewardship, and towards inspiring greater everyday actions to reduce impacts on the Bay.

The *Victorian Coastal Strategy* highlights the important role of coastal heritage values in creating our sense of place and defining who we are. There are past and present traditions of Traditional Owners, and places created by early and recent settlers, as well as customs, celebrations and special characteristics that build community pride and enhance social cohesion (Victorian Coastal Council 2014).

Improving our collective understanding of Aboriginal cultural values of the Bay is an important issue for community and stakeholders. The Plan provides an opportunity to improve understanding of Aboriginal values by government, industry and the broader community.

There is also an opportunity to empower the Aboriginal community to strengthen connections with their Sea Country, build traditional knowledge across the generations and undertake broader community education.

The people of the Kulin nation lived on and around the Bay for thousands of years prior to European settlement. These people have actively cared for the Bay and acquired extensive traditional knowledge of its flora, fauna and physical changes.

It is important that their values, interests and traditional knowledge of the Bay are recognised, and that people of the Kulin nation are empowered to continue their role as traditional custodians.

Traditional Owner groups are committed to providing a secure future for their community by upholding the dignity of their ancestors, respecting their Elders and instilling a sense of cultural pride in their children. They are working towards providing opportunities for their people to connect with and preserve cultural heritage and to manage lands appropriately, including sites of significance.

Research commissioned by the Victorian Coastal Council found that the coast is an important part of the lives of many Victorians; 84% of those surveyed had made at least one day trip to the coast in the past 12 months, with the average number of day trips in the past 12 months being 23 (Ipsos 2012).

There are more than 400 known sites of Aboriginal significance around the Bay, including shell middens, camps and burials. Many of these sites are threatened by coastal erosion. Photo – Ashley Matic

Cultural tour of the Mornington Peninsula at a significant site where the rock wall is now protecting a previously eroding midden and a rare hearth featuring cooking rocks. Photo – Bunurong Land Council

The same study found a general consensus among respondents that the Victorian coast is healthy. There was also strong agreement with the statement, 'The flora and fauna that live in marine environments are important to all Victorians' (with a mean rating of 8.4 on a zero to ten scale). However, when questioned about their knowledge of the marine and coastal environments, respondents gave an overall mean rating of 5.3. These responses indicate a high degree of awareness of the importance of the marine and coastal environment, but less confidence in their understanding or knowledge of it.

The report on community attitudes also indicated that coastal and marine management is generally not 'visible' to the community, leaving most unsure as to what is involved in actively managing these environments (Ipsos 2012). The same report indicated that Victorians generally did not feel well informed about coastal planning and management. When people were unsure about who managed the coast, there was a greater tendency to assume that it was not being well managed (Ipsos 2012).

Community groups providing submissions, survey respondents and people at the beachside listening posts also highlighted the importance of increasing awareness of the value provided by the Bay and the role of individuals in maintaining its health. This was highlighted in the online survey, with 115 mentions of 'educating and empowering community'. One respondent commented: "More education (is needed) in the community about the Bay as a natural resource and how to protect it and restore it. Government should work closely with community environment groups and support and fund them to do citizen science and education for and in the community."

In their assessment of marine values, Hale and Brooks (2015) concluded that the Bay is important ecologically, economically and socially. However, the community's depth of understanding of these values (particularly the Bay's ecological values) is less certain.

People suggested that education could improve the community's ability to participate in management and decision-making processes for the Bay.

An example of insufficient education hindering the community's participation was found in their prioritising of environmental values. Community members identified whales as a priority over saltmarsh and mangroves, despite the fact that, at the site in question, saltmarsh and mangroves provide habitat for many species and improve water quality (Hoye *et al*. 2008). This highlights the need to educate the community on the context in which decisions are made and the Bay values they aim to improve.

Respondents to the online survey indicated a need for improved management of the Bay. Responses indicated confusion over which agencies were responsible for management of the Bay. This was highlighted further by requests for clearer identification of agencies responsible for key issues such as litter prevention and jet-ski behaviour. There was also a widely-held belief in the need to communicate a whole-of-catchment view of the various actions being undertaken to protect the health of the Bay. As one respondent suggested:

"There is a need for community groups from the start of the catchment to the Bay to understand all the work that is going on to protect the catchment. For example, how do stormwater pollution prevention measures in Doncaster or Warrandyte relate to school education activities to monitor impacts on Bay beaches?"

To improve understanding of Bay values, it is important to clearly communicate the roles and responsibilities of the various management agencies. This will help to identify who people should contact if they want to report an incident, seek information or get more actively involved in caring for the Bay.

PRIORITY AREA 2

Empower Action

This priority area aims to **improve collaboration and partnerships across community, industry and government** to deliver on outcomes of the Plan. Similar to 'Connect and inspire', the idea of empowering groups to take action was supported by all stakeholder groups. Stakeholders wanted more coordination across government and better partnerships with community groups.

This priority area recognises the need to establish networks to support citizen science programs and local community groups, and to consider establishing regional support hubs. This could be undertaken on a catchment-by-catchment basis and help to identify any gaps in the existing network of capacity building programs and the best mechanisms to address these. Region-wide support programs are important, but local community groups also need access to catchment-based support to provide connections to other local community groups and on-ground projects.

As one key stakeholder group noted during the project consultation:

"More than mapping activities, or communication (e.g. Landcare network magazine), there is a need for a resource across the catchment to link all the regional community groups. Hubs like the Port Phillip EcoCentre provide the support and linkages to on-the-ground community groups. These community groups typically don't have the resources to connect to the wider network and are practically focused on activities and outcomes in their 'patch'. A resource that can travel and link regional hubs and therefore connect to local community groups with face-to-face communication would provide the connection and some inspiration that all efforts across the catchment are making a difference."

Providing adequate support to local community groups will also enable these groups to be active across a number of issues, and will provide more interesting opportunities to attract more volunteers.

As a key stakeholder group noted during the consultation: "Supported citizen science activities also need to have a multiple focus – not everyone wants to count litter as their interaction with the environment. This provides flexibility in the choice of activity with the number of people involved and required. For example, a section of beach can be measured for erosion, sea level rise, microplastics, litter and inter-tidal species in one activity. This enables different groups to rotate through multiple activities, or the number of activities can be adjusted to those where more frequent data is worth recording, dependent on the numbers involved. Coastal erosion may be measured from the widest and narrowest points on the beach annually, inter-tidal species may be collected as a school holiday program educational activity, and beach litter data may be recorded more regularly (e.g. monthly) for a database."

A number of key stakeholder groups also suggested the need for consistent and rigorous methods for citizen science and opportunities to develop innovative digital tools (such as apps) to support citizen science and on-ground management activities. For example, apps have been developed to provide field guides for identification of native flora and fauna and pest species, for entering field data, and for displaying easy to access environmental reports. An example is Birdlife Australia's '*Bird Conservation Portal*' for citizen science data collection (web-based) and analytics.

Students from Point Lonsdale Primary School attending a Coastcare Day facilitated through the Caring for Our Bays program (http://www.environmentbellarine.org.au/CaringForOurBays). Photo – Matt Crawley.

Cleanup day at Kerford Road Pier, Albert Park, organised by Tangaroa Blue Foundation. Over 75% of what is removed from our beaches is made of plastic. Photo – Tangaroa Blue Foundation (http://www.tangaroablue.org/).

Industry has the potential to reduce impacts on Bay values by adopting better management approaches and operations, but will need assistance in the form of capacity building to achieve these improvements. The term 'industry' covers all organisations whose activities impact on Bay values, such as government agencies, local councils, water corporations and research institutes, as well as businesses (including those involved in land development and agriculture). Industries' capacity-building needs are typically similar to those mentioned previously for community groups, such as access to technical guidelines, tools, training and advice, and opportunities for peer-to-peer learning and sharing knowledge.

There are a number of existing industry capacity building programs focused on improved urban stormwater and integrated water cycle management such as the Clearwater program hosted by Melbourne Water and the industry outreach activities of the CRC for Water Sensitive Cities, which are providing secondary benefits in reducing pollution to the Bay. Melbourne Water also provides support to local councils through its Living Rivers Program and to farmers through the Rural Land Program. Corangamite CMA and Port Phillip and Westernport CMA provide capacity-building support to rural landholders to reduce their pollution run-off to waterways. There is an opportunity to build upon and enhance these programs, and/or establish new programs to align with the goals and priorities of the Plan. Strong partnerships with peak industry bodies will be needed to ensure success.

PRIORITY AREA 3

Nutrients and pollutants

The aim of this priority area is to take action to **ensure nutrient and sediment loads flowing into the Bay do not exceed their current levels, and other pollutant loads are reduced where practicable.**

The Plan considers nutrients and pollutants to be a priority area for enhancing the Bay's health for the following reasons drawn from the background investigations and described in the earlier sections of this document:

- **Population growth and climate change will increase nutrient, sediment and pollutant loads.** Estimates based on catchment modelling are that nitrogen loads to the Bay will increase by about half by 2050 unless actively managed. Future scenarios indicate that the Western Treatment Plant remains the major contributor of nitrogen to the Bay, and the Yarra catchment the major contributor of sediment to the Bay. The Werribee and Dandenong catchments are predicted to have the greatest proportional increase in nutrient and sediment loads due to future urban development. Other pollutants will also increase as a result of increased stormwater runoff (and increased production and use of toxicants in the catchment).
- **Higher loads of nitrogen will increase the risk of algal blooms and near-shore impacts.** Modelling has shown that a nitrogen load of 15,000 tonnes per year would result in algal blooms in the northern part of the Bay for most of the year. Near shore waters are likely to 'tip' at this level, meaning the nitrogen cycling processes may cease to function permanently. The science knowledge synthesis conducted for this report (and earlier *1996 Port Phillip Bay Environmental Study*) recommended that nitrogen loads to the Bay should remain below 6000 tonnes per year. As loads increase beyond this level, risks to Bay values increase, including the potential for more frequent and intense algal blooms. Modelling has shown that when nitrogen loads from the Western Treatment Plant move clockwise around the Bay and combine with loads from the Yarra, algal blooms are more likely to occur along the eastern beaches, which will have significant impacts on recreational and amenity values.
- **SEPP (Waters of Victoria) water quality objectives will be exceeded if no action is taken to mitigate increased loads of nitrogen.** Water quality modelling showed that when nitrogen loads exceed 6000 tonnes per year, 75th percentiles values for chlorophyll 'a' in Hobsons Bay will exceed the *SEPP (Waters of Victoria)* water quality objective of 4µg/L.
- **Ecological functions are tightly tuned to nitrogen.** Obtaining direct evidence of ecological effects from increased nitrogen is complex. For example, nutrient loads in the north of the Bay are thought to be affecting the diversity and condition of rocky reefs, leading to 'urchin barrens' (Carnell and Keough 2014). Conversely, reduced inputs of nitrogen during the 1998-2010 drought coincided with observed declines in seagrass beds and reduced fish recruitment (Parry and Hirst 2016). Hence, maintaining the Bay's ecological function is not as simple as removing all nitrogen loads, but rather obtaining a balance that sustains productivity and avoids eutrophic conditions.

Installing water sensitive urban design features, such as raingardens, can reduce the contribution of stormwater pollutants to waterways and the Bay. Photo – Melbourne Water

- **Western Treatment Plant annual loads of nitrogen should not exceed 3100 tonnes.** Nitrogen loads from the Western Treatment Plant are forecast to increase beyond the previous Plan's annual limit of 3100 tonnes, to 3800 tonnes by 2036-37, and 4900 tonnes by 2051-52 as a result of increases in sewage flows. However, annual loads will vary significantly with rainfall. Years of above average rainfall will provide greater challenge for keeping loads below the 3100-tonne limit. The water quality modelling showed that when the 3100 tonne limit is exceeded, chlorophyll 'a' in Hobsons Bay exceeds the SEPP (Waters of Victoria) water quality objective of 4µg/L, which impacts beneficial uses.
- **Managing catchment inputs is as important as managing discharges from the Western Treatment Plant.** The efficiency of the nitrogen cycling process across the Bay is impacted more by changes in Yarra/Maribyrnong flows than discharges from the Western Treatment Plant. This is because the process can be impacted by changes in climatic conditions, phytoplankton dynamics and other factors that affect benthic microbial processes. Loads from rivers are also highly variable in comparison to treated wastewater discharges. Monitoring of nitrogen cycling in Hobsons Bay has shown that the efficiency of the process is reduced following high flow events. When this occurs there is increased likelihood of algal blooms.
- **Better knowledge of nutrient loads, both overall and between nitrogen species, can help target management actions.** Analysis of the different forms of nitrogen in waterways can indicate the likely source. This can then inform targeted interventions. For example, nitrogen loads in Queensland rivers that discharge to the Great Barrier Reef are estimated to contain 80-85% of anthropogenic dissolved inorganic nitrogen, which comes from fertiliser. This knowledge has helped focus management actions on changing farming practices to reduce nitrogen loads to the reef.
- **Planning mechanisms can be used to control the impacts of stormwater on waterway and Bay health.** Clause 56 of the *Victoria Planning Provisions* is the main mechanism for managing the impact of stormwater in new residential developments (it is not applied to development in areas that connect to existing drainage systems). Clause 56 requires the implementation of best-practice environmental management (BPEM) guidelines for stormwater quality management. This includes retention of typical urban loads of total nitrogen (45%), total phosphorus (45%), total suspended solid (80%) and litter (100%). The guidelines have been important in promoting greater adoption of water sensitive urban design, such as wetlands and bio-retention systems, in new urban areas. However, for existing urban and industrial areas there is inconsistent application of improved stormwater management. The existing urban area is far greater in size than the area of new urban development, and as such offers significant opportunity to reduce loads to waterways and the Bay.
- **Denitrification continues to be a critical process within the Bay, and should continue to be monitored.** Denitrification at both regional and bay-wide scales remains a highly efficient process at removing nitrogen from the Bay, and continues to assist in the maintenance of water quality.
- **There is a knowledge gap regarding the long-term impacts of toxicants on ecosystem components.** Toxicants are generally below guideline levels in the Bay, with increased levels found in a few localised areas. However, there is a need to better understand the short-term and long-term impacts of chemicals of emerging concern, such as endocrine-disrupting compounds, pharmaceuticals, flame retardants, pesticides (other than organochlorines), and microplastics.

Constructed wetlands require regular maintenance to ensure that they remove nutrients, sediments and other pollutants from stormwater. Photo – Melbourne Water

Setting nutrient and pollutant targets

The 2001 Plan included a 1000 tonne reduction in the annual load of nitrogen by 2006. This was to be achieved by reducing annual loads from Western Treatment Plant by 500 tonnes and the catchment waterways annual load by 500 tonnes (with a split of 350 tonnes from the Yarra/Maribrynong Rivers and 150 tonnes from other waterways but focusing on the Dandenong catchment). To allow for reporting on progress, a calculation of the baseline levels (for the period 1991–1995) was confirmed immediately following the release of the 2001 Plan.

Having a clearly defined bay-wide target and a split between sources allowed agencies to implement specific actions. The target also assisted more broadly in communicating the need for, and achieving the required reductions.

The desired 10-year outcome statement for nutrients and pollutants in the Plan (that 'the nutrient and sediment loads flowing into the Bay do not exceed their current levels and other pollutant loads are reduced where practicable') translates to a zero increase in nitrogen and sediment loads, and a need to actively mitigate forecast increases. For nitrogen, the level of mitigation equates to about a 2500-tonne reduction over 30 years, or an 800-tonne reduction over the next 10 years.

Concepts of total catchment management and its role in managing urban runoff as discussed in the early 1990s (Collett 1992) have evolved into current concepts of water-sensitive urban design and integrated water cycle management.

However, the key elements of managing the problem at the source still require further development. The individual's opportunity to influence the outcome is lost with large and costly end-of-pipe solutions.

To improve outcomes in the Bay, there is a need to address runoff at the source. Regulatory arrangements and incentives supporting local solutions (involving developers and individuals) can drive improved behaviours at the allotment scale. For urban runoff this may mean altering drainage charges or building regulations to ensure that runoff can be sustainably managed and retained on the property. This approach would reduce nutrient and pollutant loads to the Bay, and minimise investment in large-scale infrastructure.

To achieve the nitrogen and sediment targets in a sustainable manner will require a paradigm shift for stormwater management.

The actions in the Plan for nutrients and pollutants have been designed to address reduction targets by strengthening existing controls for managing loads from both wastewater and stormwater. These actions address key knowledge gaps, develop methods of tracking performance, support catchment-based decision making, and align with the state's broader directions in the *Water for Victoria* plan.

Sewage flows to Western Treatment Plant are forecast to increase in line with population growth. Further upgrades will be required to ensure the volume of nitrogen discharged does not exceed current limits. Photo – Melbourne Water

PRIORITY AREA 4

Litter

The aim of this priority area is to deliver actions that **reduce the amount (volume and count) of litter delivered to the Bay** to conserve amenity and marine life.

The 2001 Plan incorporated litter into the nitrogen program, where litter reduction benefits were gained through broader stormwater management initiatives. For example, the government funded the installation of gross pollutant traps through the *Victorian Stormwater Action Program* (DSE 2003).

According to the *2014-15 National Litter Index*, industrial and retail sites are the most littered sites in Victoria. Industrial sites were noted as generating the highest volume of litter, while retail sites generated the highest count of litter items. Beaches were next on the list with moderate numbers and volumes of litter. Other public places and recreational sites were associated with smaller numbers and volumes of litter. Overall, the index shows a continuing trend of reduced rates of littering across Victoria. However, beaches are still prominent locations for the accumulation of litter, and this is a significant concern for the community.

Beach Patrol, a volunteer-based organisation that organises litter clean-up days at 20 Bay beaches, has collected over 33,000 kilograms of rubbish since 2009, including 93,970 cigarette butts (Beach Patrol 2017).

In 2014-15, the EPA issued more than 13,000 fines, with 60% of infringement notices for lit cigarettes. The City of Melbourne is also actively involved in managing cigarette butt litter through installation of special butt bins in high-use areas and collection of butts for recycling into shipping pallets.

Currently, litter management in the Bay is a mix of clean-up and prevention activities. Bayside councils (in some cases with the assistance of community groups and committees of management) are responsible for removing litter along the foreshores, for removing suburban litter, and reducing the likelihood of litter being discharged to the Bay.

While most activities focus on capturing litter (e.g. through gross pollutant traps, street sweeping, bins in public places, beach sweeping), some councils have developed litter prevention strategies to reduce the incidence of littering.

To assist more councils and the community to reduce littering behaviour, the Victorian Government has developed the *Victorian Waste Education Strategy* (Sustainability Victoria 2016). The strategy, which is being coordinated by Sustainability Victoria, identified six strategic directions to guide waste and resource recovery education over 10 years (2016 to 2026):

1. Increase the Victorian community and business perception of waste management as an essential service.
2. Increase community awareness of waste, and support and encourage waste avoidance.
3. Improve resource recovery and reduce contamination.
4. Reduce litter and illegal dumping.
5. Support waste and resource recovery education for schools.
6. Strengthen Victoria's waste and resource recovery education capabilities.

The Litter Hotspots Program, which was part of *A Cleaner Yarra River and Port Phillip Bay – A Plan of Action* (DSE 2012), has been managed by the Metropolitan Waste and Resource Recovery Group. The program, which commenced in 2014, provided funding to local governments, businesses and community partnerships to target litter issues in local areas around the Bay.

In coordinating best-practice litter prevention, the Victorian Litter Action Alliance (VLAA) has developed a best-practice model (Figure 12) based on behaviour change theory and built around the following three elements (VLAA 2014b):

- **Education:** Includes information, incentives and communication to explain the issues associated with litter, and encouraging correct and appropriate disposal of litter in any given situation.
- **Infrastructure:** Includes bins and signs in appropriate public places to enable people to correctly dispose of litter.
- **Enforcement:** Provides consequences and penalties for those who litter, and a deterrent and powerful message that littering is unacceptable.

An evaluation of the Litter Hotspots Program found that most projects followed the VLAA best-practice model for litter prevention, with community projects largely focusing on 'education' and council projects focusing more on 'infrastructure' and 'enforcement'. It was also deemed that many inter-organisation relationships were developed and strengthened. The program also improved the amenity of public spaces that impact on the water quality of the Yarra River and the Bay (Alluvium 2016).

Since the 2001 Plan, research and monitoring has commenced into the impact of microplastics in the Bay. Citizen science projects have sampled sediment and beach sands for microplastics. Research specific to the Bay is being conducted at RMIT and the EPA.

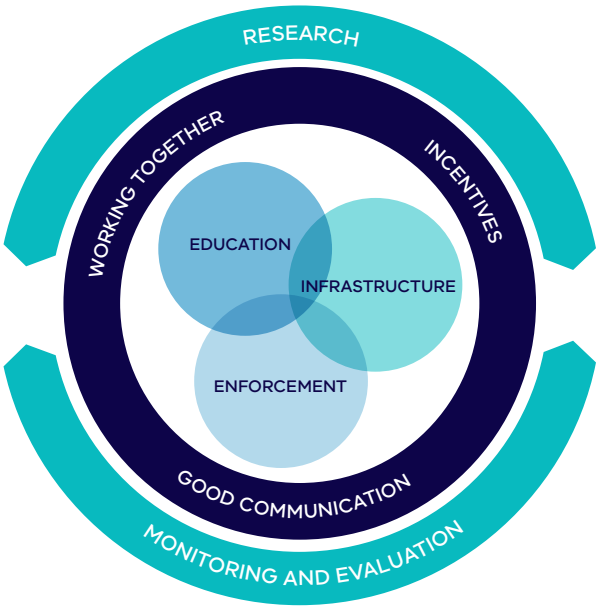


Figure 12 Victorian Litter Action Alliance best practice model (VLAA 2014b)

The Litter Hotspots Program has funded initiatives such as Operation Clean Sweep (led by Tangaroa Blue Foundation) to educate and change practices in managing loss of nurdles (plastic pre-production pellets) from manufacturing sites. Additionally, the Federal Government has initiated a voluntary phase-out, by July 2018, of microbeads in personal care products, with a proposal to ban microbeads if voluntary adoption rates are low.

Beach clean-up day at Altona organised by Melbourne Water and the Bay Keeper (http://www.bay-keeper.com/). Photo – Melbourne Water

The Plan considers litter to be a priority area. The background investigations, risk assessment and consultation support this decision, as outlined here:

- **Litter poses a risk to the Bay's health.** The environmental risk assessment identified litter (including microplastics) as a high risk to Bay health. The assessment noted large amounts of litter are still being discharged into the Bay, affecting the amenity and use of beaches and marine life.
- **Litter is a threat to marine life.** The science knowledge synthesis conducted for the Plan reiterated the threat of litter to marine life that was noted in the environmental risk assessment. The impact of large plastic material on marine life such as birds and seals is well established. However, research is increasingly highlighting microplastics as a major issue for litter management. Smaller sized plastic particles can be ingested by marine life and have a large surface area to absorb and release toxicants.
- **Litter loads to the Bay are likely to increase with population growth.** The science knowledge synthesis and environmental risk assessment both emphasised the effect population growth and increased urbanisation will have on litter loads to the Bay.
- **Stormwater is the primary vector for litter entering the Bay.** It was estimated that up to 95% of litter polluting the Bay is transferred through the drainage network. The 1991–1993 Tagged Litter Study showed that potentially all litter that enters the drainage network could reach the Bay (Melbourne Water 1993). However, the final volume reaching the Bay is dependent on the characteristics of the drain (natural or constructed) proximity to the Bay, and interventions (litter traps). Travel time is related to size of rainfall events and flow patterns within waterways.
- **Litter is a concern to the community.** In the online survey conducted for the Plan, litter was mentioned 373 times in free text comments; plastic, microplastic and nurdles were mentioned 167 times. Various sources of litter were mentioned, including industry, anglers, smokers, visitors and festivals/events. Stakeholders and the community were concerned about the impact of litter on both water quality and the cleanliness of beaches.
- **Littering behaviour has improved, but is still a significant issue.** In 2013-14, 10,240 cubic metres of litter, silt and debris were removed from waterways around Melbourne (Melbourne Water 2014). The Victorian Litter Report 2013 notes that littering behaviour, although less than in 2003, plateaued between 2011 and 2013. Littering behaviour at waterfront precincts and easement sites improved, while littering behaviour at beaches, markets, public buildings, parks, malls and shop areas deteriorated (Sustainability Victoria 2014).
- **Litter clean-up costs are significant.** In 2012–2013, litter and street cleaning maintenance cost Victorian local councils more than $94 million (Sustainability Victoria 2014). The majority of this cost was directed at clean-up activities.

The actions in the Plan for litter have been designed to connect and strengthen the efforts already proposed as part of the *Victorian Waste Education Strategy*, as well as build on the efforts of community groups and government agencies.

Litter on the bank of the Yarra River. Much of the litter on our streets washes into drains that flow to the Bay. Photo – Tangaroa Blue Foundation (http://www.tangaroablue.org/)

PRIORITY AREA 5

Pathogens (human health)

The aim of this priority area is to **minimise risks to human health from pathogens**, and to ensure the Bay's water quality supports the community's recreational uses. It also aims to provide assurance that shellfish collected from the Bay are not contaminated by human pathogens.

Pathogens are microscopic organisms including viruses, bacteria, fungi and parasites. Contamination by pathogens can make water unsafe for swimming as they may lead to infections and illness in humans. The presence and concentration of pathogens is a key measure of recreational water quality.

Pathogens are also a risk to aquaculture and for harvesting of shellfish by the public. This includes blue mussels, a bivalve mollusc that is grown commercially in fishery reserves in the Bay, and other bivalves that may be collected from the Bay. Mussels, like other bivalves, are filter feeders that extract phytoplankton, bacteria and suspended organic and inorganic particles from the surrounding water as their food supply. As a consequence of their ability to bioaccumulate pathogens and toxins derived from contaminated waters, and because they are often eaten raw or only lightly cooked with the gastrointestinal tract intact, bivalves have been associated with numerous outbreaks of human disease (ASQAAC 2009).

Sources of pathogens

In dry weather, sources of pathogens entering the Bay include spills of sewage as a result of blockages and leakage from sewers, cross-connections between the sewerage and stormwater system, poor house-keeping in industrial and retail sites, unregulated discharge from onsite wastewater systems (septic tanks), animals (e.g. animal faeces, aquaculture), direct discharge of waste from marine vessels, and bather shedding (shedding of bacteria from the skin of people in the water).

In wet weather, pathogen concentrations are likely to increase due to temporary discharge of sewage from the sewerage systems and runoff from urban and rural land. Infiltration and inflow into the sewerage system during wet weather events can exceed the capacity of the sewer and result in overflows.

Rather than these overflows occurring in a residential property, sewerage systems are designed with emergency relief structures to release this diluted sewage into areas of lower risk in the environment, such as waterways. *SEPP (Waters of Victoria)* requires sewerage infrastructure to be designed to contain flows associated with a 1-in-5 years rainfall event. The expectation is that when overflows occur during such rainfall events, there is sufficient dilution to minimise the impact on beneficial uses. However, not all sewerage infrastructure in the catchment currently meets this standard.

Other known sources of pathogens include discharges from wastewater treatment plants and onsite domestic wastewater systems such as septic tanks. Wastewater treatment plants ensure that sewage is treated and disinfected to reduce risks where effluent is discharged to receiving waters. Similarly, onsite systems require proper maintenance to prevent the transport of nutrients, pathogens and other pollutants to surface waters and to prevent any impacts on groundwater.

SEPP (Waters of Victoria) and nationally *MARPOL* (which is the International Convention for the prevention of pollution from ships), regulate the discharge of wastewater from vessels. This means that sewage produced on board a boat or ship must not be discharged into the Bay.

One of the highest risks to recreational water quality is from discharges or flows during dry weather from stormwater drains or waterways that contain high concentrations of faecal contamination (EPA 2012a). As there are often no apparent reasons for these higher concentrations, the associated risks cannot be forecast and communicated to the public. Weekly water quality sampling is unlikely to detect these unexpected discharges or flows, and only detects them if they occur on the day of sampling. If these incidents occur during summer, there is greater likelihood of beach users being at risk of sickness. Some work tracking pathogens at Mornington and Frankston has been completed by the EPA to help identify and manage sources.

Using risk profiles to set water quality objectives for pathogens

The intent of recreational water quality objectives in *SEPP (Waters of Victoria)* was to set pathogen levels that protect beneficial uses of primary and secondary contact, and seafood consumption. These objectives were not based on relationships of pathogen concentrations and health outcomes.

For primary and secondary contact, objectives linked to health outcomes are available in more recent national guidelines, but are based on an overseas epidemiological study conducted more than ten years ago. Future water quality objectives would benefit from being based on accurate representation of health risks for the Bay and other Victorian marine waters.

It is also unclear whether the legislative requirements in place for reporting and collating information on swimmer-related illnesses are providing suitable data to inform the health risk from swimming. Another consideration is that Bay users can modify their behaviour in response to potential or known contamination, and this may have flow-on effects when developing risk profiles.

If receiving water quality objectives are set at a higher level than is needed to protect human health, there is potential for water corporations and other stakeholders to over-invest in mitigation, with no increase in health benefit for Bay users.

Improving the quantification of human health risks will support:

- Decisions on investment in mitigation of faecal sources (e.g. sewer or treatment upgrades, council integrated water plan actions) to be based on evidence of health risk, with less investment needed where health risk is low.
- Recreational water quality objectives to be more protective of public health, set at the microbial levels linked to health outcomes, resulting in better management of faecal sources and communication of risk.

Communicating risk to beach users

As part of the Beach Report program, the EPA monitors water quality in the Bay. Water samples are collected weekly at 36 beaches. Enterococci, which is used as the indicator for bacteriological water quality in marine waters, is a group of bacteria found in the intestinal tracts of mammals (including humans), and is strongly associated with faecal waste (i.e. sewage).

The EPA's Beach Report provides recreational water quality information to the public, so people can make informed decisions about when and where it's safe to swim in the Bay. The Beach Report also provides EPA and catchment managers with water quality data to inform on immediate risk to beach users during the summer, and to inform where management is needed to protect and improve water quality.

Stormwater drain at St Kilda.
Photo – Tangaroa Blue Foundation
(http://www.tangaroablue.org/)

Current end-of-season reporting for the last five years shows that approximately half of the Bay's beaches met objectives between 2011-12 and 2012-13 (due to wetter summers), with 94–97% of beaches meeting objectives in the last two summers. During the 2016-17 summer season, 97% of beaches around Port Philip Bay met the water quality objectives for swimming. The Department of Health and Human Services has not reported any outbreaks of water-borne illnesses from recreation in the Bay during this period.

There has been considerable development in approaches and technologies to improve Beach Report's capability to monitor and inform on water quality risk to the public, and to assist catchment managers to mitigate risk. Examples of this are microbial techniques with faster analysis times, better source tracking and real-time water quality information. This could also include monitoring linked to changes in flows in local drains and waterways.

The EPA's current forecast model provides basic information on water quality risk but it could be improved by using the latest modelling techniques. The current model is also not easily automated for increased timeliness of forecasts.

Communication of Beach Report forecasts and beach advisories is via the Yarra and Bay website (http://yarraandbay.vic.gov.au/beach-report) and EPA Twitter account. This communication could benefit from improved adoption of digital technologies and other strategies that result in behaviour change. The program's communication and detection of risk could also be further improved by inclusion of citizen science to communicate and gather data.

Actions to reduce risk from pathogens

The Plan has included recreational water quality as a priority area for the following reasons:

- **Current standards and indicators for recreational water quality are being reviewed.** The *SEPP (Waters)* review includes a component of work reviewing water quality standards required to protect the beneficial uses for primary and secondary contact for recreational users.
- **The community's use of the Bay is impaired after storm events.** Beach Report recommends people avoid swimming near stormwater or river outlets 24–48 hours after heavy rain. This is due to the associated risk of contamination.
- **Better information on sources of faecal contamination would enable more targeted improvement strategies.** Faecal contamination sources are likely to be from diffuse sources and are difficult to isolate. As a result, the relative contribution of various sources and their impact on the recreational water quality in the Bay is unknown.
- **The community's top values for the Bay are recreational.** Opportunities for relaxation, socialising and recreation (21%); and swimming (17%) were two of the top ranked community values tested through the development of the Plan. Many survey respondents also used the free text comments to elaborate on their desire for clean water to swim in with fewer impacts after wet weather and less risk of illness from swimming.

The actions in the Plan will contribute to protecting the beneficial uses of primary and secondary contact, and seafood consumption in the Bay.

During summer, beach users can access the EPA's Beach Report to get daily forecasts for recreational water quality at popular beaches around the Bay (http://yarraandbay.vic.gov.au/beach-report). Photo – Parks Victoria

PRIORITY AREA 6

Habitat and marine life

The aim of this priority area is to **conserve and restore habitats** and to ensure conditions are suitable for marine life to thrive.

The Bay's habitat is described in Section 2. The Plan takes an active role in conserving and restoring Bay habitats and allowing marine life to thrive. Including it as a priority area is supported by the following points drawn from the background investigations and consultation. The findings from the Seagrass and Reefs research program on the ecology and management of seagrass and temperate reefs in the Bay have also informed this priority area (particularly the actions given in the Plan).

- **Habitats and marine life are key values of the Bay:** *SEPP (Waters of Victoria) Schedule F6* identifies ecosystems – natural, substantially natural with some modifications, and highly modified – as protected beneficial uses of the Bay. The Plan recognises that the conservation of all habitats and marine life in the Bay is required to maintain environmental values.
- **Healthy habitats and marine life are key factors in delivering economic benefits.** The value of habitats was not specifically assessed in the economic work valuing the benefits provided by the Bay. However, the Bay's habitats directly underpin services such as commercial and recreational fishing, aquaculture and tourism.
- **The community values the Bay's habitats and wants to see them conserved.** The online survey identified 'maintain and improve marine life and habitat' as the equal top challenge (36% of respondents). The top value of the Bay was 'a healthy marine habitat and wildlife' (26%). Support for habitat and marine life at the beachside listening post events was also high.
- **The consultation identified jet skis as a key challenge,** with respondents concerned about the potential dangers of jet skis on marine life from collisions, noise and petrol leaks.
- The environmental risk assessment (Hale and Brooks 2015) identified waterbirds, marine mammals, subtidal and intertidal reefs, and fish as most at risk, including:
  - **Waterbirds:** changes in habitat through erosion of shorelines and sea level rise.
  - **Marine mammals:** entanglement in marine debris, toxicants and disturbance by marine vessels (out of the scope of the Plan).
  - **Subtidal and intertidal reefs:** increased nutrients, leading to a decline in the diversity of macroalgae (seaweeds), and loss of habitat-forming kelps.
  - **Fish:** effects of sea urchin barrens and loss of habitat; and increased fishing pressure on target species (out of the scope of the Plan).
- **Research is needed to understand the spatial distribution of habitats and impact of stressors:** Hutchinson *et al.* (2010) in their *Temperate Reefs Literature Review*, stated that further research is required to understand the ecology of reefs, particularly sub-tidal reefs. Gaps identified included understanding of species composition, and the effect of spatial and temporal variation on assemblages. Current understanding is limited to particular sampling sites and times of year. Basic data on species composition, behaviour and ecology is lacking for subtidal reefs, while the potential impacts of sedimentation, pollutants and sea level rise on intertidal reefs is largely unknown.
- **Climate change is likely to have a significant impact on Bay habitats and marine life.** The science knowledge synthesis conducted for the Plan makes reference to a decline in fish biomass (up to 69% in the deep centre) during the drought from 1997 to 2010 (Parry and Hirst 2016). This was based on data from the Port Phillip Bay Annual Trawl Program (which ceased in 2011) and is further supported by observations of reduced algal growth and development of urchin barrens during this period, especially in the north of the Bay. The decline in fish stocks was attributed mainly to a reduction in algal productivity during the drought period. Warry and Hindell (2009) in their *Review of Victorian Seagrass Research*, identified climate change (as well as population pressures along the coast) as a significant threat to seagrass habitats.

- **Elevated sea urchin densities are a threat to the integrity of kelp beds on rocky reefs.** Grazing by large populations of the native sea urchin, *Heliocidaris erythrogramma*, has been implicated in the loss of macroalgal cover on reefs (particularly the once-dominant canopy-forming macroalga, *Eklonia radiata*) (Carnell and Keough, 2014). Urchin barrens have been formed on more than 90% of the reefs in the western and northern parts of the Bay. This is thought to have negatively affected reef-associated fish that depend on the macroalgae for food and shelter. *The Reef Ecosystem Evaluation Framework (REEF)* program for restoring the macroalgal canopy in the Bay, which was developed as part of the Seagrass and Reefs program, suggested that urchin densities be reduced to help rehabilitate kelp beds on rocky reefs (Johnson *et al.* 2015). However, as information is limited, an adaptive management approach is most appropriate.
- **Seagrass habitat is important to the enhancement of key fish stocks in the Bay and maintaining the value of fishing.** Seagrass beds provide important nurseries for many fish species, including species fished commercially and recreationally. Analysis by Blandon and Ermgassen (2014) estimated that seagrass habitat enhances the stock of King George whiting at a rate of 5 kilograms/hectare/year, which for commercial fishing has an economic value of $5.6 million per year. The value of other target species such as Snapper is also enhanced by seagrass habitat.
- **Bay activities are known to have damaged key habitats in the past.** Water pollution, marine pests and commercial fishing for scallops by dredging have significantly impacted shellfish reefs and other habitats in the Bay. Scallop dredging in the Bay was stopped in 1996 after more than 30 years of operation, and there have been continuing efforts to reduce water pollution and marine pests. Effort is now being invested in restoring some of these impacted habitats. Examples include the shellfish reef restoration projects being undertaken by The Nature Conservancy in partnership with Fisheries Victoria, The Thomas Foundation and the Albert Park Yachting and Angling Club (The Nature Conservancy 2016).

The actions in the Plan address key concerns raised by the community and build on existing government and non-government programs to address the management needs and knowledge gaps of this priority area. The impacts to marine animals through entanglement and other litter-related issues are addressed in the 'litter' priority area of the Plan.

The Common Greenshank (*Tringa nebularia*) is a migratory shorebird that arrives in early spring to feed on intertidal and wetland invertebrates, prior to their arduous northward passage in early autumn.
Photo – Dillon Wan

PRIORITY AREA 7

Marine biosecurity

The aim of this priority area is to **manage the risks to Bay values from marine pests.**

The 2001 Plan acknowledged that risks associated with marine pests are most effectively addressed by nationally agreed arrangements and, in their absence, statewide programs. The 2001 Plan's marine pest program, therefore, aimed to address key Bay-focused tasks and form an additional layer to the relevant statewide and national programs. Specifically, the objective of the 2001 Plan was, 'Continue to improve the management of vectors that lead to the introduction of marine pests to the Bay, reduce the impact from introductions through early detection and rapid response action where possible, and reduce the impact on the Bay from established pest populations where technically feasible'.

The background investigations support continued specific management of marine pests in the Plan because:

- **Marine pests may pose a risk to Bay values.** While the Bay has been relatively resilient to the impacts of marine pests to date, the environmental risk assessment (Hale and Brooks 2015) found that marine pests remain a high risk to the values, with the greatest risk posed to denitrification, intertidal and subtidal reefs and primary contact recreation.
- **Migrations of marine pests from the Bay have occurred.** The science knowledge synthesis notes marine pests endemic to the Bay have invaded other Victorian waters and embayments since the development of the 2001 Plan (e.g. *Undaria pinatifida* has been present at Apollo Bay since 2009).
- **Boat traffic will increase in the future.** Shipping traffic will increase in the future to meet the growing demand for goods of a growing population. Small vessel movements are also likely to increase. Consequently, the risk of marine pests being introduced to and spread from the Bay is also likely to increase unless appropriately managed at both ports and marinas.
- **Future incursions are likely if not managed appropriately.** Repeat invasions are very likely due to the voracious nature of many of the marine pests endemic to the Bay, and in many cases will require management interventions.
- **Current governance arrangements and records are hindering effective management.** Performance audits of the management of marine protected areas (VAGO 2011) and terrestrial parks (VAGO 2010) note that complicated, unclear governance arrangements and outdated records have hindered effective, coordinated management of invasive species and marine pests.
- **Marine vessels are the primary vector for marine pests entering, leaving and travelling within the Bay.** Vessels can transport marine pests externally through the growth and accumulation of aquatic organisms (biofouling) and internally through the uptake and discharge of ballast or bilge water. Larval dispersals are another vector path.
- **Biofouling on aquaculture equipment is also a potential vector for marine pest transfer.** Translocation of mussel ropes occurs within the Bay and to and from Western Port, increasing the risk of movement of marine pests to new locations.
- **Spread of marine pests through ballast water can be controlled through appropriate boat hygiene.** Ballast water is water used by ships to improve stability and safety under variable load conditions. It is taken up and discharged from the vessel when cargo is loaded or unloaded, or when a vessel requires additional stability in bad weather. This water can contain marine pests and therefore unregulated discharge can result in marine pest populations being transferred to unaffected waters. High-risk ballast can be dealt with during a journey by 'exchanging' at sea with uptake of waters distant from the coast (where there are no pests).
- **Community members and stakeholders are concerned about the potential risk of marine pests.** At the listening posts, 'Ecosystem issues' received 28% of nominations. There were 44 mentions of marine pests and invasive species in the survey. Invasive species were mentioned in formal submissions and interviews, with some stakeholders highlighting the lack of funding as a barrier to proper management.

- **Further work and follow up is required on original Environmental Management Plan actions.** While many of the actions in the 2001 Plan relied on action at a national or state level, work is still required to ensure the full intent of these actions is realised. This particularly relates to actions 2.3 (Vector Management – Fouling of Small Vessels – To improve management of biotic fouling of small vessels to reduce the risks of introduction and dispersal of marine pests), 2.5 (Early Detection – To monitor priority locations within the Bay for new marine pest introductions) and 2.6 (Mitigate Effects of Introductions – To respond rapidly to new introductions of marine pests and reduce the impact of established populations on the Bay's management objectives, where technically feasible and environmentally, socially and economically beneficial).
- **There is a lack of monitoring data regarding marine pests.** As stated earlier, the last systematic survey for marine pests in the Bay was in 2003. Parks Victoria undertakes monitoring of subtidal reefs and intertidal areas in the marine parks and sanctuaries, which includes documenting the presence of known marine pests (e.g. Woods and Edmunds 2014). There have also been localised surveys of specific pest species associated with smaller research projects.
- **Marine pest management arrangements in Australia are currently being reformed.** The Commonwealth Government has introduced new legislation that will affect marine pest management in Victoria. Currently, the protection of Victorian waters from the introduction of marine pests is supported by three key items of subordinate legislation: the *Environment Protection (Ships Ballast Water) Regulations 2006,* the *Waste Management Policy (Ships Ballast Water)*, and the protocol for environmental management *'Domestic ballast water management in Victorian state waters'*.

Consistent with the directions of the 2001 Environmental Management Plan, the Plan acknowledges that marine pests are best managed through nationally agreed arrangements. However, there are actions that can directly assist management of marine pests in the Bay. The actions in the Plan are based on the recommendations and key findings from the science knowledge synthesis and review of the marine pests program in the 2001 Plan.

Adherence to the Commonwealth guidelines for ballast water management and anti-fouling for ships reduces the risk of the transfer of marine pests. Photo – Anna Kilborn

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Acronyms and abbreviations

Abbreviation	Definition
ASQAAC	Australian Shellfish Quality Assurance Advisory Committee
BPEM	Best Practice Environmental Management guidelines
CAPIM	Centre for Aquatic Pollution Identification and Management
Chla	Chlorophyll a
CMA	Catchment Management Authority
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEDJTR	Department of Economic Development, Jobs, Transport and Resources
DELWP	Department of Environment, Land, Water and Planning
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EDC	Endocrine disrupting compound
eDNA	environmental DNA (genetic material left behind in the environment)
EMMV	Emergency Management Manual Victoria
EMP	Environmental Management Plan
EPA	Environment Protection Authority, Victoria
MARPOL	International Convention for the Prevention of Pollution from Ships
PP&W CMA	Port Phillip and Westernport Catchment Management Authority
REEF	Reef Ecosystem Evaluation Framework
RMIT	Royal Melbourne Institute of Technology University, Melbourne
SEPP (Waters of Victoria)	State Environment Protection Policy (Waters of Victoria).
SEPP (Waters)	State Environment Protection Policy (Waters). These are new regulations, currently being developed
µg/L	Micrograms per litre
VAGO	Victorian Auditor-General's Office
VLAA	Victorian Litter Action Alliance
VNPA	Victorian National Parks Association
WSUD	Water sensitive urban design

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