Report on the Condition of Yaringa Marine National Park - 2002 to 2013

NUMBER 112

November 2015

Carey, J., Howe, S., Pocklington, J., Rodrigue, M., Campbell, A., Addison, P. and Bathgate, R.

Parks VICTORIA
Healthy Parks Healthy People®
VICTORIA State Government

Published by Parks Victoria

Level 10, 535 Bourke St, Melbourne Vic 3000

Cover image

Yaringa Marine National Park, Jo James.

Author(s)

Carey, J., Pocklington, J., Addison, P. and Bathgate, R. – University of Melbourne, Victoria

Howe, S., Rodrigue, M. – Parks Victoria

Campbell, A.

National Library of Australia

Cataloguing-in-publication data

Includes bibliography.

ISSN 1448-4935

Citation:

Carey, J., Howe, S., Pocklington, J., Rodrigue, M., Campbell, A., Addison, P. and Bathgate, R. (2017) Report on Condition of Yaringa Marine National Park - 2002 to 2013. Parks Victoria Technical Series No. 112. Parks Victoria, Melbourne.

Executive Summary

Parks Victoria has developed a series of report cards to provide timely, accurate, and reliable information on the condition of natural assets, level of threats and management effectiveness. These report cards form part of Parks Victoria's State of the Parks evaluation.

Yaringa Marine National Park
Date established 2002
Size 980 Ha
IMCRA Marine Bioregion Victorian embayments - Western Port
Traditional Owners The park is part of the *Country* of the Boonwurrung People.

Conservation Vision
A future visitor to Yaringa MNP finds a wide range of marine ecosystems in a dynamic tidal environment. The complex interactions and biological processes that underpin and sustain the marine communities are healthy. The park is protected from inappropriate visitor use and the pressures of increasing urban and maritime development by management that is integrated with that of the adjacent land, water and wider catchment, providing a model for other area managers.

Park Description
Yaringa MNP is heavily influenced by tidal flows which leave large areas of mudflats and seagrass beds exposed at low tide. Some of the park's natural values include highly diverse and extensive salt marsh communities, undisturbed mangroves, extensive sea grass meadows, rich mudflats, and deep channels.

The ecosystems in the park provide key roosting and feeding areas for a resident and migratory shorebirds, including many of conservation significance. In-water ecosystems provide habitat for a wide range of fish including juveniles of a number of species important to fishers.

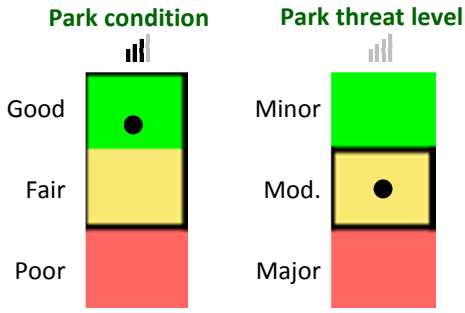
The park is part of two internationally recognised special protection areas in Western Port including the Western Port Ramsar Site and Mornington Peninsula and Western Port UNESCO Biosphere Reserve. More than two thirds of the park is covered by a Special Protection Area for sensitive mangrove and saltmarsh.

Poor water quality entering the park from Watson Creek, one of the region's most challenged waterways, represents a key concern for the park, along with the potential for marine pest introductions, and oil spills associated with adjacent port and catchment activity.

Status Summary

Overall the key natural assets in Yaringa Marine National Park (MNP) are in good condition.

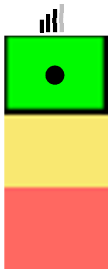
Seagrass, mangrove and saltmarsh ecosystems are all in good condition, while unvegetated soft sediments and the water column are in fair condition. Condition of the soft sediment ecosystem has declined.



Overall key threats have had a moderate impact on natural assets. Illegal fishing, oil and chemical spills have had a very low impact, while invasive species, and pollutants from the catchment have had a low to moderate impact. Sediments and nutrients from the catchment and stormwater have had the greatest impact on some key park values.

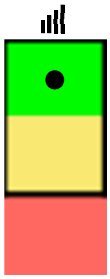
Natural Assets – Ecosystems

Seagrass Beds - Aim: *Maintain water quality and extent, cover and heterogeneity of intertidal and subtidal seagrass communities in order to support an abundant and diverse assemblage of invertebrate and fish communities.*

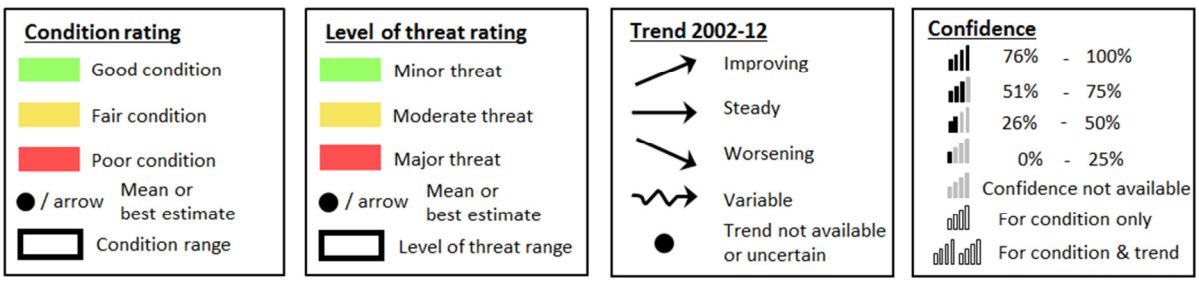


- Seagrasses provide critical habitat for many invertebrates and fish, including juveniles of a number of important species.
- Sunlight trapped by seagrasses is a major source of energy for marine food chains.
- Seagrasses help slow water movement, bind sediments together, and thus reduce erosion and improve water clarity.

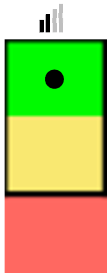
Mangroves - Aim: *Maintain the extent, cover and heterogeneity of mangrove communities in order to support an abundant and diverse assemblage of invertebrate, bird and fish species along the coastline of Yaringa MNP.*



- Mangroves and their complex root systems provide important habitat for many invertebrates, fish and birds.
- Falling mangrove leaves contribute large quantities of organic matter and energy to marine food chains.
- Dense mangroves trap and bind sediments and protect shorelines by reducing wave erosion.



Saltmarsh - Aim: *Maintain the extent, cover and heterogeneity of saltmarsh communities in order to support an abundant and diverse assemblage of bird communities, and habitat for rare and threatened species.*



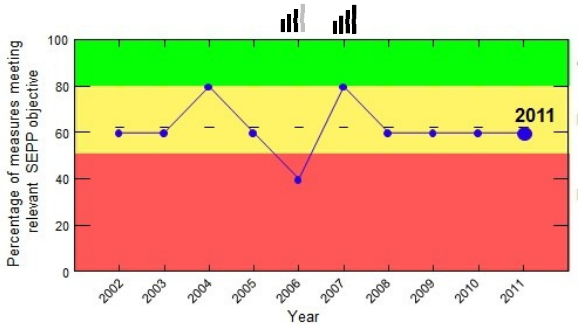
- Saltmarsh plant communities within the park are very diverse and are of state conservation significance.
- Temperate coastal saltmarsh is listed nationally as Vulnerable.
- Yaringa's saltmarshes provide potential habitat for a range of rare and threatened species, including the endangered Orange Bellied Parrot.

Unvegetated Soft Sediments - Aim: *Maintain natural sediment transport patterns and the structural integrity and composition of intertidal and subtidal soft sediments, in order to support an abundant and diverse assemblage of invertebrate and bird species.*

- Intertidal and subtidal soft sediments support an abundance of deposit feeding invertebrate communities, which play an important role in nutrient cycling.
- Soft sediments are important feeding areas for significant resident and migratory shorebird populations.

Water Column - Aim: *Improve water quality to provide suitable habitat for water column communities.*

- The water column provides habitat for many species including fish and plankton communities.
- Water quality within the park is critical in the overall health of the park's ecosystems including seagrass and unvegetated soft sediments.



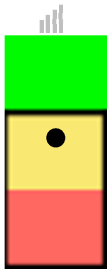
- The chart summarises EPA data for 5 key water quality indicators for the water column. Between 2002-12 the water column generally remained in fair condition, dipping to 'poor' in 2006 before returning to 'fair'.

Threats – Across the whole park

Sediments from Catchment - Objective: *Reduce the suspended sediment levels from catchment and stormwater inputs.*

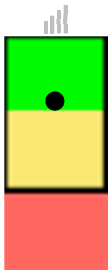
- Increased sediment in the water column reduces light penetration and affects growth of seagrass and phytoplankton.
- High sediment loads smother seagrass beds, mangroves, and burrowing fauna.
- Sediments from the catchment represent a significant threat to some park values.

Nutrients from Catchment/Stormwater - Objective: *Reduce the nutrient levels from catchment and stormwater inputs.*



- Excessive nutrients result in increased growth of epiphytic algae on seagrass and mangroves which can eventually smother plants and cause dieback.
- Excessive nutrients in the water column also causes algal blooms leading to the eutrophication and loss of many species that require oxygen.
- Poor water quality entering the park from Watson Creek, one of the region's most challenged waterways, represents a key concern for the park.

Pollutants from Catchment - Objective: *Reduce pollutant levels from catchment and stormwater inputs.*

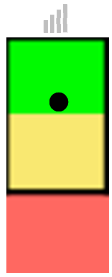


- Pollutants including pesticides, hormones, and heavy metals from industry, agriculture, or domestic sources have potential for harmful impacts on marine flora and fauna, but these have had limited impact on park values.

Oil & Chemical Spill or Leak - Objective: *Minimise the impact of potential oil/chemical spills.*

- Oil, from marine or terrestrial sources, smothers sensitive intertidal ecosystems such as mangroves, saltmarshes and seagrasses, and the species that live within them.
- Chemical spills can have toxic effects or cause physical damage to flora and fauna reducing health or causing death.
- There have been no oil or chemical spills in Yaringa MNP.

Invasive Species - Objective: *Prevent the establishment of marine pests and weeds and reduce the impact of existing infestations.*

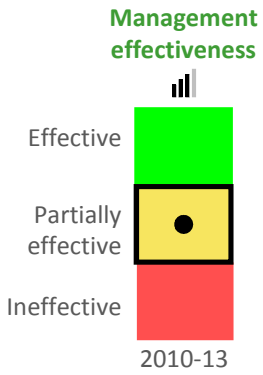


- Marine pest species compete with other plants and animals for space or food resources, and lead to a decrease in the diversity and abundance of native species.
- The Asian Bag Mussel been recorded in the park with the Pacific Oyster also recorded at low densities. The highly invasive Northern Pacific Seastar and Cordgrass (*Spartina anglica*) are known in Western Port.

Illegal Fishing - Objective: *Minimise the incidence of* illegal *resource use and extraction within Yaringa MNP.*

- Illegal fishing in the MNP reduces the size and abundance of targeted species.
- Fish and other targeted species play an important ecological role in the park and their removal has flow on effects for the rest of the food web.
- Illegal fishing has minimal impact because of the remote location and relative inaccessibility of the park.

Management Focus and Effectiveness



Management of the park was considered 'partially' effective with management effort since the park was declared focusing on key threats to priority natural assets. Several emerging threats have also been identified.

Future management will focus on addressing existing and emerging threats.

Since the declaration of the park in 2002, Parks Victoria's management priorities have included:

- Partnership building and stakeholder engagement to address water quality issues through improved agricultural, urban and land use practices within the park catchment, with a particular focus on Watson Creek.
- Compliance and enforcement patrols, maintenance of boundary markers, and removal of an illegal jetty in the park.
- Building community understanding and stewardship for the park's important values through community engagement and collection and use of high quality images and video footage.
- Improving knowledge of the park through marine habitat mapping, seagrass monitoring, marine pest surveys, and developing methods for monitoring soft sediment communities.

Emerging Threats

Many of the threats identified as high risk in the future overlap with the existing threats, however physical disturbance to sensitive seagrass, mangrove and saltmarsh habitats was identified as an additional threat. Climate change is recognised as an important driver of change for the MNP in the medium to long term but other threats were considered more important over the next five years.

Future Management Response

Following the assessment of condition of key natural assets, level of threats and management effectiveness, the following management strategies have been identified as high priorities over the next five years:

- Work collaboratively with Port Phillip and Western Port CMA to reduce the impacts of land use and catchment management on the planning area and develop appropriate actions in the Regional Catchment Strategy.
- Work collaboratively with EPA and Melbourne Water to minimise impacts associated with discharge of waste into the environment, particularly from Watson Creek.
- Establish an ongoing program to minimise the risk of marine pest and weed introduction and subsequent spread. This should include improving the understanding of the potential means of introduction and spread and formalising arrangements for prevention, reporting, monitoring and response.

- Work collaboratively with Department of Transport Planning and Local Infrastructure on marine pollution incidents, and update contingency plans for marine pollution incidents as required, and communicate arrangements to staff, relevant agencies and interested parties.
- Work with Fisheries Victoria to undertake education, patrols and targeted compliance operations to ensure appropriate behaviours, and encourage visitors to assist with compliance management by reporting illegal fishing to the Fisheries Victoria hotline.
- Continue to implement the marine science program to fill remaining critical knowledge gaps and address key management challenges.

Contents

EXECUTIVE SUMMARY 1

INDEX OF FIGURES 9

INDEX OF TABLES 11

1. PARK DESCRIPTION 12

2. ASSETS AND THREATS 15

2.1 Seagrass Beds 15
2.2 Mangroves 16
2.3 Coastal Saltmarsh 17
2.4 Unvegetated sediments 17
2.5 Water column 18
2.6 Threats to Natural Assets 20

3. METHODS 21

3.1 The concept of ecosystem condition 23
3.2 Types of data 23
3.3 Control charts 24
3.4 Eliciting expert opinion 25

4. STATUS OF THE PARK 27

4.1 Seagrass beds 28
4.2 Mangroves 29
4.3 Coastal Saltmarsh 29
4.4 Unvegetated sediment 30
4.5 Water column 31
4.6 Threat Status 36

5. MANAGEMENT OF THE PARK 37

5.1 Management priorities 38
5.2 Management focus and effectiveness 38
5.3 Future management response 38

6. REFERENCES 40

7. GLOSSARY OF TERMS 45

8. APPENDIX 1– DETAILS OF INDICATORS AND THREATS 50

8.1 Criteria for Selection of Indicators 50
8.2 Detailed Threat Matrix 51
8.3 Threats to Yaringa MNP 52

8.3.1 SEAGRASS BEDS 52
8.3.2 MANGROVE 53
8.3.3 COASTAL SALTMARSH 53
8.3.4 INTERTIDAL UNVEGETATED SEDIMENT 54
8.3.5 WATER COLUMN 55

9. APPENDIX 2– METHOD DETAIL 57

9.1 SEAGRASS SAMPLING 57
9.2 SAMPLING INVERTEBRATES IN UNVEGETATED SEDIMENTS 57
9.3 DESIGN OF CONTROL CHARTS FOR REPORT CARDS 58
9.4 STATISTICAL POWER & CONTROL CHARTS 62

10. APPENDIX 3 – PARK STATUS RAW DATA 64

10.1 SEAGRASS DATA 64
10.2 SAMPLING OF INVERTEBRATES IN UNVEGETATED SEDIMENTS RAW DATA 64
10.3 WATER QUALITY RAW DATA 66

11. APPENDIX 4 - CONCEPTUAL MAP OF GENERAL MARINE ECOSYSTEM IN VICTORIAN MPA 70

12. APPENDIX 5 – SUMMARY LEVEL REPORT CARD 71

13. APPENDIX 6: EXAMPLE OF EXPERT OPINION QUESTIONNAIRE 77

Index of figures

Figure 1 - Yaringa Marine National Park habitat map 13
Figure 2 - Visualisation of Yaringa Marine National Park ecosystem showing identified assets and threats 14
Figure 3 - Parks Victoria Adaptive Management Framework 21
Figure 4 - An example of the way in which experts are asked to record their judgements about the current condition of a natural asset 24
Figure 5 - Example control chart. This chart has a lower control limit (here set at 50%) indicating the level indicating the level when conditions are sufficiently poor that some management response is required 25
Figure 6 - Depiction of expert confidence 27
Figure 7 - Seagrass condition 28
Figure 8 - Mangrove condition 29
Figure 9 - Coastal Saltmarsh condition 29
Figure 10 - Unvegetated sediment condition 30
Figure 11 - Water quality summary of 5 indicators 31
Figure 12 - Annual medians for Total Phosphorus present in water column 33
Figure 13 - Annual medians for total nitrogen present in water column 33
Figure 14 - Annual medians for Chlorophyll a present in the water column 34
Figure 15 - 75th percentile for chlorophyll a present in the water column 34
Figure 16 - Minimum dissolved oxygen concentration in the water column 35
Figure 17 - Median Secchi disk depth 35
Figure 18 - 25th percentile Secchi disk depth 36
Figure 19 - Median suspended solids in water column 36
Figure 20 - 75th percentile suspended solids in water column 36
Figure 21 - Interactions between ecosystems and threats 37
Figure 22 – Management Effectiveness (Yaringa) 38
Figure 23 - Matrix of the interactions between ecosystems and threats in Yaringa Marine National Park 51
Figure 24 – Nested Asset: Seagrass plant communities 53
Figure 25 – Nested Asset: Mangrove vegetation 53
Figure 26 – Nested Asset: coastal saltmarsh plant communities 54
Figure 27 - Nested Asset: habitat for specified rare species 54
Figure 28 - Nested: Deposit feeding intertidal invertebrate communities 54
Figure 29 - Nested Asset: Migratory & resident shorebirds 55
Figure 30 - Nested Asset: Water quality 56
Figure 31 – Principles behind the Acceptance Control Chart as applied to Report Cards (after Montgomery 2009) 60
Figure 32 - Illustration of correspondence between control chart and 'conventional' approach to statistical power 62

Figure 33 - The mean number of species a. the mean number of individuals b. and mean Simpson's diversity c. per core (15 cm diameter X 40 cm depth) collected at each site in Western Port, Victoria, in 2006 (open bars) and 2007 (filled bars). Sites within Marine National Parks are shaded. Error bars show one standard error 66
Figure 34 – Total Phosphorus in the water column 67
Figure 35 – Total Nitrogen in the water column 67
Figure 36 – Total Nitrogen in the water column 68
Figure 37 – Dissolved Oxygen (% saturation) in the water column.....68
Figure 38 – Secchi disk depth in the water column.....69
Figure 39 – Suspended solids in the water column.....69
Figure 40 - Conceptual map of general marine ecosystem in Victorian marine Protected Areas (Fig. 1 from Pocklington *et al. (2012) Conceptual Models for Victorian Ecosystems: Marine and Estuarine Ecosystems.* Parks Victoria Technical Series No. 66. Parks Victoria, Melbourne) 70

Index of tables

Table 1 – Nested Assets and Key Ecological Attributes / Indicators for seagrass plant communities in Yaringa MNP.....15
Table 2 – Nested Assets and Key Ecological Attributes / Indicators for mangrove forest in Yaringa MNP 16
Table 3 - Nested Assets and Key Ecological Attributes / Indicators for coastal saltmarsh in Yaringa MNP 17
Table 4 - Nested Assets and Key Ecological Attributes / Indicators for unvegetated intertidal sediments in Yaringa MNP.....18
Table 5 - Selected water quality objectives for Entrances and North Arm segment of Western Port. Taken from SEPP WoV Schedule F8 or ANZECC Guidelines for Fresh and Marine Water Quality 19
Table 6 - Categories of current condition.....26
Table 7 - Categories for trend in condition.....26
Table 8 - Categories of threat impact.....26
Table 9 - Categories of trend in threat impact 27
Table 10 - Criteria for selection of indicators (Parks Victoria).....50
Table 11 - Conversion of categorical responses to numerical scores 63
Table 12 - Summary site data for seagrass sampling in Yaringa MNP in 2008 and 2009 64
Table 13 - Data for invertebrates recorded from Yaringa MNP.....64

1. Park Description

The system of Marine National Parks and Sanctuaries has been established to represent the diversity of Victoria's marine environment, its habitats and associated flora and fauna.

Yaringa Marine National Park covers 980 ha and lies in a shallow embayment in northern Western Port (Figure 1). The park is heavily influenced by tidal flows which leave large areas of mudflats and seagrass beds exposed at low tide. The park's natural values include highly diverse and extensive salt marsh communities, undisturbed mangroves, extensive sea grass meadows, rich mudflats, and deep channels (see Figure 2).

The ecosystems in the park provide key roosting and feeding areas for resident and migratory shorebirds, including many of conservation significance. In-water ecosystems provide habitat for a wide range of fish including juveniles of a number of species important to fishers.

The park is part of two internationally recognised special protection areas in Western Port including the Western Port Ramsar Site and Mornington Peninsula and Western Port UNESCO Biosphere Reserve. A Special Protection Area for sensitive mangrove and saltmarsh covers more than two thirds of the park.

Poor water quality entering the park from Watson Creek, one of the region's most challenged waterways, is a key concern for the park, along with the potential for marine pest introductions, and oil spills associated with adjacent port and catchment activities (see Figure 2).

IMCRA Marine Bioregion: Victorian embayments - Western Port
Traditional Owners: The park is part of the *Country* of the Boonwurrung People.

> **Conservation vision:** *A future visitor to Yaringa MNP finds a wide range of marine ecosystems in a dynamic tidal environment. The complex interactions and biological processes that underpin and sustain the marine communities are healthy.*
> *The park is protected from inappropriate visitor use and the pressures of increasing urban and maritime development by management that is integrated with that of the adjacent land, water and wider catchment, providing a model for other area managers.*

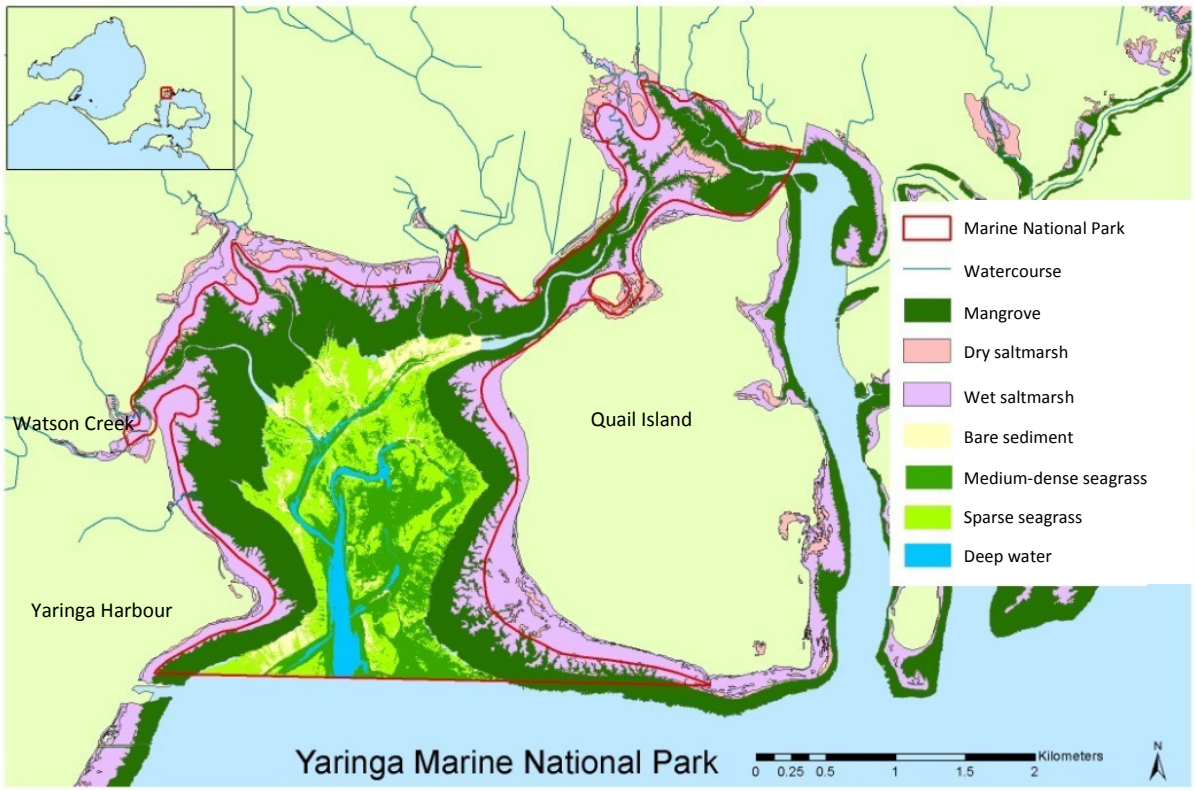


Figure 1 - Yaringa Marine National Park habitat map

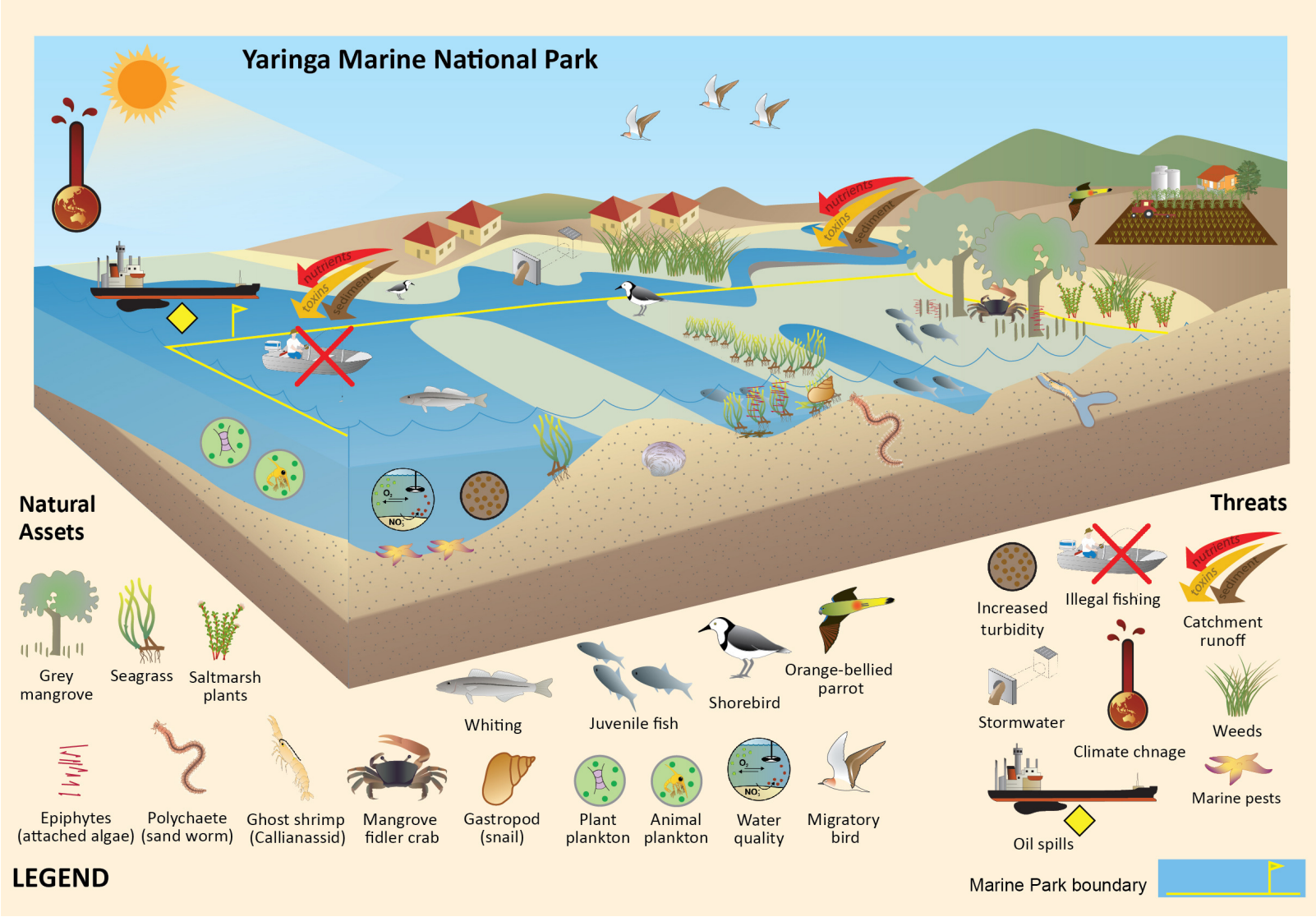


Figure 2 - Visualisation of Yaringa Marine National Park ecosystem showing identified assets and threats

2. Assets and Threats

Parks Victoria has undertaken a review of natural assets in the Marine National Parks. Focal ecosystems have been nominated within each park and for each focal ecosystem, one or more Key Ecological Assets (KEAs) have been identified along with priority threats to those assets. Potential indicators for both assets and threats have been selected for monitoring purposes and limits of acceptable variation for the indicators are being determined (See Methods section for more details on the selection process).

The following focal ecosystems have been identified within Yaringa MNP:

- Seagrass Beds
- Mangrove
- Coastal Saltmarsh
- Unvegetated Sediments
- Water Column

A range of threats to the natural assets of the park (see section 2.6 Threats to Natural assets) has also been identified, including nutrients and sediments from the adjacent catchment, pollutants and introduced marine pests.

2.1 Seagrass Beds

Seagrasses are important habitat-forming plants in Yaringa MNP. Seagrass beds provide habitat for many other species, and be important nursery areas for fish and crustaceans (see Table 1 for attributes). The roots of seagrasses help bind sediments together and thus reduce erosion. Seagrass leaves slow water movement, thus encouraging the settlement of fine particles to the sea bed and improving water clarity.

> **Ecosystem Aim:** *To maintain water quality and the extent, condition and connectivity of intertidal and subtidal seagrass communities in order to support an abundant and diverse assemblage of invertebrate and fish communities.*

Table 1 – Nested Assets and Key Ecological Attributes / Indicators for seagrass plant communities in Yaringa MNP

Nested Asset	Key Ecological Attribute / Indicator
Seagrass (*Zostera muelleri*, *Zostera nigricaulis*) plant communities – these seagrass communities may also contain seaweeds such as small filamentous red species and larger greens of the genus *Caulerpa*.	Areal extent of seagrass beds (*Z. muelleri* & *Z. nigricaulis*)
	Fragmentation (patchiness) of seagrass beds
	Percentage cover of seagrass within beds (a measure of the density or 'thickness' of the seagrass)
	Shoot density and shoot length of seagrass

2.2 Mangroves

Mangroves are trees and shrubs adapted to live in saline, water-logged environments. They have very high rates of primary production and provide important habitat for a range of fish and invertebrates. Their leaf litter makes a major contribution to food webs in the forest. Mangroves are distinguished by specialised upright roots called pneumatophores that protrude above the sediment surface. When covered by water, these provide a refuge from predators for juvenile fish and shelter from physical disturbance.

The local species is the white mangrove *Avicennia marina* var. *australasica*. Here in Victoria, this species is at the southern limit of its distribution.

Mangrove forests provide nursery habitat for commercially important species of fish. They protect shorelines during storm events by absorbing wave energy and reducing water velocity. They influence water quality by cycling nutrients, pollutants and sediments from land-based sources (see Table 2 for attributes).

The mangrove forest of Yaringa MNP lies within a Special Protection Area where additional management controls are in place to protect sensitive communities and habitats for seabirds and shorebirds.[A1]

> **Ecosystem Aim:** *Maintain the extent, cover and heterogeneity of mangrove communities in order to support an abundant and diverse assemblage of invertebrate, bird and fish species along the coastline of Yaringa MNP.*

Table 2 – Nested Assets and Key Ecological Attributes / Indicators for mangrove forest in Yaringa MNP

Nested Asset	Key Ecological Attribute / Indicator
Mangrove plants - The white mangrove *Avicennia marina* var. *australasica*	Total extent of mangrove vegetation
	Fragmentation (patchiness) of mangrove forest
	Age/size class distribution (densities of seedlings, saplings and adult trees)
	Tree health (dead limbs, height, diameter, foliage cover, canopy cover, pneumatophore count)
Leaf litter/detritus	Litter volume (and rate of collection)

2.3 Coastal Saltmarsh

Coastal saltmarsh plants are salt-tolerant grasses, succulents and small shrubs found in areas subject to some degree of tidal inundation. In Yaringa MNP, saltmarsh tends to fringe the landward side of the mangrove forest. (Note that much of the saltmarsh in the area lies outside the park borders.[A2])

Saltmarsh plant communities in Yaringa MNP are very diverse, with multiple Ecological Vegetation Communities (EVCs) including seven recently-described discrete EVCs.[A3] Saltmarsh provides important habitat for faunal communities including shorebirds, fish, reptiles, spiders and insects (see Table 3 for attributes). It is the preferred habitat of the orange-bellied parrot *Neophema chrysogaster*, the swamp skink *Egernia coventryi*, and Lewin's rail *Rallus pectoralis pectoralis*, all of which are listed species under one or both of the *Flora and Fauna Guarantee Act 1988* (FFG Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).[A3]

The temperate coastal saltmarsh community such as that found in Yaringa MNP has been listed as a vulnerable ecological community under the *EPBC Act 1999*. The coastal saltmarsh of Yaringa MNP lies within a Special Protection Area where additional management controls are in place to protect sensitive communities and habitats for seabirds and shorebirds.[A1]

> **Ecosystem Aim:** *To maintain the extent, cover, diversity and heterogeneity of saltmarsh communities in order to support an abundant and diverse assemblage of invertebrate and bird communities, and habitat for rare and threatened species, along the coastline of Yaringa MNP over 15 years.*

Table 3 - Nested Assets and Key Ecological Attributes / Indicators for coastal saltmarsh in Yaringa MNP

Nested Asset	Key Ecological Attribute / Indicator
Coastal saltmarsh plant communities	Extent of saltmarsh vegetation, both in total and by EVC
	Fragmentation (patchiness) of saltmarsh
	Percentage cover of saltmarsh
	Proportion of saltmarsh that is weed-free
Preferred habitat for Orange Bellied Parrot, Swamp Skink and Lewin's Rail	Percentage cover of food plants (e.g. beaded glasswort, shrubby glasswort, Austral sea-blite)
	Extent of saltmarsh vegetation in excellent condition

2.4 Unvegetated sediments

Although plants and animals may not be conspicuous in unvegetated sediments, this habitat is rich with marine life. Many species of invertebrates and some fish species live on or within soft sediments. Those species are in turn important as a food source for migratory shorebirds and commercially important fish species. Microscopic algae, collectively known

as the microphytobenthos, may also be abundant, increasing the productivity of the ecosystem (see Table 4 for attributes).

Among the invertebrates are species known as 'ecosystem engineers'. An example is the ghost shrimp which builds an extensive tunnel system that changes the sediment environment, which can in turn lead to changes in community composition. Ghost shrimps play an important role in nutrient cycling in the park and wider bay.[A4] Another group of engineering species is the deposit feeders who ingest sediments, extract associated bacteria, microalgae and other organic material, then expel the 'cleaned' sediment. Examples include some polychaete worms, bivalve molluscs and crustaceans.

The unvegetated soft sediments of Yaringa MNP provide protected feeding areas for twenty-seven internationally important migrant species protected under the Australia Migratory Bird Agreement with either China (CAMBA) or Japan (JAMBA).[A3] The sediments also provide important roosting habitat for many FFG-listed resident shorebird species.

> **Ecosystem Aim:** *To maintain natural sediment transport patterns and the structural integrity and composition of intertidal and subtidal soft sediments, in order to support an abundant and diverse assemblage of invertebrate and bird species.*

Table 4 - Nested Assets and Key Ecological Attributes / Indicators for unvegetated intertidal sediments in Yaringa MNP

Nested Asset	Key Ecological Attribute / Indicator
Deposit feeding intertidal invertebrate communities	Abundance of key invertebrate species (e.g. ghost shrimps *Trypaea australiensis* and *Biffarius arenosus*, the crab *Macrophthalmus latifrons*, and the polychaete worm *Lumbrineris* sp.)
Migratory and resident shorebirds (some listed under state and national legislation and/or international agreements)	Extent of intertidal sediment as shorebird foraging habitat
	Abundance of key bird species (Red neck stint, Eastern curlew, curlew sandpiper, bar-tailed godwit, green shank, red-capped plover, pied oystercatcher) as a proportion of the flyway population
	Diversity of migratory shorebirds

2.5 Water column

Good water quality is important for marine life. Particular concerns in Yaringa MNP include high nutrient loads from the land (which may encourage excessive growth of epiphytes), high turbidity (blocking sunlight to the seagrasses) and low dissolved oxygen (an issue for fish and invertebrates).

The selection of aims, indicators and limits of acceptable change for water quality was guided by the State Environment Protection Policy (SEPP) for the Waters of Victoria (WoV)

which includes a special schedule for Western Port. Schedule F8, Waters of Western Port and Catchment (2001)[A5] specifies water quality objectives for the various segments of Western Port, including the Entrances & North Arm segment where Yaringa MNP lies (see Table 5 for attributes). There have been no studies of the biota of the water column in Yaringa MNP.[A2]

> **Ecosystem Aim:** *Improve water quality to provide suitable habitat for water column communities and other communities dependent on good water quality.*

Table 5 - Selected water quality objectives for Entrances and North Arm segment of Western Port. Taken from SEPP WoV Schedule F8 or ANZECC Guidelines for Fresh and Marine Water Quality

Nested Asset	Key Ecological Attribute / Indicator	Limits of Acceptable Change ^
Water quality	**Nitrogen:**	
	Total Nitrogen *	annual median < 120 µg/L
	Dissolved Inorganic Nitrogen	annual median < 7 µg/L annual 75th percentile < 15 µg/L
	Phosphorus:	
	Total Phosphorus *	annual median < 25 µg/L
	Dissolved Inorganic Phosphorus	annual median < 6 µg/L annual 75th percentile < 8 µg/L
	Light availability:	
	Transparency (Secchi disk)	annual median > 2.4 m annual 25th percentile > 1.4 m
	Total Suspended Solids	annual median < 9 mg/L annual 75th percentile < 19 mg/L
	Chlorophyll a	annual median < 1.6 µg/L annual 75th percentile < 2.1 µg/L
	Dissolved Oxygen	minimum > 90% saturation

[#] Where objectives are not specified in Schedule F8, the Schedule specifies that values should be taken from the ANZECC Guidelines for Fresh and Marine Water Quality[A6].

^ The median is the mid point of a series of values that have been arranged in increasing order. The 25th percentile is the point where 1/4 of the values in the series are lower than the percentile and 3/4 higher. The 75th percentile is the value where 3/4 of the values are lower than the percentile

and 1/4 are higher. Together these three points divide an ordered set of data into 4 groups of equal size.

* Schedule refers to ANZECC water quality guidelines for TP and TN. ANZECC values given in µg/L rather than mg/L used in Schedule. Schedule gives parameter as 'maximum at base flow' for terrestrial segments, so annual median used in keeping with ANZECC approach.

2.6 Threats to Natural Assets

Threats to the natural assets of Yaringa MNP have been identified in various ways over a number of years[A7][A8][A9]. It should be noted that many of these threats originate outside the park or relate to environmental drivers that affect marine ecosystems in general[A9] Such external threats are beyond the direct control of Parks Victoria. For example, the effects of an environmental driver such as climate are impossible for the agency to manage directly.

The following have been identified as threats to Yaringa MNP:

- Sediments from catchment run-off
- Pollutants from catchment run-off/stormwater (e.g. poisons, herbicides, hydrocarbons, septic tanks)
- Nutrients from catchment run-off/stormwater
- Oil and chemical spills
- Sediment movement and transport from changes to coastal hydrology.
- Invasive exotic species (weeds and marine pests)
- Climate change (sea-level rise, climate-related changes e.g. temperature, more intense weather events increasing sediment resuspension)
- Marina and port operations and/or development
- Recreational vessels (grounding, propeller scour, anchoring)
- Illegal fishing (including invertebrates)
- Pest animals (terrestrial species - feral cats and foxes)

3. Methods

In keeping with its Adaptive Management Framework (AMF), Parks Victoria is developing an integrated approach to management of the state's Marine National Parks and Marine Sanctuaries (see Figure 3).

Natural systems are complex and there will always be information gaps and uncertainty. Adaptive management provides a structured approach to inform park management decisions in times of uncertainty. Adaptive management is based on the following principles:

- Objectives must be clearly defined
- Management responses must be measured against those objectives
- Further management responses are adjusted to incorporate evaluation and feedback.

Important stages in the AMF of particular relevance to the Marine Report Cards include the specification Key Ecological Attributes (KEAs), threats to KEAs, aims and objectives, indicators, and limits of acceptable change in condition and level of threat:

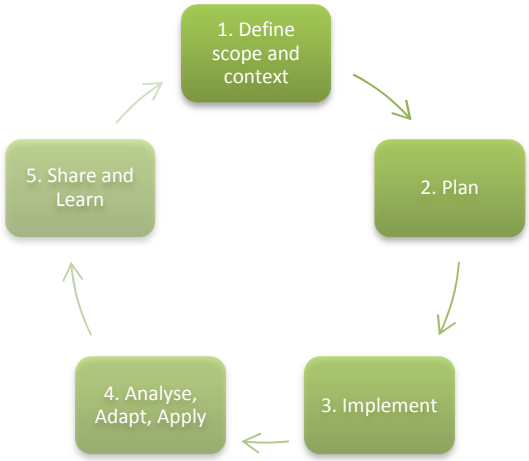


Figure 3 - Parks Victoria Adaptive Management Framework

The “Define Scope and Context” step is the first stage in the AMF and involves improving understanding of what is being managed and the context of management. This is a critical step in the AMF, however it is the following five steps that are most relevant to the Marine Report Cards.

Plan (Stage 2)

Develop aims for ecosystems within a park.

- Identify all natural assets within the park, then identify a short list of Key Ecological Attributes (KEAs) for each ecosystem.
- Identify major threats to those attributes
- Specify measurable indicators for those KEAs and threats
- Specify ecologically relevant limits of acceptable change for the KEA indicators and objectives for threats to those attributes

- Identify management strategies

Implement (Stage 3)

- Implement management actions/tasks
- Implement monitoring of indicators

Analyse, Adapt, Apply (Stage 4)

- Evaluate & report on effectiveness
- Recommend and implement changes

Share and Learn (Stage 5)

- Develop communications products

The use of "outcome-based performance indicators which are strongly linked to the aims and objectives sought by managers and stakeholders" has been flagged as an important aspect of performance assessment in the management of the National Representative System of Marine Protected Areas (NRSMPA).[M1] The NRSMPA plan recognises that Marine Protected Areas (MPAs) differ in terms of species and habitats and that the limits of acceptable change may also differ from one MPA to another.[M1] Parks Victoria held a series of Conservation Outcomes workshops across the state in 2011 and 2012 for the Marine National Parks and Sanctuaries. These workshops were designed to engage with staff and some external stakeholders to identify priority natural assets for each ecosystem in the park and key threats to those assets, and to develop appropriate ecosystem aims and threat objectives.[M2] Following these workshops the list of priority natural assets was further refined to a short list of Key Ecological Attributes using agreed criteria. A second series of internal workshops were held in 2013 to review the outputs of the first workshop and list of Key Ecological Attributes, and to prioritise management strategies. Indicators were identified following the second series of workshops, and where possible, these are reported against in the marine report cards.

Criteria used to distinguish the most useful of the indicators were as follows:

- having an obvious and direct link to the attribute
- degree of natural variability
- responsiveness
- cost effectiveness
- low impact of data collection
- existence of established protocols for measurement
- existing use by partner agencies/institutions
- ability to be used by community groups
- value as a predictor of future change

Further details on the selection criteria can be found in Table 12 - Criteria for selection of indicators (Parks Victoria).

The workshops also aided development of Conservation Action Plans which set priorities for management, monitoring and reporting.

Setting ecologically sensible and relevant limits of acceptable change for indicators is a complex matter. These need to be tailored to specific parks and ideally, based on long-term data and a sound understanding of ecosystem function. However, when there are few studies specific to a particular park or sanctuary, interim limits of acceptable change may be set initially, to be modified in coming years as more data become available and our understanding of the systems improve.

3.1 The concept of ecosystem condition

Ecosystem condition is a somewhat loosely-applied term, with few formal definitions. It has been variously equated with several similar concepts:

- *state* in the Pressure-State-Response scheme for environmental indicators[M3],[M4]
- *ecosystem health* [M5][M6] encompassing the extent of degradation, level of organisation, and resilience to stress[M7]
- *ecosystem integrity*, combining both biotic components and ecological processes to consider the capacity of a system to support natural assemblages[M8]

Ideas about what constitutes 'good' condition and how it might best be measured vary from one expert to another.[M9][M10] Underlying such differences of opinion is the fact that condition is not a single variable/parameter that can be directly measured, but a broader concept that may incorporate a number of different indicators. The key indicators and their relative importance will vary from one ecosystem to another. Even within an ecosystem, there may still be little agreement on the most important indicators for the assessment of condition or what the appropriate limits of acceptable change might be. As recently as 2011, a study was charged with developing a method of assessing the ecological condition of saltmarsh in Victoria.[M11] A 2010 study aimed to identify indicator species for assessing the condition of soft sediments in Western Port.[M12]

One possible approach is to combine a number of measures together in some sort of index[M13][M14], but care is needed to choose a sensible suite of measures that do in fact indicate something of relevance.[M15] Many indices also lack basic properties considered desirable in an index.[M16] Rather than select or develop a complex multivariate index, the Report Cards summarise multiple indicators by the relatively simple strategy of reporting the proportion of indicators that meet their own individual objectives.

3.2 Types of data

The marine report cards incorporate both quantitative data, and where such data is not available, expert opinion. The aim is to apply a common presentation style that will accommodate different types of data.

Examples of quantitative data are counts of individual organisms, percentage cover of modular or clonal species (i.e. species for which discrete individuals cannot be distinguished,

e.g. seagrass, compound ascidians), morphological measurements (e.g. shoot length), the presence or absence of particular species, grain size measurements, and concentrations of chemicals. Ideally such data would come from a targeted monitoring program to be of greatest use in decision-making for management.[M17] Sadly, this is not always feasible. So as well as using data from dedicated park-specific programs such as the Subtidal Reef Monitoring Program[M18], the Report Cards will also make use of data from other studies undertaken in or around the parks (e.g. routine water quality monitoring by EPA).

In some cases where an ecosystem aim has been defined and an appropriate indicator has been identified, there may nonetheless be no 'hard' data for that indicator, and thus no quantitative measure of status or progress toward the conservation objective. In such cases, expert opinion provides the only means of assessing the state of park.

By adopting a structured approach to eliciting information from relevant experts, the quality of information gained can be improved (i.e. overconfidence can be minimised) and any differences of opinion among experts taken into account. Experts are asked to assess the condition of specific assets and impacts of threats according to a standard set of qualitative criteria (Figure 4). The elicitation process is designed to capture any implicit assumptions the experts may make and also to record their confidence in their own assessments.[M19]

Condition category	Estimate	Confidence rating	Description
Good		90%	The natural asset(s) is/are currently largely or entirely intact. There may be minor impacts of threatening processes but the natural asset(s) is/are not currently at risk.
Fair			The natural asset(s) is/are being moderately impacted by threatening processes and is/are at some risk.
Poor			The natural asset(s) is/are not intact and is/are at continuing risk without corrective action.
Unsure			Unable to make an accurate assessment of the current condition of the natural asset(s).

Figure 4 - An example of the way in which experts are asked to record their judgements about the current condition of a natural asset

3.3 Control charts

In appearance, a control chart is a simple line graph tracking a measure (e.g. scores for an indicator) through time, but with the addition of upper and/or lower 'control limits'. These limits are pre-set levels where the measure is flagged as being 'out of control' and indicate that some management action is required. That action may take the form of continued monitoring, additional monitoring to better understand the change taking place and/or specific action to attempt to control the change. Control charts also possess some desirable statistical properties (for details see Appendix 2 - Statistical power & control charts) such

as control of the chance of detecting a given change from average conditions within a set number of samples.[M20]

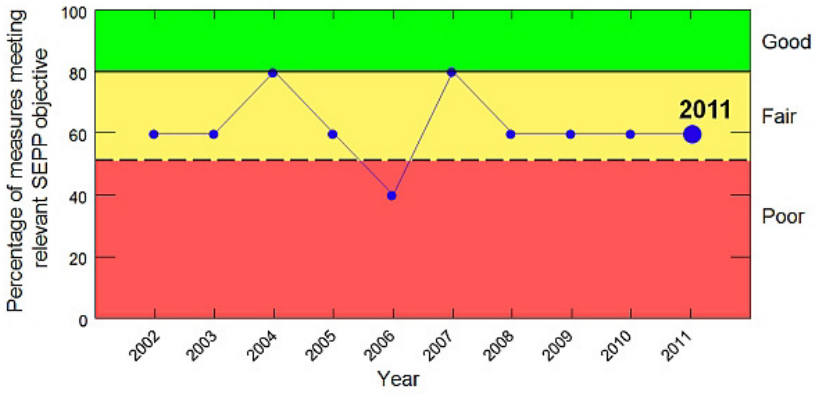


Figure 5 - Example control chart. This chart has a lower control limit (here set at 50%) indicating the level indicating the level when conditions are sufficiently poor that some management response is required

The control chart is a tool developed in the 1930s for the manufacturing industry to help control drift and variation in a process (e.g. the manufacture of brake parts for cars) in order to maintain production quality. Control limits may be either warning limits designed to indicate that further investigation is necessary, or action limits which flag the need for immediate management action. A control chart may show one or both types of limit. In a manufacturing context, limits are typically set at two and/or three standard deviations from the mean, but this is not an absolute requirement, provided a sensible justification exists for the choice made.[M21] Scientific applications for control charts are relatively new, but they have been recommended for water quality monitoring[M22] (see Figure 5 for example), and were applied to turbidity data in the Channel Deepening Project in Port Phillip Bay[M23].

3.4 Eliciting expert opinion

Where quantitative data on the condition of ecological assets was limited or not available, the opinions of relevant experts were sought. A questionnaire (see appendix Appendix 6: Example of expert opinion questionnaire) was sent to experts in particular fields who had agreed to assist with the assessment of a park. The elicitation process also aimed to capture the underlying assumptions made by experts in framing their assessments so that their judgments can be interpreted by others.

Using a set of qualitative criteria (Tables 6 to 9) and taking into account their own understanding of specific indicators, experts were asked to estimate the following for nominated assets:

(i) the current condition of the assets
(ii) the trend in condition over time
(iii) the current level of impact by key threatening processes
(iv) the trend in impacts over time
(v) their level of confidence in each judgement made

Because questionnaires of this type may be prone to different interpretation by different people,[M26] we provided descriptions of each category and in the questionnaires (see Tables 6 to 9), some explanation of how the questions should be approached and our reasons for asking them.

Table 6 - Categories of current condition

Condition	Description
Good	The natural asset(s) is/are currently largely or entirely intact. There may be minor impacts of threatening processes but the natural asset(s) are not currently at risk.
Fair	The natural asset(s) is/are being moderately impacted by threatening processes and are at some at risk.
Poor	The natural asset(s) is/are not intact and are at continuing risk without corrective action.
Unknown	The current condition of natural assets is unknown.

Table 7 - Categories for trend in condition

Trend in Condition	Description
Improved	The condition of the natural asset(s) improved between 2002 - 2012, due to management or external influences.
Maintained	The condition of the natural asset(s) has generally been maintained between 2002 - 2012.
Declined	The condition of the natural asset(s) declined between 2002 - 2012, due to management or external influences.
Unknown	It is not known if the condition of the value has changed between 2002 - 2012.

Table 8 - Categories of threat impact

Condition	Description
Major	Major medium- to long-term impact on natural assets. Slow recovery with substantial management intervention required.
Moderate	Considerable and short to medium-term impact on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Minor	Minor short-term or minimal impact on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Unknown	Impact of threat on natural assets unknown.

Table 9 - Categories of trend in threat impact

Trend in Condition	Description
Decreased	The impact of the threat on natural assets decreased between 2002 - 2012.
Stable	The impact of the threat on natural assets did not change between 2002 - 2012.
Increased	The impact of the threat on natural assets increased between 2002 - 2012.
Unknown	The trend in the impact of the threat between 2002 - 2012 was unknown, due to either lack of information or undetectable effects.

The experts' confidence in their own estimates is illustrated by 'wireless bars' as shown in Figure 6 with more bars indicating greater confidence.

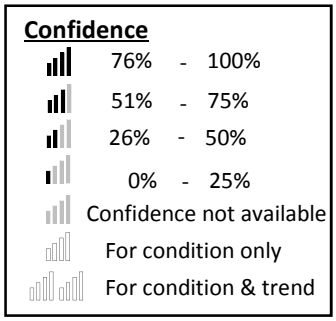


Figure 6 - Depiction of expert confidence.

4. Status of the Park

Overall, the key natural assets in Yaringa Marine National Park (MNP) are in fair to good condition. Seagrass, mangrove and saltmarsh ecosystems are all in good condition, while unvegetated soft sediments and the water column are in fair condition. Condition of the soft sediment ecosystem has declined.

Further information on the status of the different ecosystems is detailed within the Ecosystems section of this report for the following ecosystems:

- Seagrass Beds
- Mangrove
- Coastal Saltmarsh
- Unvegetated Sediment
- Water Column

Overall, key threats have had a moderate impact on natural assets. Illegal fishing, oil and chemical spills have had a very low impact, while invasive species, and pollutants from the catchment have had a low to moderate impact. Sediments and nutrients from the catchment and stormwater have had the greatest impact on some key park values.

4.1 Seagrass beds

Understanding of the condition of seagrass beds in Yaringa MNP is based on four separate sources of information. On-ground sampling of three sites in intertidal seagrass beds was undertaken in March-April 2008 and again in January-March 2009, generating quantitative data for two of the nominated indicators (see

Table 1) of condition for seagrass plant communities: seagrass cover, and shoot density and length data. Remote sensing has provided an estimate of the extent of beds within Yaringa MNP, and new approaches to generating estimates of fragmentation are being explored using the remote technology. To supplement this sparse quantitative data, expert opinion was sought on the condition of seagrass beds in the park.

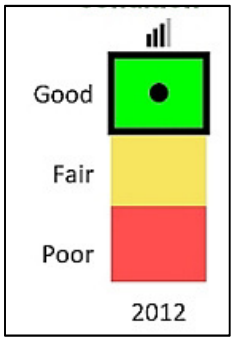


Figure 7 - Seagrass condition

Intertidal seagrass cover from the 2008 and 2009 on-ground surveys[S1][S2] ranged from 34% to 75%, values overlapping those reported from a separate study of soft sediment invertebrates.[S3] In that study, Yaringa MNP had the highest mean seagrass cover of 10 locations sampled in Western Port in 2006-2007. Shoot length of intertidal seagrass averaged 13.6 cm with a standard deviation (a measure of variability among averages; st.dev.) of 3.6. There were on average 990 shoots per m^2 (st.dev.=569), within the range of means recorded for three other sites in Western Port in 1989/90[S4]. (For more detail on the 2008 and 2009 sampling see Method Detail - Seagrass Sampling in Appendix 2).

Habitat mapping in Yaringa MNP has recently been updated and improved by combining WorldView2 satellite imagery, LiDAR (Light Detection and Ranging) bathymetry and ground-truthing at a resolution of 2 m.[S5] Habitat maps were also produced using aerial photographs collected in 1999 and 2009 (see Figure 1 for map developed using the most recent imagery). The aerial photograph collected in 1999 was lower resolution and did not use infrared, while the image collected in 2009 was finer resolution and did use infrared. Tracking of future changes in seagrass beds will be greatly improved using remote sensing techniques, but the different methods used here does limit comparison of beds back through time. The complete-coverage map of Yaringa MNP indicates that dense or medium/sparse seagrass covers over 241 ha or nearly 25% of the park.[S5] These figures may serve as a baseline for any future monitoring.

Seagrass expert Dr Hugh Kirkman stated that “The seagrass bed at Yaringa has been there a long time subjected to some of the impacts to which other seagrass beds in Western Port have succumbed.” His assessment was based on his understanding of the following factors:

- extent of seagrass beds
- fragmentation of those beds
- the upper and lower edges of those beds
- shoot density within the beds
- epiphyte cover within beds

The expert assessment of seagrass beds currently being in good condition (Figure 7) helps us to interpret the small amount of quantitative data on seagrass condition. This knowledge will lay the foundation for the setting of limits of acceptable change for any future monitoring of seagrass beds in Yaringa MNP.

4.2 Mangroves

Mangrove shrubland (Ecological Vegetation Community 140) covered some 320 ha or 33% of Yaringa MNP in the most recent mapping of the park (Figure 2).[S5] Changes to mapping methods hinder comparison with earlier estimates of the extent of mangroves, but there is evidence of localised seaward movements of the mangrove/mudflat boundary in recent years.[S6]

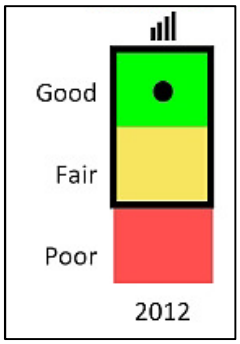


Figure 8 - Mangrove condition

Mangrove (and saltmarsh) expert Prof. Paul Boon believes the extensive area of mangrove in Yaringa MNP to be in fair to good condition (Figure 8) due to the relative lack of "human interference", basing this judgement on personal experience including recent work on the 2011 Victorian Saltmarsh Study[S7]. He is, however, uncertain how condition might have changed from 2002 to 2012, commenting on the lack of monitoring data (e.g. for indicators such as age/size class distribution of trees or measures of tree health), as well as a lack of general agreement on the best measures to assess mangrove condition.

4.3 Coastal Saltmarsh

The multiple Ecological Vegetation Communities that make up the coastal saltmarsh ecosystem in Yaringa MNP (Figure 1) cover about 305 ha or 31% of the park.[S5] In spite of the difficulty of making comparisons of mapping developed using different methods, there is evidence of a loss of saltmarsh in the park as the seaward boundary has moved somewhat shorewards.[S6] (The relatively stable shoreward edge of the saltmarsh is not within the MNP).

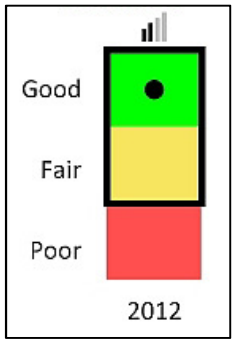


Figure 9 - Coastal Saltmarsh condition

Saltmarsh expert Prof. Paul Boon believes the extensive area of coastal saltmarsh in Yaringa MNP to be in fair to good condition (Figure 9) due to the relative lack of "human interference" (as was the case with mangrove shrubland), again basing this judgement on personal experience dating back to the mid-1980s and including recent work on the 2011 Victorian Saltmarsh Study.[S7] He was, however, uncertain how condition might have changed from 2002 to 2012, noting a lack of monitoring data, as well as general uncertainty about what constitutes 'good' condition for saltmarsh vegetation.

Some nominated indicators (see Table 3) for saltmarsh condition relate not directly to the plants themselves, but to the provision of habitat for threatened animal species. On these,

Dr Mark Antos has provided expert opinion. He noted differences in the habitat preferences for the orange-bellied parrot, the swamp skink and Lewin's rail, thus his condition ratings varied from poor to good, with more emphasis on the higher ratings.

4.4 Unvegetated sediment

Nominated indicators (see Table 4) for this ecosystem are the abundance of key invertebrate species, the extent of intertidal sediment, the abundance of key bird species and the diversity of migratory shorebirds.

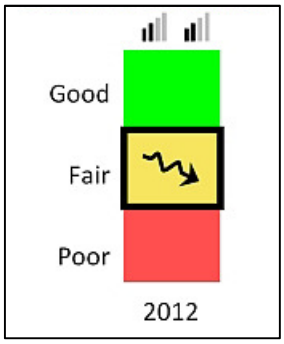


Figure 10 - Unvegetated sediment condition

Updated mapping of Yaringa MNP (see Figure 1) indicated there is about 38 ha of unvegetated sediment within Yaringa MNP, but did not distinguish intertidal from subtidal.[S5] However, mapping based on 2009 aerial photography determined that about 90% of bare sediment in the park was intertidal.[S5] (It should be noted that birds may also forage over intertidal seagrass beds. Based on 2009 aerial photography, some 200 ha of seagrass beds are intertidal.[S5]).

In 2006 and 2007, a study of macroscopic invertebrates (animals visible to the naked eye and lacking a backbone) in the intertidal sediments of Western Port MNPs and other non-park sites recorded 32 species from large cores collected in Yaringa MNP. Among the most common species in the park were polychaete worms, the ghost shrimp *Biffarius arenosus* and the sentinel crab *Macrophthalmus latifrons*.[S3] Another ghost shrimp *Trypaea australiensis* considered an indicator (see Table 4) was not recorded in Yaringa MNP during this survey. Reanalysis of the data revealed the average numbers of species and individuals at Yaringa MNP were significantly higher than those at French Island and Churchill Island MNPs. For further information on the results of sampling invertebrates of unvegetated sediments see “Sampling invertebrates in unvegetated sediments raw data” in Appendix 3.

Sampling for a study of nutrient cycling in Western Port indicated abundances of macroscopic invertebrates in the order of 1000 per m^2 in Yaringa MNP, with over 40% contributed by four common polychaete worms and 20% by the ghost shrimp *Biffarius arenosus*.[S8]

Expert Dr Sarah Butler judged the condition of the macroscopic invertebrate in Yaringa MNP to be fair to good (see Figure 10). The high number of species relative to other sites in Western Port was a positive, but she was concerned about the presence of the invasive Asian bag mussel *Musculista senhousia* in the park.

Dr Mark Antos provided expert opinion on shorebirds, distinguishing between migratory and resident species. He believed the migratory species to be faring worse (poor to fair, and declining) than the residents (fair and steady), noting that the two groups have differing

vulnerability to threats and citing land-sourced pollutants, climate change and exotic species as threats of particular concern (see Figure 10).

4.5 Water column

No water quality data are routinely collected within Yaringa MNP. However, the EPA regularly collects data from a fixed monitoring station some 5 km from the park, near Barrallier Island. Melbourne Water regularly monitors water quality 3 km upstream of the park in Watson Creek (see Figure 2).

Figure 11 summarises 13 measures of water quality for the following 5 indicators from near Barrallier Island: Total Phosphorus (3 measures), Total Nitrogen (3 measures), Chlorophyll a (2 measures), Dissolved Oxygen and Water clarity (4 measures). For each year, it shows the percentage of measures that met their SEPP objective.

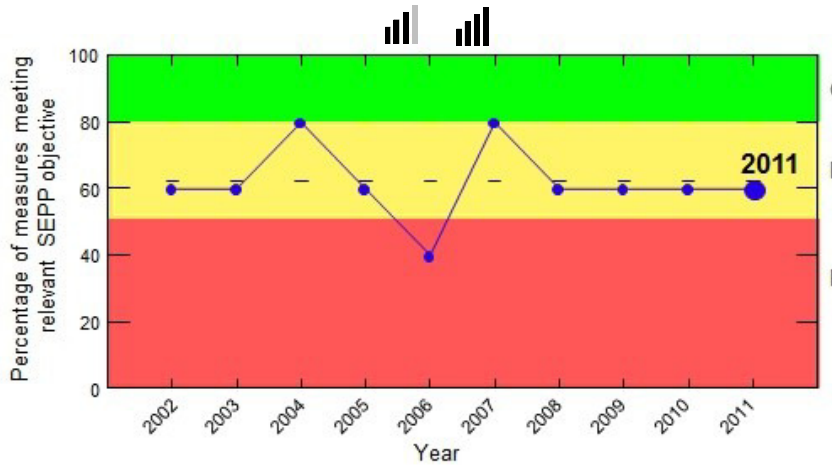


Figure 11 - Water quality summary of 5 indicators

The indicators failing to meet the relevant objectives in 2011 were dissolved oxygen and nitrogen. Further detail is available, below in this report, on the five indicators:

- Phosphorus
- Nitrogen
- Chlorophyll
- Dissolved oxygen
- Water clarity

Additional data of relevance to Yaringa MNP is water quality data for Watson Creek provided by Melbourne Water.[S9] Over 12 months for 2010-2011, the minimum dissolved oxygen, maximum total phosphorus and maximum total nitrogen exceeded the relevant SEPP objectives[S10] for the Lowlands & Phillip Island segment, while the median turbidity level did meet its objective. This water flows into Yaringa MNP where it mixes with marine waters and is diluted and dispersed.

A short-term study in and around Yaringa MNP to assess temporal and spatial variation in water quality was undertaken in January 2007.[S11] Key findings of relevance to this report are as follows:

- Peaks in chlorophyll a concentrations in the Watson Inlet channel are likely to be due to water draining off the intertidal mudflats.
- Turbidity is consistently highest at the entrance to the Yaringa channel, with values on the ebb tide being higher than when the tide is flooding back into the park.
- Phosphorus concentrations change little with the tide and are not dominated by either terrestrial or marine origins.

Water quality was also examined at a site in Yaringa MNP as part of a wider study into nutrient cycling in Western Port.[S8] This study noted that there was little retention of the bioavailable nitrogen from Watson Creek in the waters of Watson Inlet where Yaringa MNP is located.

Water quality expert Mr Rhys Coleman considered nutrients from the surrounding catchment to pose a major risk (see Water Column). In the light of that perceived risk and the high concentrations of phosphorus upstream of the park in Watson Creek, the lack of a major terrestrial influence in phosphorus concentrations at the southern end of the park is noteworthy, as is the lack of retention of bioavailable nitrogen in the water column.

Phosphorus

Two forms of phosphorus are recommended as indicators of nutrient status. Dissolved Inorganic Phosphorus (DIP) represents phosphorus that is available to biota. In contrast, Total Phosphorus (TP) is the sum of the dissolved and particulate forms of both organic and inorganic phosphorus, and is indicative of the cycling of phosphorus through the ecosystem.[S15]

Following the recommendations of Schedule F8[S10][S16], the following chart (Figure 12) shows annual medians for TP. Medians largely met the SEPP objective of less than 25 ug/L[S10], with the 2006 median falling right on the boundary. Due to anomalies in some raw data for phosphorus, DIP is not presented here.)

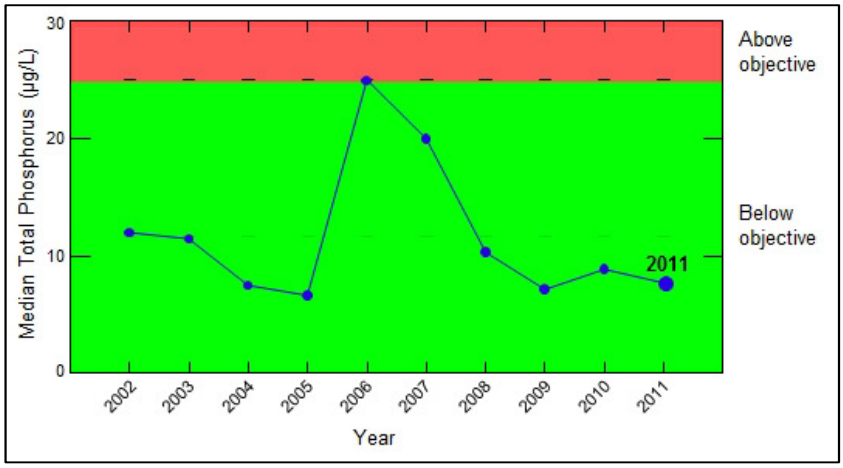


Figure 12 - Annual medians for Total Phosphorus present in water column

Nitrogen

Two forms of nitrogen are recommended as indicators of nutrient status. Dissolved Inorganic Nitrogen (DIN) represents nitrogen that is available to biota. In contrast, Total Nitrogen (TN) is the sum of the dissolved and particulate forms of both organic and inorganic nitrogen, and is indicative of the cycling of nitrogen through the ecosystem.[S15]

Following the recommendations of Schedule F8[S10][S16], the following chart (Figure 13) shows annual medians for TN. Medians were consistently above the SEPP objective of less than 120 ug/L.[S10][S16] (Due to an anomaly with raw nitrite data, DIN will not be presented here.)

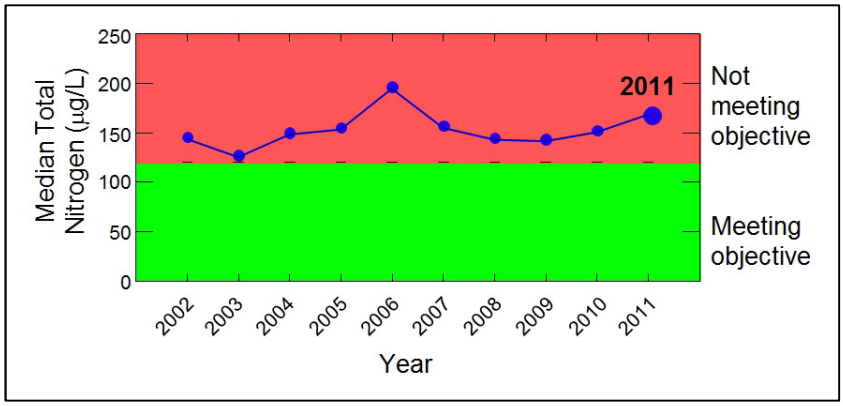


Figure 13 - Annual medians for total nitrogen present in water column

Chlorophyll

Chlorophyll a is recommended as an indicator of nutrient status. Nutrient availability is one factor that can affect the biomass of phytoplankton in the water column, and chlorophyll a is a coarse measure of phytoplankton abundance.[S15]

The following charts (Figures 14 and 15) plot the chlorophyll measures specified in Schedule F8[S10], i.e. the median and the 75th percentiles for chlorophyll a. end .content The SEPP objective for each chlorophyll measure has been met consistently since 2002.

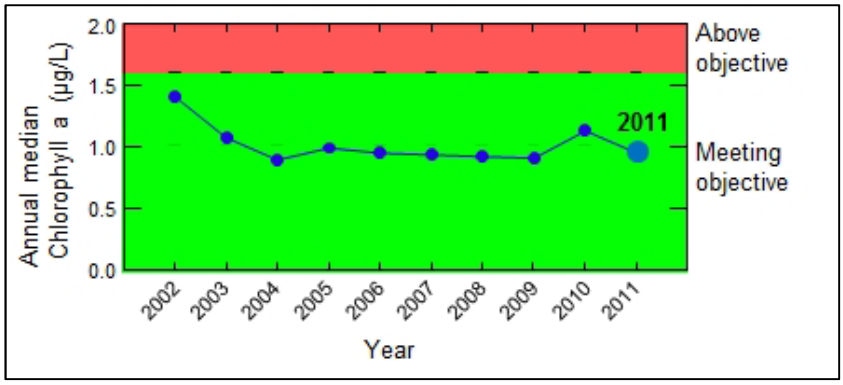


Figure 14 - Annual medians for Chlorophyll a present in the water column

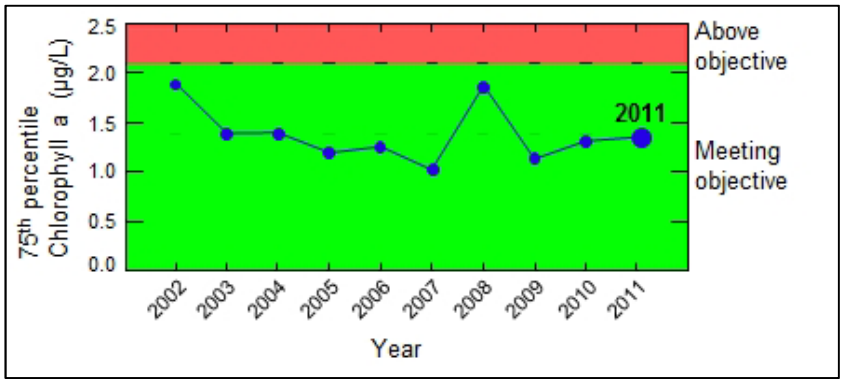


Figure 15 - 75th percentile for chlorophyll a present in the water column

Dissolved oxygen

Dissolved Oxygen (DO) is recommended as an indicator of nutrient status as it can be reduced by blooms of phytoplankton resulting from high nutrient levels.[S15] In addition, adequate levels of DO are essential for marine biota in general. Here DO is recorded as percent saturation; higher values are better than lower values.

The following chart (Figure 16) plots the annual minimum DO. It also indicates the SEPP objective of that minimum being greater than 90% saturation, as specified in Schedule F8.[S10] In 2011, the annual minimum was below the SEPP objective. Since 2002, the minimum DO has been below the objective for 5 of the 10 years to 2011.

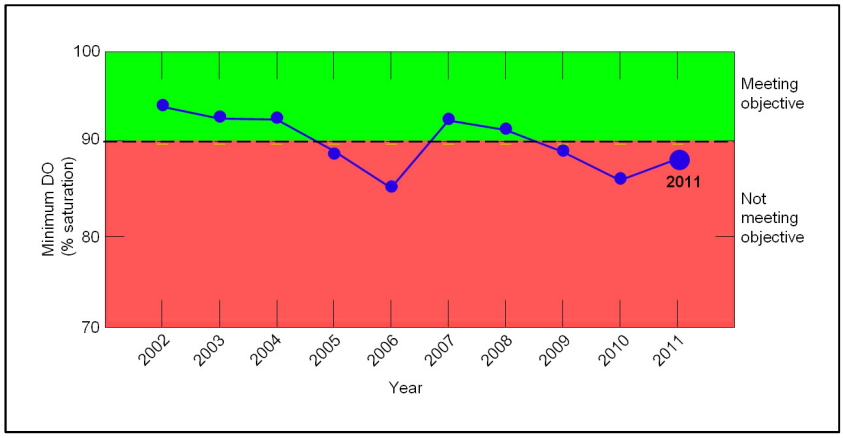


Figure 16 - Minimum dissolved oxygen concentration in the water column

Water clarity

Water clarity is important for seagrasses and seaweeds that need light to photosynthesise.

It can be measured in various ways. Secchi depth is the water depth at which a specially marked disk is just visible; larger values indicate clearer water. Suspended solids (SS) are particulates in the water with the potential to smother marine life if and when they settle to the sea bed; lower values represent clearer water.[S15] The following charts plot medians and percentiles for both Secchi depth (Figures 17 and 18) and SS (Figures 19 and 20). In the case of SS, Schedule F8 sets an objective for the 75th percentile, in contrast to use of the 25th percentile for Secchi depth where smaller values indicate poorer conditions.[S10]

The annual median for Secchi disk depth fell below the SEPP objective of greater than 2.4 m[S10] in three years - 2002, 2003 and 2008. However, corresponding 25th percentiles were consistently above their objective of greater than 1.4 m[S10]. This means that although the middle values of Secchi depth for some years were lower than desired, the overall spread of values remained acceptable over the ten year period.

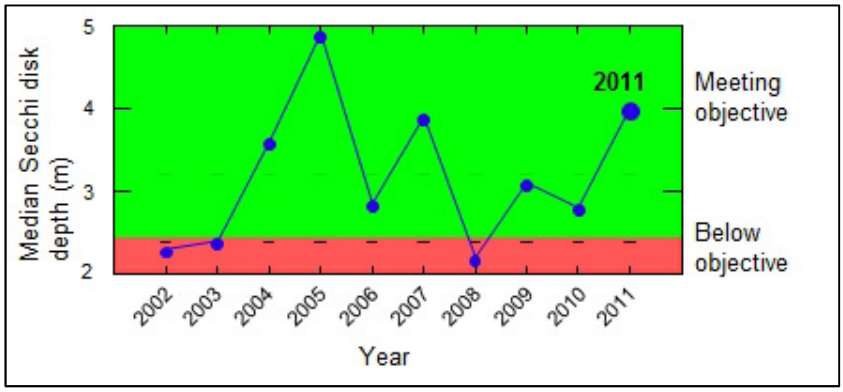


Figure 17 - Median Secchi disk depth

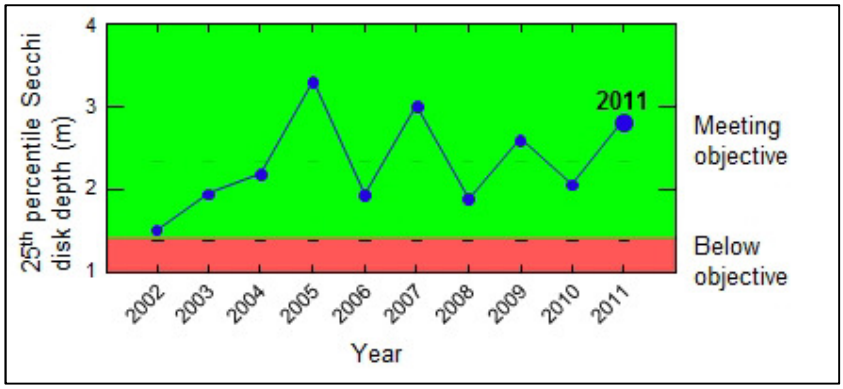


Figure 18 - 25th percentile Secchi disk depth

The SEPP objective for the annual median SS was to be less than 9 mg/L and for the 75th percentile, the objective was to be less than 19 mg/L.[S10] end .content Both SS measures met the relevant SEPP objectives in all ten years.

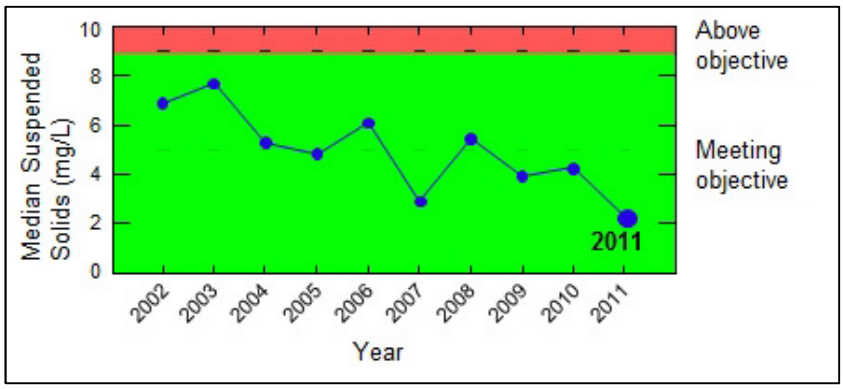


Figure 19 - Median suspended solids in water column

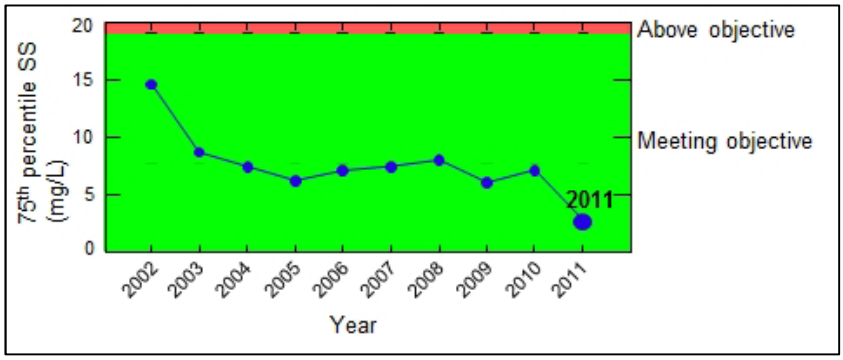


Figure 20 - 75th percentile suspended solids in water column

4.6 Threat Status

The figure below (Figure 21) summarises the key threats to the natural assets of Yaringa MNP, drawn from the larger list shown above that has been developed over the last decade. The ecosystem of greatest concern is the seagrass. Suspended sediments and catchment-

related nutrients have been recognised as threats to seagrasses, not only in Yaringa MNP and the rest of Western Port, but also globally, as a result of major declines seen in seagrasses around the world in the 1970s and 1980s.[S12] Watson Creek on the west side of the park is of particular concern as a source of nutrients.

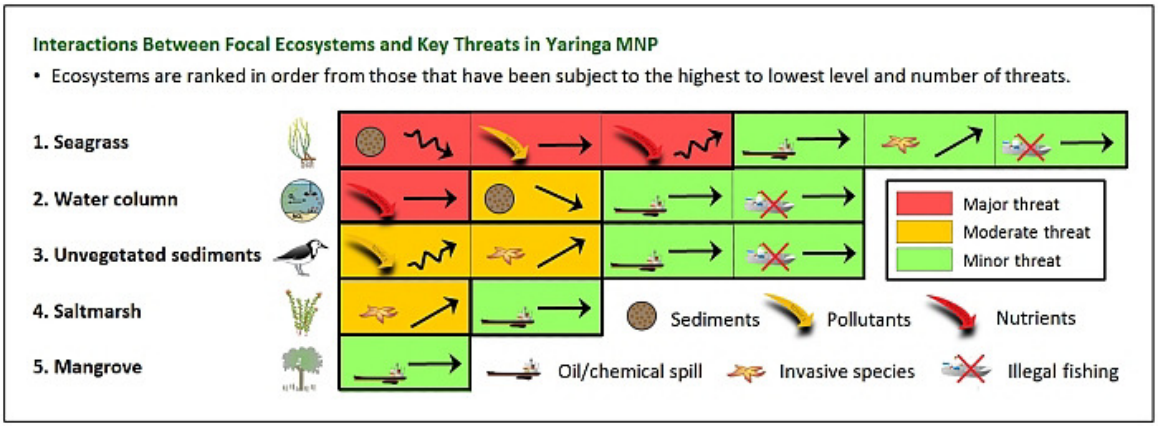


Figure 21 - Interactions between ecosystems and threats

Other concerns are exotic species, of which several are known to be present in Western Port and one, the Asian bag mussel, has already been found in the park[S3]. Physical disturbance to sensitive seagrass, mangrove and saltmarsh habitats was identified as an additional threat. Climate change is recognised as an important driver of change for the park in the medium to long term but other threats were considered more important over the next five years.

Experts on the different ecosystems provided their judgements of the impacts of threats to the Key Ecological Attributes (KEAs) within those ecosystems over the ten years from 2002 to 2012. The matrix below summarises the impacts of threats by KEAs, in a way that allows you to easily see which of the threats affect multiple KEAs, or conversely, which KEAs are subject to multiple threats. A multicoloured cell indicates that the expert estimate(s) spanned more than a single category (e.g. amber plus red indicates the impact of threat was rated 'moderate to major').

5. Management of the Park

Marine protected areas (MPAs) by their nature present a particular suite of management challenges that may need different approaches to protected areas on land. Boundaries in the sea can be difficult to define, and the effects of human activities can be hidden from view. Natural, recreational and cultural values may be affected by the use of both land and marine areas some distance away, over which park managers have no direct control. Impacts on one marine habitat can quickly affect another, and human activities and natural events on land and in the atmosphere can have widespread consequences for the marine environment[P1]. The effects of some environmental drivers such as climate are much more difficult or impossible to manage. Effective management of threats to natural assets requires an integrated coastal zone management (ICZM) approach. This involves

collaborative partnerships with key government agencies, industry and the community to protect environmental health.

5.1 Management priorities

Since the declaration of Yaringa MNP in 2002, Parks Victoria's management priorities have included:

- Partnership building and stakeholder engagement to address water quality issues through improved agricultural, urban and land use practices within the park catchment, with a particular focus on Watson Creek.
- Compliance and enforcement patrols, maintenance of boundary markers, and removal of an illegal jetty in the park.
- Building community understanding and stewardship for the park's important values through community engagement and collection and use of high quality images and video footage.
- Improving knowledge of the park through marine habitat mapping, seagrass monitoring, marine pest surveys, and developing methods for monitoring soft sediment communities.

5.2 Management focus and effectiveness

Management of Yaringa MNP was considered partially effective, with management effort since the park was declared focusing on key threats to priority natural assets (Figure 22). Many of the threats identified as high risk in the future overlap with the existing threats (see Assets and Threats). Physical disturbance to sensitive seagrass, mangrove and saltmarsh habitats was identified among existing threats (i.e. recreational boating, more intense weather events) as likely to pose a higher risk in future.

Climate change is recognised as an important driver of change for the MNP in the medium to long term but other threats were considered more important over the next five years.

Future management will focus on addressing both existing and emerging threats.

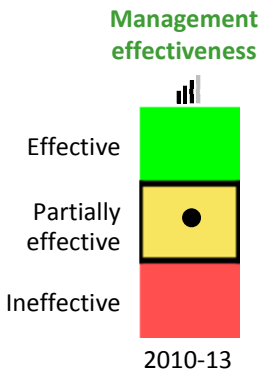


Figure 22 – Management Effectiveness (Yaringa)

5.3 Future management response

Following the assessment of condition of key natural assets, impact of existing threats, risk of emerging threats, and management effectiveness, the following management strategies have been identified as high priorities over the next five years:

- Work collaboratively with Port Phillip and Western Port CMA to reduce the impacts of land use and catchment management on the planning area and develop appropriate actions in the Regional Catchment Strategy.
- Work collaboratively with EPA and Melbourne Water to minimise impacts associated with discharge of waste into the environment, particularly from Watson Creek.
- Establish an ongoing program to minimise the risk of marine pest and weed

introduction and subsequent spread. This should include improving the understanding of the potential means of introduction and spread and formalising arrangements for prevention, reporting, monitoring and response.

- Work collaboratively with Department of Transport Planning and Local Infrastructure on marine pollution incidents and contribute to updating of contingency plans for marine pollution incidents as required, and communicate arrangements to staff, relevant agencies and interested parties.
- Work with Fisheries Victoria to undertake education, patrols and targeted compliance operations to ensure appropriate behaviours, and encourage visitors to assist with compliance management by reporting illegal fishing to the Fisheries Victoria hotline.
- Continue to implement the marine science program to address critical knowledge gaps and information needs that will assist management.

6. References

[A1] Parks Victoria. (2007) Yaringa Marine National Park, French Island Marine National Park and Churchill Island Marine National Park management plan. Parks Victoria, Melbourne.

[A2] Barton, J., Pope, A. and S. Howe (2012) Marine Natural Values Study Vol 2: Marine Protected Areas of the Victorian Embayments Bioregion, Part 2 Western Port Bay & Corner Inlet. Parks Victoria Technical Series No. 78. Parks Victoria, Melbourne.

[A3] Boon, P.I., Allen, T., Brook, J., Carr, G., Frood, D., Hoye, J., Harty, C., McMahon, A., Mathews, S., Rosengren, N., Sinclair, S., White, M. & Yogovic, J. (2011) Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management. Technical Report. Institute for Sustainability and Innovation, Victoria University, Melbourne.

[A4] Ross, J. (2012) Ecosystem processes. In: Understanding the Western Port Environment: A summary of current knowledge and priorities for future research. Keough, M. & Bathgate, R. (Eds) Ch. 14, pp. 184-197. Melbourne Water, Melbourne.

[A5] State Environment Protection Policy (Waters of Victoria). Schedule F8. Waters of Western Port and Catchment. 2001.

[A6] ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australia and New Zealand Environment and Conservation Council, and the Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

[A7] Carey, J.M., Boxshall, A., Burgman, M. A., Beilin, R. & Flander, L. (2007) State-wide synthesis of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries. Parks Victoria Technical Series No. 34. Parks Victoria, Melbourne.

[A8] Parks Victoria (2011) Marine Conservation Objectives of Victorian Marine Protected Areas workshop. Parks Victoria, Melbourne.

[A9] Pocklington, J.B., Carey, J.M., Murshed, M.T.D. & Howe, S.A.J. (2012) Conceptual models for Victorian ecosystems: marine and estuarine ecosystems. Parks Victoria Technical Series No. 66. Parks Victoria, Melbourne.

[M1] ANZECC Task Force on Marine Protected Areas (1999) Strategic plan of action for the National Representative System of Marine Protected Areas: A guide for action by Australian Governments. Environment Australia, Canberra.

[M2] Parks Victoria (2011) Marine Conservation Objectives of Victorian Marine Protected Areas workshop. Parks Victoria, Melbourne.

[M3] DEST. (1994) State of the Environment Reporting: Framework for Australia. Department of Environment, Sport and Territories, Canberra.

[M4] OECD. (1993) OECD Core Set of Indicators for Environmental Performance Reviews. Environment Monographs No. 83. Organisation for Economic Co-operation and Development, Paris.

[M5] Cairns J., Jr & Pratt J. R. (1995) The relationship between ecosystem health and delivery of ecosystem services. In: Evaluating and Monitoring the Health of Large-scale Ecosystems. NATO ASI Series, Vol. I 28. (Eds D. J. Rapport, C. L. Gaudet & P. Calow) Springer-Verlag, Berlin, in cooperation with NATO Scientific Affairs Division.

[M6] Fairweather P. G. (1999) State of environment indicators of 'river health': exploring the metaphor. Freshwater Biology. 41: 211-220.

[M7] Rapport D. J., Costanza R., Epstein P., Gaudet C. & Levins R. (Eds) (1998) Ecosystem Health. Blackwell Science, Malden, MA.

[M8] Karr J. R. (1996) Ecological integrity and ecological health are not the same. In: Engineering within Ecological Constraints. (Ed P. C. Schulze) National Academy of Engineering. National Academy Press, Washington, D.C.

[M9] McCarthy, M. A., Parris, K. M., Van Der Ree, R., McDonnell, M. J., Burgman, M. A., Williams, N. S., McLean, N., Harper, M.J., Meyer, R., Hahs, A. & Coates, T. (2004). The habitat hectares approach to vegetation assessment: an evaluation and suggestions for improvement. Ecological Management & Restoration. 5: 24-27.

[M10] Parkes, D., Newell, G. & Cheal, D. (2004) The development and raison d'être of 'habitat hectares': a response to McCarthy et al. (2004). Ecological Management & Restoration. 5: 28-29.

[M11] Boon, P.I., Allen, T., Brook, J., Carr, G., Frood, D., Hoye, J., Harty, C., McMahon, A., Mathews, S., Rosengren, N., Sinclair, S., White, M. & Yogovic, J. (2011) Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management. Technical Report. Institute for Sustainability and Innovation, Victoria University, Melbourne.

[M12] Butler, S. and Bird, F.L. (2010) Monitoring the macroinvertebrates and soft sediments in the Marine National Parks in Western Port. Parks Victoria Technical Series No. 60. Parks Victoria, Melbourne.

[M13] Browne, M., Kuhnert, P., Peterson, E., Bartley, R., Steven, A. & Harch, B. (2007) Review of existing approaches used to develop integrated report card frameworks (IRCF) and their relevance to catchments draining to the Great Barrier Reef. Marine and Tropical Sciences Research Facility report. Reef and Rainforest Research Centre, Cairns.

<http://www.rrrc.org.au/publications/downloads/Revised-Project-377-Final-Report-250607.pdf> http://www.rrrc.org.au/publications/downloads/Revised-Project-377-Final-Report-250607.p> Accessed 5 May 2010.

[M14] Arundel, H., Pope, A., & Quinn, G. (2009). Victorian Index of Estuary Condition: recommended themes and measures. School of Life and Environmental Sciences, Deakin University, Warrnambool.

[M15] McCarthy, M. (2012) Ecological indices behaving badly. Decision Point. 56: 4-5. <http://www.decision-point.com.au/past-issues/dpoint56.html> Accessed 2 March 2012.

[M16] Whittaker G, Lautenbach S, Volk M. 2012. What is a good index? Problems with statistically based indicators and the Malmquist index as alternative. International Environmental Modelling and Software Society (iEMSs) 2012 International Congress on Environmental Modelling and Software Managing Resources of a Limited Planet, Sixth Biennial Meeting, R Seppelt, AA Voinov, S Lange, D Bankamp (eds.), Leipzig, Germany.

[M17] Nichols, J. D., Runge, M. C., Johnson, F. A., & Williams, B. K. (2007). Adaptive harvest management of North American waterfowl populations: a brief history and future prospects. Journal of Ornithology. 148(2): 343-349.

[M18] Edmunds, M. and Hart, S. (2003) Parks Victoria Standard Operating Procedure: Biological Monitoring of Subtidal Reefs. Parks Victoria Technical Series No. 9. Parks Victoria, Melbourne.

[M19] Cook, C. (2012) Eliciting expert knowledge about the condition of priority assets and impacts of priority threats for Parks Victoria's marine protected areas. Report to Parks Victoria for RPP Project RPP 0809 P18c.

[M20] Montgomery, D.C. (2009) Introduction to Statistical Quality Control. 6th Ed. John Wiley & Sons, New York.

[M21] Morrison, L. W. (2008). The use of control charts to interpret environmental monitoring data. Natural Areas Journal. 28: 66-73.

[M22] ANZECC & ARMCANZ. (2000a) Australian guidelines for water quality monitoring and reporting. Australia and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

[M23] Environmetrics Australia (2007) Statistical methods for turbidity monitoring: control charting. Report to Port of Melbourne Corporation by Environmetrics Australia Pty Ltd, Parkville, Vic.

[M24] State Environment Protection Policy (Waters of Victoria). Schedule F8. Waters of Western Port and Catchment. 2001.

[M25] ANZECC & ARMCANZ. (2000b) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australia and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

[M26] Hockings, M., Cook, C. N., Carter, R. W., & James, R. (2009). Accountability, reporting, or management improvement? Development of a State of the Parks assessment system in New South Wales, Australia. Environmental Management. 43: 1013-1025.

[S1] Sue, W.X. (2008) Optimisation of Sea Search for seagrass monitoring protocol in Yaringa Marine National Park. Honours thesis, School of Botany, the University of Melbourne.

[S2] Parks Victoria. (unpublished) Seagrass monitoring in Yaringa MNP, January-March 2009.

[S3] Butler, S. and Bird, F.L. (2010) Monitoring the macroinvertebrates and soft sediments in the Marine National Parks in Western Port. Parks Victoria Technical Series No. 60. Parks Victoria, Melbourne.

[S4] Campbell S.J. & Miller C.J. (2002) Shoot and abundance characteristics of the seagrass Heterozostera tasmanica in Westernport estuary (south-eastern Australia). Aquatic Botany. 73:33-46.

[S5] French, T., Monk, J., Ierodiaconou, D., Pope, A. & Ball, D. (2014) Yaringa and French Island marine habitat mapping. Parks Victoria Technical Series No. 96. Parks Victoria, Melbourne.

[S6] Ball, D. (in press) Remote sensing for Victorian Embayment Marine National Parks. Parks Victoria Technical Series. Parks Victoria, Melbourne.

[S7] Boon, P.I., Allen, T., Brook, J., Carr, G., Frood, D., Hoye, J., Harty, C., McMahon, A., Mathews, S., Rosengren, N., Sinclair, S., White, M. & Yogovic, J. (2011) Mangroves and coastal saltmarsh of Victoria : distribution, condition, threats and management. Technical Report. Institute for Sustainability and Innovation, Victoria University, Melbourne.

[S8] Evrard, V., Eate, V., Woodland, R., Ross, J., O'Brien, A., Keough, M., Longmore, A., Wilson, R. & Cook, P. (2013) Nutrient processing on tidal flats in Western Port: interactions with ecology and implications for bay-wide nutrient budgets. A report prepared for Melbourne Water, 23 July 2013. Water Studies Centre, Monash University, Melbourne.

[S9] Melbourne Water (2012) Environmental Compliance Report - Q3/4 2010-11. http://melbournewater.com.au/aboutus/reportsandpublications/compliance-reports/Documents/2010-11%20Environmental%20compliance%20report%20(Jan-Jun).pdf. Accessed 11 October 2012.

[S10] State Environment Protection Policy (Waters of Victoria). Schedule F8. Waters of Western Port and Catchment. 2001.

[S11] Lee, R. (unpublished) Watson Creek study, 5-7 January 2007. Report to Parks Victoria.

[S12] Walker, D. (2012) Seagrasses. In: Understanding the Western Port Environment: A summary of current knowledge and priorities for future research. Keough, M. & Bathgate, R. (Eds) Ch. 10, pp. 134-141. Melbourne Water, Melbourne.

[S13] Koss, R., Bunce, A., Gilmour, P. & McBurnie, J. (2005) Sea Search: Community–Based

Monitoring of Victoria's Marine National Parks and Marine Sanctuaries - Seagrass Monitoring. Parks Victoria Technical Series No. 16. Parks Victoria, Melbourne.

[S14] McKenzie, L.J., Campbell, S.J. & Roder, C.A. (2003) Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) volunteers. 2nd Edition. QFS, NFC, Cairns. 100pp.

[S15] EPA (2001) Water Quality Objectives for Marine and Estuarine Waters – Ecosystem Protection. Draft State Environment Protection Policy (Waters of Victoria). EPA Publication 794. Environment Protection Authority, Southbank, Melbourne.

[P1] Pocklington, J.B., Carey, J.M., Murshed, M.T.D. & Howe, S.A.J. (2012) Conceptual models for Victorian ecosystems: marine and estuarine ecosystems. Parks Victoria Technical Series No. 66. Parks Victoria, Melbourne.

7. Glossary of Terms

The following definitions are provided for acronyms or technical terms used in the Report Cards.

Adaptive management - Style of management where alternative management strategies are treated as experiments to distinguish between alternative models of a system. [Walters 1997] It allows for ongoing learning by continually assessing the success of past management actions in meeting management objectives, and allowing refinement of management actions in the future.

AMF (Parks Victoria) - Adaptive Management Framework

ANZECC - Australian and New Zealand Environment and Conservation Council. Produced numerous documents relating to environmental protection matters, including the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* ANZECC ceased to exist in 2001, as a result of restructuring by the Council of Australian Governments. Current equivalent is the National Environment Protection Council.

Chlorophyll - Principal photosynthetic pigment of green plants and algae. [Lawrence 1995]

Community - A group of plants and animals that live together in a particular environment and interact with one another. [after Allaby 1994 and Lawrence 1995]

Conceptual model - Model representing components in a system, including inputs and outputs, flows, cycles, system boundaries, causal links, etc. Models can take various forms, including verbal, diagramatic, pictorial and mathematical. [after Burgman 2005]

Condition - e.g. As in 'ecosystem condition'. Condition is a somewhat loosely-applied term, with few formal definitions. It has been variously equated with ecosystem health [Cairns *et al*. 1995; Fairweather 1999], or state in the Pressure-State-Response scheme for environmental indicators [DEST 1994; OECD 1993]. Condition is not a single variable/parameter that can be directly measured, but a broader concept that may incorporate a number of different indicators. The key indicators and their relative importance will vary from one ecosystem to another.

Conservation outcome statements (Parks Victoria) - A statement about the desired condition of natural assets in a park or parks, & the acceptable level of threat to those assets, which management is seeking to achieve. These statements will help focus management on the key natural assets Parks Victoria is managing for and will be used to assess the extent to which management actions are working and to diagnose why some actions succeed while others do not. [Parks Victoria 2013]

Control chart - Graphical tool in Statistical Process Control developed in the 1930s for the manufacturing industry to help control drift and variation in a process (e.g. the manufacture

of brake parts for cars) in order to maintain production quality. In an industrial context, a control chart plots a process statistic through time, along with control limits designed to indicate that management action or further investigation is necessary. [Montgomery 2009]

Deposit feeder - Animal that lives on or in the sediment of the seabed, and feeds by ingesting sediment rich in organic material. [after Allaby 1994]

Driver - Thing that determines the distribution of habitats and a major factor that acts in these systems to influence their state or condition e.g. hydrodynamics. [Pocklington *et al*. 2012]

Ecosystem - Community of different species interdependent on each other together with their non-living environment, which is relatively self-contained in terms of energy flow, and is distinct from neighbouring communities. [Lawrence 1995] Only ecosystems that include at least one Nested Asset are included in the reports/report cards for each park.

Ecosystem engineer - Organism that directly or indirectly modulates the availability of resources to other species, by causing physical state changes in biotic or abiotic materials. In so doing it modifies, maintains or creates habitats. [Jones *et al*. 1994]

Ecosystem aim (Parks Victoria) - A statement about the desired condition of an ecosystem in a park, which management is seeking to achieve. Aims are developed for each natural ecosystem and usually include information such as 'do what' (e.g. maintain, improve etc.), 'to what' (e.g. Key Ecological Attributes within the ecosystem), 'where' (e.g. the park or particular 'focal' area within the park), 'why' (e.g. to provide habitat etc.) and 'by when' (usually 15 years for Ecosystem aims).

EPA - Environment Protection Authority (Victoria) EPA's sole role is to regulate pollution and has independent authority to make regulatory decisions under the *Environment Protection Act 1970*. <http://www.epa.vic.gov.au>

EVC - Ecological Vegetation Class. Component of a classification scheme for native vegetation in Victoria. An EVC consists of one or a number of floristic communities that appear to be associated with a recognisable environmental niche, and which can be characterised by a number of their adaptive responses to ecological processes that operate at the landscape scale level. Each EVC is described through a combination of its floristic, life-form and reproductive strategy profiles, and through an inferred fidelity to particular environmental attributes. <http://www.dse.vic.gov.au/conservation-and-environment/ecological-vegetation-classes-evc>

FFG - The *Flora and Fauna Guarantee Act 1988* (FFG Act) is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.

<http://www.depi.vic.gov.au/environment-and-wildlife/threatened-species-and-communities/flora-and-fauna-guarantee-act-1988>

ICMZ - Integrated Coastal Zone Management

IMCRA - Integrated Marine and Coastal Regionalisation of Australia. A spatial framework for classifying Australia's marine environment into bioregions that make sense ecologically and are at a scale useful for regional planning. These bioregions are the basis for the development of a National Representative System of Marine Protected Areas (NRSMPA). <http://www.environment.gov.au/node/18075>

Intertidal - The part of the shoreline that occurs between the mean high and mean low water marks (the mean high water mark usually marks the landward boundary of the Marine National Parks and Sanctuaries). Intertidal areas are sometimes covered by the sea and other times exposed to the air.

Key Ecological Attribute (Parks Victoria) - Aspects of the Nested Assets or threats that can be measured/assessed to provide an understanding of the status of each attribute or threat. This is a short list of attributes that should collectively provide a summary of the most critical attributes to provide an overall understanding of the status or health of the Nested Asset.

Limits of acceptable change (Parks Victoria) - Limits of acceptable change (LACs) are defined as the variation that is considered acceptable in the value of an indicator or the category of condition of a Natural Asset or level of a Threat. On control charts, LACs delineate acceptable categories of condition or threat, or acceptable values for parameters. LACs represent management objectives, and are determined by the ecological knowledge of the system, management priorities, and agency and stakeholder values. LACs may be above or below the preferred 'target range', or both, depending on the Natural Asset or Threat.

Management Effectiveness Evaluation - The assessment of how well protected areas are being managed - primarily the extent to which management is protecting values and achieving aims and objectives [Hockings *et al*. 2006]. The *State of the Parks* (SoP) program is Parks Victoria's mechanism for evaluating the effectiveness of park management across its parks network. The reporting on management effectiveness in the marine report cards is based on an evaluation of the extent to which management objectives were met for a particular issue across the park during the SoP survey period (2010- 2013).

Median - The 'middle' value in a set of data such that half of the observations have values numerically greater than the median and half have values numerically less than the median. For small data sets, the sample median is obtained as either the single middle value after sorting in ascending order when n is odd, or the average of the two middle observations when n is even. [ANZECC & ARMCANZ 2000a]

Microalgae - Microscopic algae

Microphytobenthos - Microscopic algae that live on soft sediments where they typically appear as a subtle, often marbled, brownish or greenish film.

MNP (Parks Victoria) - Marine National Park

MPA - Marine Protected Area. A general term applied globally to marine areas subject to some level of protection.

MS (Parks Victoria) - Marine Sanctuary

Natural Assets (Parks Victoria) - Parts of the environment valued by people and considered to be proxies for biodiversity and natural processes (for the purposes of the marine report cards they do not include geological or geomorphological features). The term is broad and includes Ecosystems and Focal Ecosystems. A subset of the Natural Assets within an ecosystem may be selected as Key Ecological Attributes. Natural Assets include:

- *Nested assets – assemblages and communities:* Assemblages and communities that are characteristic, highly-valued and/or critical elements of the ecosystem.
- *Nested assets – species:* Single species should only be selected when there are strong reasons not to use assemblages or communities.
- *Important habitat features:* These are the important habitat elements of the ecosystem (such as seagrass/seaweed wrack, water quality…).

NRSMPA - Australia's National Representative System of Marine Protected Areas. Aims to establish and manage a comprehensive, adequate and representative system of marine protected areas to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels. <http://www.environment.gov.au/node/18075>

Parameter - A measurable or quantifiable characteristic or feature. [ANZECC & ARMCANZ 2000b]

Percentage cover - Method of recording abundance for plants or animals where individual organisms cannot be distinguished (e.g. turfing seaweeds or compound ascidians).

Percentile - The value in an ordered set of data such that the given percentage of observations have values numerically less than the percentile and the remainder have values numerically greater than the percentile. e.g. 90% of values lie below the 90th percentile, and 10% of the values lie above it.

Ramsar - Short for "Ramsar Convention". The Convention on Wetlands (Ramsar, Iran, 1971) is an intergovernmental treaty that embodies the commitments of its member countries to

maintain the ecological character of their Wetlands of International Importance and to plan for the "wise use", or sustainable use, of all of the wetlands in their territories. <http://www.ramsar.org>

SEPP - State Environment Protection Policy. Subordinate legislation made under the provisions of the *Environment Protection Act 1970* to provide more detailed requirements and guidance for the application of the Act to Victoria. <http://www.epa.vic.gov.au/about-us/legislation/state-environment-protection-policies>

SOP (Parks Victoria) - State of the Parks

Subtidal - Marine areas lying below the low tide mark and thus generally submerged.

Threat (Parks Victoria) - Agent or process identified through a risk assessment as likely to have a significant impact on Key Ecological Attributes if not managed effectively

Threat agent (Parks Victoria) - Past or present activity (or other factor) that influences ecosystem structure, function, state or condition (e.g. poaching). [Pocklington *et al*. 2012]

Threatening process (Parks Victoria) - The process through which the threats influence system structure, function and state, or condition (e.g. species loss and/or population decline as a consequence of poaching). [Pocklington *et al*. 2012]

Type I / Type II errors - To claim the sample mean differs from the target when it really doesn't is known as a Type I error. To fail to identify a true difference between the mean and the target is known as a Type II error.

UNESCO - United Nations Educational, Scientific and Cultural Organization <http://en.unesco.org>

8. Appendix 1– Details of Indicators and Threats

8.1 Criteria for Selection of Indicators

Table 12 - Criteria for selection of indicators (Parks Victoria)

Criterion	4 – Excellent	3 – Good	2 – Fair	1 – Poor	0 - Unknown
Value for money	Relative to other marine monitoring, almost free (e.g. other people collect and provide the data)	Relative to other marine monitoring, reasonably priced	Relative to other marine monitoring, rather expensive	Unaffordable	Unknown
Precision	Very low temporal/spatial variability (interannual, seasonal); CV≤ 10%	Low temporal/spatial variability (interannual, seasonal); 10%<CV≤ 20%	Moderate temporal/spatial variability (interannual, seasonal), 20%<CV≤40%	High temporal/spatial variability (interannual, seasonal), CV>40%.	Unknown
Link to natural assets	Obvious, direct link to the asset	Reasonable link to the asset	Poor link to the asset	Link to the asset is not obvious	Unknown
Low impact	No or little disturbance to the location (e.g. remote aerial photography)	Minimal disturbance to area (e.g. trampling) but non-destructive (e.g. condition assessment)	Some disturbance and destructive sampling (e.g. voucher specimens)	Destructive sampling required and additional disturbance (e.g. biomass)	Unknown
Sensitive to threats and responds in a known manner	We understand how each threat will impact this indicator, and it is very sensitive to multiple threats	We have an understanding of how at least the primary threat will affect the indicator, and it is sensitive to that threat	We have some knowledge about which threats impact the indicator, but may not always know how the indicator will respond	Very limited knowledge of threats and how they impact the indicator	Unknown
Protocols exist	Protocols are published, widely available, and can be used as is.	Protocols are available in a draft form	Protocol mostly conceptual stage, nothing written	No protocol exists	Unknown
Partners use it	All relevant partners use it	Most relevant partners use it	Some partners use it	No partners use it	Unknown
Simplicity of methods	Can be used without any special training	Can be used with training	Can be used with training and supervision	Too complicated	Unknown
Anticipatory	Serves as an excellent early warning system, the first part of the ecosystem likely to respond to a threat	Provides information about a threat, that, in most cases, will allow us to act on that threat before it is too late	Provides information about a threat, that, in some cases, will allow us to act on that threat before it is too late	By the time we document a change in this indicator, it is likely to late to manage the threat	Unknown

8.2 Detailed Threat Matrix

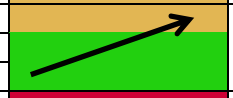
Threat		By KEA within Focal Ecosystem						
		Seagrass beds	Mangrove forest	Coastal saltmarsh		Unvegetated sediments		Water column
		Seagrass plant communities	Mangrove vegetation	Saltmarsh plant communities	Habitat for specified rare species	Benthic fauna/ infauna	Migratory &resident shorebirds	Water quality
Sediments from catchment	U BE L							
Sediment transport via coastal hydrology	U BE L							
Oil & chemical spills	U BE L							
Pollutants from catchment	U BE L							?
Nutrients from catchment/stormwater	U BE L							
Climate change	U BE L							
Invasive marine species	U BE L							
Marinas and ports	U BE L							
Recreational vessels	U BE L							
Terrestrial pest animals (feral cats and foxes)	U BE L							

Figure 23 - Matrix of the interactions between ecosystems and threats in Yaringa Marine National Park

8.3 Threats to Yaringa MNP

In this section, we present the individual judgements of experts for Key Ecological Attributes (KEAs) within each of the focal ecosystems.

On all graphs, the ends of the black bars indicate the lower and upper bounds of the expert judgement, while the filled circle on the bar shows the best estimate. Wireless bars indicate the confidence with which the expert has made his or her judgement.

8.3.1 Seagrass beds

Seagrass expert Dr Hugh Kirkman believed sediments to be a key threat in Yaringa MNP. Sedimentation and turbidity may arise from erosion of north shore of Western Port and from the catchment, with future developments around the bay possibly resulting in increased sediment loads from the catchment. Increasing development on land may increase loads of pollutants and nutrients from on-shore. Dr Kirkman noted that the fringe of saltmarsh and mangrove provide some protection to the seagrasses from contaminants originating on land. Sediments from marine sources pose less of a problem for seagrasses.

He notes that oil spills do not seem to have a long lasting effect on seagrasses themselves, but do affect biodiversity within seagrass beds.

Future impacts from climate change may include shorewards migration of seagrass beds as sea level rises, in order maintain water depth and avoid the reduced light availability associated with deeper water. More extreme weather events may cause physical damage to seagrasses in shallow water, resulting in disturbance to seed beds and increased turbidity.

Thinking of exotic species, Dr Kirkman is particularly concerned with the aquarium weed *Caulerpa taxifolia* and the Northern Pacific seastar *Asterias amurensis*. (Neither have been reported from Yaringa MNP to date, but numbers of the seastar have been collected at San Remo.) The potential for introduced species increases with port activity. Dredging associated with port development is likely to result in increased turbidity and sedimentation, while small boat activity can cause physical damage to beds due to propeller scour and subsequent increased run-off from the beds at low tide.

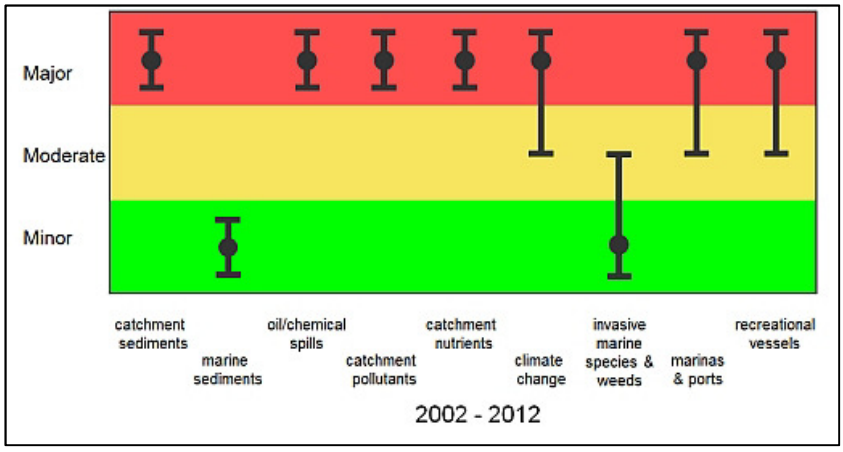


Figure 24 – Nested Asset: Seagrass plant communities

8.3.2 Mangrove

When asked about three specific threats to mangrove vegetation, Prof. Paul Boon believed that one, sediments from the catchment, is not a problem for mangroves but a positive factor, as high sediment loads in run-off might help mangroves to keep pace with rises in sea-level.

In the absence of any major oil or chemical spills in Western Port in the period 2002 to 2010, he believed the *future* threat from oil or chemical spills to be major, based on published information on the impacts of oil spills in other parts of the world.

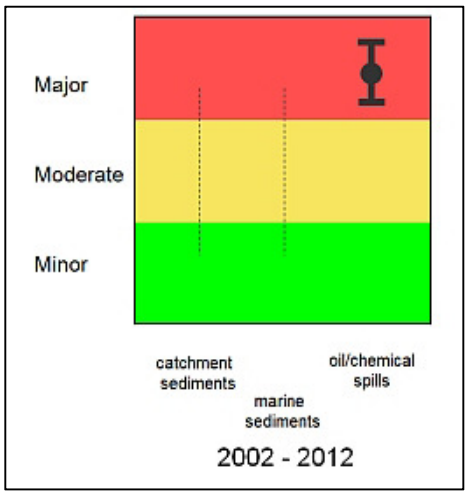


Figure 25 – Nested Asset: Mangrove vegetation

8.3.3 Coastal Saltmarsh

Saltmarsh expert Prof. Paul Boon believes climate change will have a major impact on coastal saltmarsh via sea-level rise, higher air temperatures and higher $C0_2$ concentrations. The timing of plant growth and reproduction will be affected, as will competitive relationship between C4 and C3 plants. Indirect effects will include altered freshwater run-off, altered patterns of nutrient and sediment loading, altered rates of sediment elevation with different river discharge and suspended sediment loads. As mentioned above for mangroves, there is a *future* threat to saltmarsh from oil or chemical spills in Western Port. Although saltmarsh is subject to invasion by exotic species from both the land and the sea, and there have been no weed surveys undertaken in Yaringa MNP, Prof. Boon sees exotic species as less of a threat than climate change or the potential for hydrocarbon pollution.

Dr Mark Antos has some concerns about the habitat of threatened species such as the orange-bellied parrot, the swamp skink and Lewin's rail. He believes their habitat is somewhat protected from the full effects of oil or chemical spills, and is likely to be resilient in the face of invasion by weeds. However, he is concerned with the impacts of climate change. Although the short-term impacts of sea level rise are likely to be low, the longer-term cumulative impacts could be high.

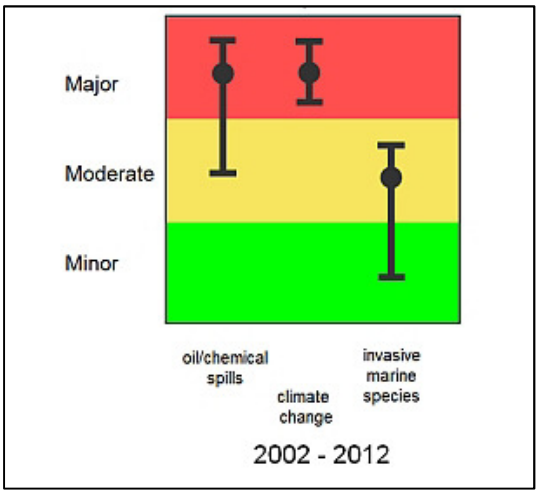


Figure 26 – Nested Asset: coastal saltmarsh plant communities

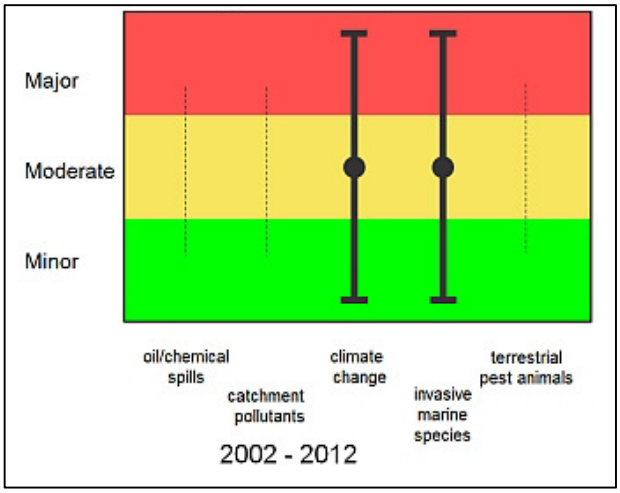


Figure 27 – Nested Asset: habitat for specified rare species

8.3.4 Intertidal Unvegetated Sediment

Dr Sarah Butler reasons that the large tides in Western Port may disperse any oil or chemical spill relatively quickly and the invertebrate fauna may recover quickly particularly if juveniles settle into the sediments soon after the spill passes. However, scientific studies show that oil/chemical spills can result in large reductions in species richness and diversity.

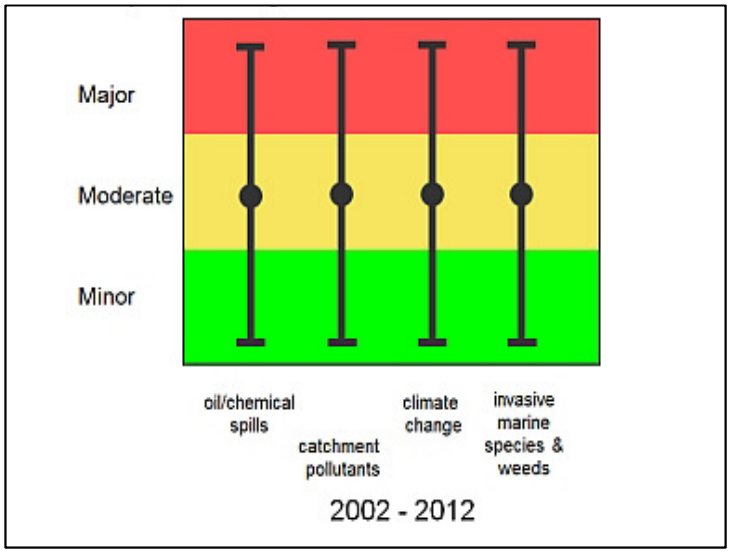


Figure 28 – Nested Asset: Deposit feeding intertidal invertebrate communities

Pollutants from the catchment may benefit some invertebrate species but have a negative impact on others. However, seagrass and particularly mangroves may filter out some nutrients before they reach the intertidal mudflats.

The temperature of seawater and sediments is known to be important for reproduction and development of invertebrate eggs and larvae. Therefore, the predicted increases in water temperature are likely to cause some changes in the reproductive success of particular invertebrate species. It has been suggested that temperature can affect the number of burrow openings that ghost shrimp construct. This would in turn affect bioturbation with possible flow-on effects for species composition.

During her own studies, Dr Butler found the Asian bag mussel *Musculista senhousia* in Yaringa MNP. This species forms dense byssal mats which can change soft-sediment communities, but may also provide food for shorebirds.

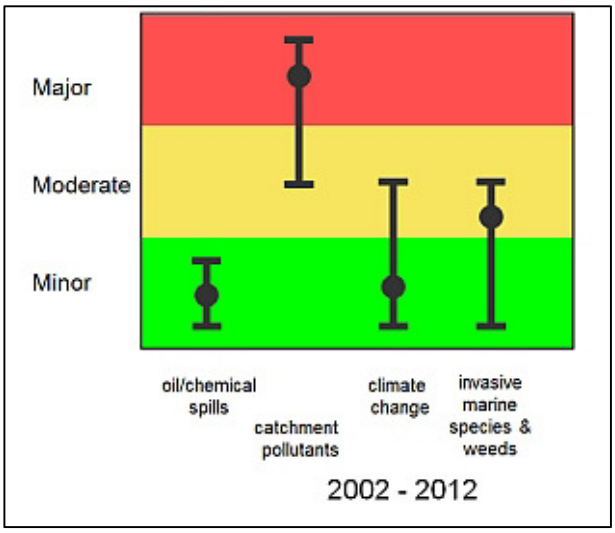


Figure 29 – Nested Asset: Migratory & resident shorebirds

For migratory and resident shorebirds which feed over unvegetated sediments, Mr Mark Antos saw pollutants originating in the catchment as having the greatest impact. He based his judgements on published reports, EPA data and information from park rangers and bird observers.

8.3.5 Water Column

Dr Rhys Coleman believes sediments from the catchment takes a long time to be flushed from the park as they need to be constantly reworked and resuspended for this to occur. In contrast, he sees no threat from marine-sourced sediments. Nutrients from the catchment are a more important threat than similarly-sourced pollutants. Dr Coleman suspects that any climate-related impacts may have been masked by drought, but is concerned about climate change impacts in the future. He is concerned by the potentially high risk of marina and port development due to changes in hydrodynamics that may be brought about by such project, but unsure about the current impacts of recreational boating.

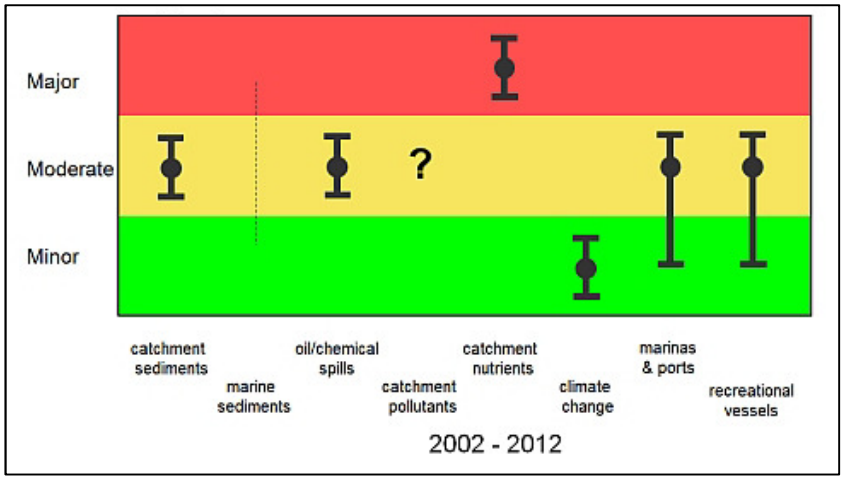


Figure 30 – Nested Asset: Water quality

9. Appendix 2– Method Detail

9.1 Seagrass sampling

Sampling of the intertidal seagrass beds at two sites inside and two sites just outside Yaringa MNP was undertaken over two weeks in March-April 2008[S1] using a modification of Parks Victoria's Sea Search protocol[S13]. Similar sampling was repeated one year later in January-March 2009, with the addition of a third site inside the park.

Sampling was undertaken when the tide was out to minimise the disturbance of sediments which would lead to serious reduction in visibility.

At each site, two 50m transect lines were laid across the seagrass bed. These transects were laid parallel to one another and 50m apart, giving rise to a 50m x 50m study area at each site. Along each transect, six $1m^2$ quadrats were sampled at 10m intervals. Each quadrat was further subdivided into eight subquadrats, of which three were chosen at random to measure shoot length and shoot density. Due to encroachment of the returning tide over the sampling sites, only one transect was sampled at Sites 1 and 2 in 2009.

Seagrass cover was visually estimated as percentages in the field, with the aid of pictorial standards from the Seagrass-Watch manual[S14].

Shoot length was measured by randomly selecting three seagrass shoots from each subquadrat, giving a total of 45 shoots measured at each site (i.e. 3 shoots x 3 subquadrats x 5 quadrats). Length was measured from the base of the shoot to the leaf tip.

Shoot density was measured by counting individual shoots in each subquadrat.

It should be noted that in this sampling design, quadrats serve only as subsamples to improve the overall confidence in the statistics for each site; they are not replicates for any test of differences between sites.

9.2 Sampling invertebrates in unvegetated sediments

Sampling of invertebrates was undertaken in unvegetated sediments in Yaringa MNP and at eleven other sites around Western Port in 2006 and 2007. The following data summary and brief description of sampling are based on the Parks Victoria Technical Series Report No. 60 by Drs Sarah Butler and Fiona Bird.[S3]

At each site, three 30 m long transects were positioned 20 m apart and running down towards the low tide mark. Along each transect, three large cores 15 cm in diameter and 40 cm deep were taken at 10 m intervals. Ten smaller cores 5 cm in diameter and 10 cm deep were taken at 3 m intervals. All cores were sieved in the field to collect the invertebrates contained within them, large cores through a 1mm sieve size and small cores through both 1 mm and 0.5 mm sieves. Invertebrates were collected and preserved. In the laboratory, they

were identified and counted. Other variables including seagrass cover were recorded in the field, at three equally-spaced points along each of the three transects.

9.3 Design of control charts for Report Cards

Five different types of control chart will be used in the Report Cards, each with its own design specifics.

1. Attribute chart - for binary data summarising multiple indicators.
2. Acceptance chart - for a continuous indicator when the centreline is a zone rather than a point estimate.
3. Median Chart - when the summary statistic of a single indicator is the median.
4. Multivariate chart- when multiple attributes are considered simultaneously as a single indicator.
5. Multinomial chart - for data in more than two categories summarising the opinion of multiple experts.

Attribute chart

Attribute charts are designed to summarise binary data. One type of attribute chart is the *p* chart, which in industrial applications typically presents the fraction nonconforming of items produced.[M20] For the Report Cards, we have chosen to switch to the fraction conforming and to present the results as a percentage rather than a fraction, both recognised variations on the typical attribute chart[M20]. We thus summarise multiple parameters as the percentage of parameters meeting their own objectives.

This type of control chart is based on the binomial distribution. The centreline and control limits for a *p* chart as applied to the Report Cards are described as

$$\text{UCL} = (1\text{-}p) + L\sqrt{\frac{p\text{-}(1\text{-}p)}{n}}$$

$$\text{Centreline} = 1\text{-}p$$

$$\text{LCL} = (1\text{-}p) - L\sqrt{\frac{p\text{-}(1\text{-}p)}{n}}$$

where UCL = Upper Control Limit, LCL = Lower Control Limit, p = fraction nonconforming, L = number of standard deviations corresponding to desired Type I error rate, and n = sample size.

Example calculation:

For the summary of water quality, 80% compliance with SEPP objectives is considered acceptable by Parks Victoria, thus $p = 0.2$ is set as the target for the fraction nonconforming, with the complement $1\text{-}p = 0.8$. A one-sided chart is appropriate because our interest is unidirectional (i.e. that the percentage conforming be greater than or equal to 80).

There are 5 groups of indicators, thus *n*=5. Note that the individual statistics are grouped to avoid giving greater weight to those indicators for which multiple measures are available.

Conventionally in industrial applications, *L* = 3 resulting in a Type I error rate of 0.00135 for a one-sided chart.[M20] In the environmental context of the Report Cards, this is far too stringent a criterion for the following reasons:

- The inverse relationship that exists between the Type I and Type II error rates means that the Type II error rate would be correspondingly higher, which is undesirable in an environmental application.
- In what is a very short data series by industrial standards, there is less need for so stringent a Type I error rate.

Thus for a one-sided chart with a Type I error rate of 0.05, we set L = 1.645.

Centreline = 0.8

LCL = $0.8 - (1.645 \times (0.8 \times 0.2 / 5)^{0.5}) = 0.506$

Acceptance chart

When tracking the mean of a process where the target (centreline) is a point estimate and the control limits are driven only by the natural variability of the process, the control chart of choice would be the $\bar{X}$ chart.[M20] However, when there is a zone of acceptable values around the centreline, the *acceptance control chart* is a better option.[M27] In an industrial context, *Upper* and *Lower Specification Limits* (USL and LSL respectively) are defined, possibly by managers, engineers or customers. Acceptable upper and lower population means (sometimes called *Acceptable Process Levels*[M27] or *Acceptable Process Means*[M28]) are then calculated by reference to an acceptable fraction of items nonconforming, and upper and lower control limits (or *acceptance limits*[M28]) set around those acceptable population means.[M20] Such calculations assume an approximately normal distribution.[M20]

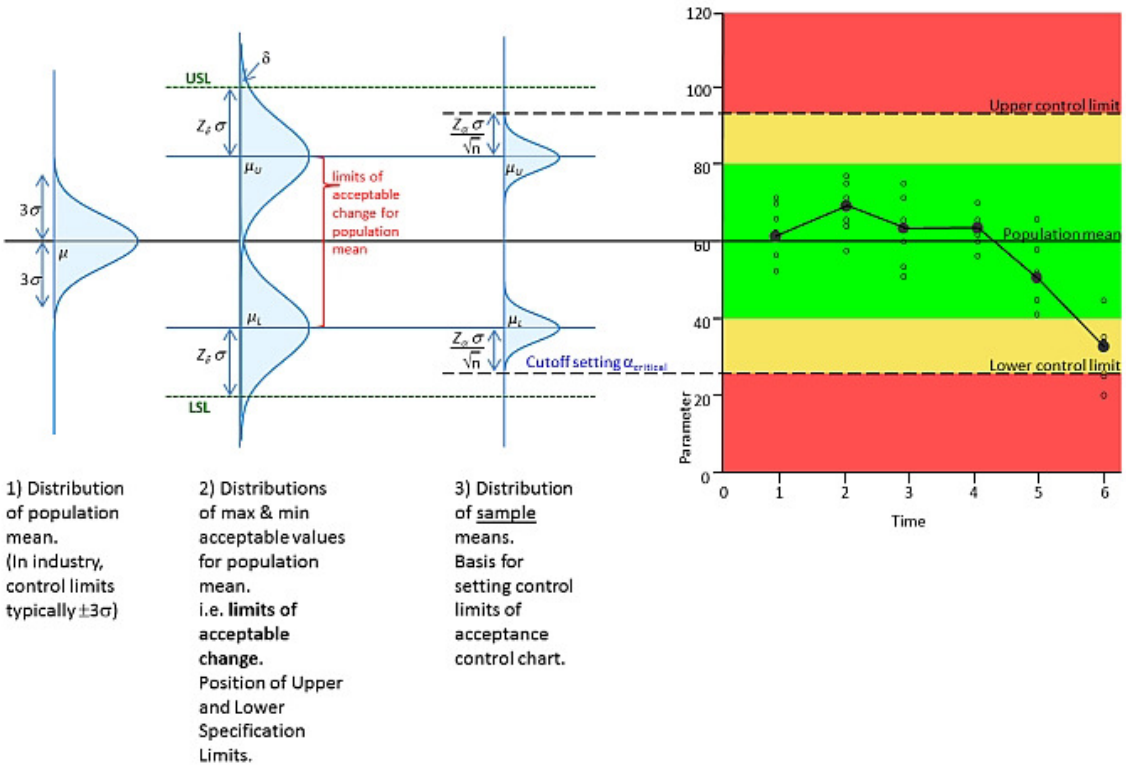


Figure 31 – Principles behind the Acceptance Control Chart as applied to Report Cards (after Montgomery 2009).

For the Report Cards, ecologists and park managers define limits of acceptable change in terms of the upper and lower population means (zone shaded green on charts). Control limits around those population means are based on the desired Type I error rate as follows:

$$UCL = \mu_U + \frac{Z_\alpha \sigma}{\sqrt{n}}$$

$$Centreline = \mu$$

$$LCL = \mu_L - \frac{Z_\alpha \sigma}{\sqrt{n}}$$

where UCL = Upper Control Limit, LCL = Lower Control Limit, μ_U = upper acceptable population mean, μ_L = lower acceptable population mean, z_α= multiplier for number of standard deviations to correspond with desired Type I error rate α, σ= weighted average standard deviation, and n = modal sample size to allow for possibly unequal sample sizes.[M20] (A control chart designed in this way may also be referred to as a *modified control chart*.[M20])

Example calculation:

Imagine an invertebrate indicator with a long-term mean count of 60 per m^2. For a stable but naturally variable biological population, there is no expectation that annual means will necessarily remain close to 60. Drawing on both ecological experience and practicalities of

management, 40 and 80 are set as the limits of acceptable change for the population mean. For a Type I error rate of 0.05 on a two-sided chart, z_α= 1.96. Weighted average standard deviation = 16. Sample size varies from one year to another, with a mode of 6.

UCL = 80 + (1.96 x 16 / 2.45) = 92.8

Upper acceptable population mean = 80

Centreline = 60

Lower acceptable population mean = 40

LCL = 40 - (1.96 x 16 / 2.45) = 27.2

Median Chart

The median chart may be used instead of the $\bar{x}$ chart when data is not normally distributed. Various methods have been proposed for the calculation of control limits around a median centreline.[M29]

In the case of water quality indicators for the Report Cards, median charts are used because SEPP water quality objectives are expressed in terms of medians (and other percentiles).[M24] While a median chart could have control limits based on percentiles analogous to those found on an $\bar{x}$ chart, the Australian Guidelines for Water Quality Monitoring and Reporting illustrate the use of a control chart where a trigger value is effectively used as the control limit.[M22] That example is followed for water quality indicators in the Report Cards, for both medians and other percentiles.

For water quality data, one-sided charts are appropriate because the SEPP objectives for the selected indicators are unidirectional (e.g. median for total nitrogen < 120 µg/L).

Multivariate chart

While multivariate charts are increasingly used for statistical process control in industry[M20], a method has also been developed specifically for ecological and environmental monitoring.[M30] It analyses abundance data for multiple species sampled at multiple sites repeatedly through time, employing distance-based resemblance measures (dissimilarity measures) to characterise community composition. The method has no distributional assumptions and is "is designed to identify impacts at individual sites as quickly as possible".[M30]

For a given sampling site and time, the monitoring criterion *d* is the deviation from a centroid in multivariate space calculated from either a baseline set of sampling times or all previous sampling times.

Bootstrapping is used to generate mean percentiles of the deviations from the centroid, one of which is then chosen as an upper control limit to identify deviations greater than expected/acceptable.

A dedicated Fortran computer program[M31] is available to generate the deviations and percentiles, which are then used to plot the multivariate control charts with other software.

Multinomial chart

The multinomial chart is a variation on the *p* chart for attributes when there are more than two categories (e.g. good/fair/poor, as opposed to complying/not with a *p* chart).[M32][M33] It will be used in future iterations of the Report Cards when additional rounds of expert opinion have been collected.

9.4 Statistical power & control charts

Natural variation often makes correctly identifying change in the environment difficult. For example, we may take multiple samples of seawater to measure the concentration of nitrogen in the water. The concentrations from the different samples are unlikely to be *exactly* the same, but can be summarised as an average value (known as the *sample mean*). The important question is whether this estimate based on a few samples is really different to the target value (e.g. the SEPP objective for nitrogen) or just seems to vary from it a little because of the 'noisiness' of our sample data. The more our individual sample concentrations vary, the harder it is to determine if the sample mean is truly different to the target value. To claim the sample mean differs from the target when it really doesn't is known as a Type I error. To fail to identify a true difference between the mean and the target is known as a Type II error.

One valuable characteristic of control charts is the ability to determine the chances of claiming a limit is breached when in fact it isn't (i.e. committing a Type I error) or failing to detect a breach when it really has occurred (known as a Type II error).[M20] The Type I error rate of a control chart is determined by its control limits.[M20]

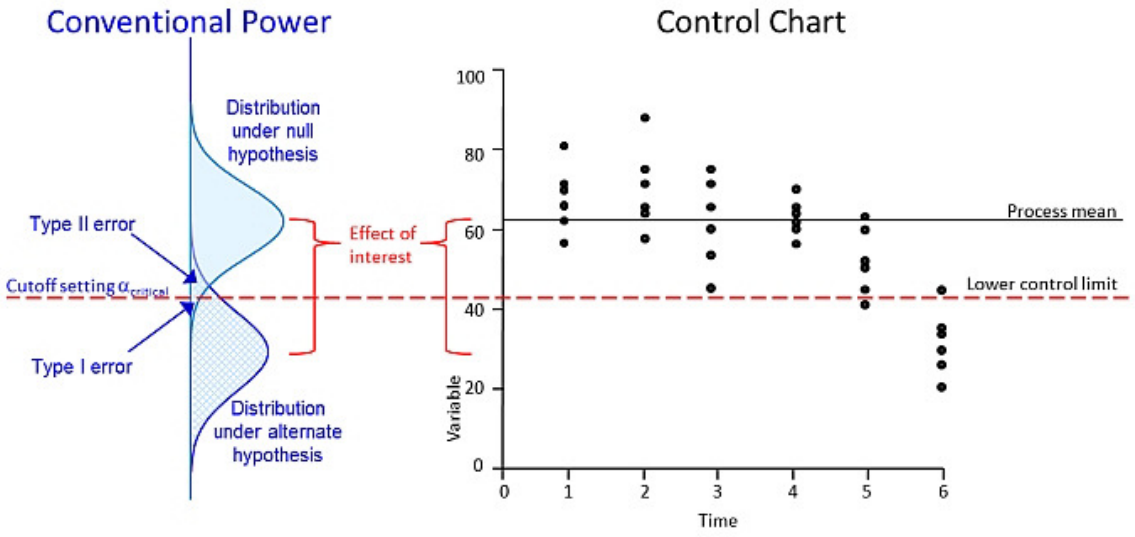


Figure 32 - Illustration of correspondence between control chart and 'conventional' approach to statistical power

In order to summarise expert opinions across experts, focal ecosystems, KEAs or threats, the categorical responses of the experts were first converted to numeric scores as shown in Table M5. Numeric scores were then combined according to the following rules:

- For combined Upper Bound, use 80th percentile of individual Upper Bounds
- For combined Lower Bound, use 20th percentile of individual Lower Bounds
- For combined Best Estimate, use average of individual Best Estimates

Table 13 - Conversion of categorical responses to numerical scores

Condition Category	Threat Category	Numeric Score assigned	Range of Scores for post-calculation conversion back to Category
Good	Major	5	score >=4
Fair	Moderate	3	2 <= score < 4
Poor	Minor	1	0.0001 < score < 2
Unsure	Unknown	0.0001	0.0001
(no response)	(no response)	0	

Such conversion to ratio scales also serves as a form of quality control for consistency in rank ordering of the categorical responses.[M34] Not constraining the experts to point estimates allows them to indicate a level of uncertainty in the categories if they wish, and the use of interval arithmetic[M35] when combining scores across multiple experts, KEAs or focal ecosystems allows for propagation of any differences of opinion among the experts or variation with asset.

10. Appendix 3 – Park Status raw data

10.1 Seagrass data

Table 12 - Summary site data for seagrass sampling in Yaringa MNP in 2008 and 2009.

MNP sites	2008		2009			Mean	St.Dev.	range
	Site 1	Site 2	Site 1	Site 2	Site 6			
Seagrass cover (%)	49	34			46-75			34 - 75
Shoot length (cm)	9.4	11.0	13.5	16.3	18.0	13.6	3.6	
Shoots per 1.0 m^2	1080	704	1816	1080	272	990	569	

10.2 Sampling of invertebrates in unvegetated sediments raw data

In Table 11, the data collected by Butler & Bird[S3] and reported in Parks Victoria Technical Series Report No. 60 has been reworked to focus on only those invertebrates recorded from Yaringa MNP.

Table 13 - Data for invertebrates recorded from Yaringa MNP.

Bird & Butler Reference No. Species name	Type of animal	Total in small cores 2006	Total in large cores 2006	Total in large cores 2007	Grand total
8. *Barantolla lepte*	Polychaete worm	73	12	43	128
46. *Musculista senhousia*	Bivalve mollusc	29	3	30	62
62. *Prionospio aucklaudica*	Polychaete worm	58	0	0	58
11. *Lumbrineris* sp.	Polychaete worm	8	14	26	48
12. *Biffarius arenosus*	Ghost shrimp	2	19	23	44
92. Paratanaidae sp.	Tanaid crustacean	20	0	2	22
2. *Macrophthalmus latifrons*	Crab	1	11	7	19
16. *Nephtys australiensis*	Polychaete worm	12	4	3	19
35c. & 71. & 79. *Gammaropsis* sp.	Amphipod	15	0	0	15
41a. *Armandia* sp. MoV 282	Polychaete worm	11	1	0	12
6. & 50. Sipunculan sp.2	Peanut worm	0	2	6	8
40. *Alpheus richardsoni*	Snapping shrimp	1	4	3	8
29. & 51. *Polycirrus tesselatus*	Polychaete worm	2	1	3	6
30. *Glycera ovigera*	Polychaete worm	1	4	0	5
14. *Tellina deltoidalis*	Bivalve mollusc	2	0	2	4
52. & 76. & 76b. *Melita* Group sp. 1	Amphipod	0	3	1	4
3. *Ebalia crassipes*	Crab	0	0	3	3
15. *Laternula creccina*	Bivalve mollusc	0	0	3	3
35. *Aora mortoni*	Amphipod	2	1	0	3
54. *Photis* sp.	Amphipod	1	1	1	3
93. *Pista australis*	Polychaete worm	3	0	0	3
13. *Phoronopsis albomaculata*	Phoronid worm	0	0	2	2
30b. Glycinde sp. MoV 1403	Polychaete worm	0	2	0	2
66. Syllidae sp. MoV 532	Polychaete worm	2	0	0	2
97. *Goniada antipoda*	Polychaete worm	1	1	0	2

102. *Cominella lineolata*	Gastropod mollusc	2	0	0	2
10. *Bellidilia laevis*	Crab	0	1	0	1
17. *Nassurius pauperatus*	Gastropod mollusc	0	0	1	1
26. *Phyllodoce* sp. MoV 2876	Polychaete worm	1	0	0	1
27. & 27b. *Themiste* sp.	Peanut worm	0	1	0	1
28. & 69. *Polinices didymus*	Gastropod mollusc	0	0	1	1
33. *Mysella donaciformis*	Bivalve mollusc	0	0	1	1
38. *Maldane sarsi*	Polychaete worm	0	0	1	1
47. *Schistomeringos loveni*	Polychaete worm	0	1	0	1
55. Harpacticoidea sp. 1	Copepod	1	0	0	1
58. *Limnoporeia yarragu*e	Amphipod	1	0	0	1
61a. *Acmira lopezi*	Polychaete worm	1	0	0	1
61b. *Aricidea pacifica*	Polychaete worm	1	0	0	1
63. *Tornatina* sp. 2	Opisthobranch mollusc	0	0	1	1
90. *Scalibregma inflatum*	Polychaete worm	0	0	1	1
100. *Synasterope* sp.	Ostracod	1	0	0	1
101. Apseudidae sp.	Tanaid crustacean	1	0	0	1
102b. Cirratullidae sp. 1	Polychaete worm	1	0	0	1
103. *Epitonium tenellum*	Gastropod mollusc	1	0	0	1
109. *Tethygeneia megalophthalma*	Amphipod	0	0	1	1
137. *Terebellides kowinka*	Polychaete worm	0	0	1	1
Total number of species		29	19	24	46
Total number of individuals		255	86	166	507

The graphs below show number of species and individuals per large core, plus Simpson's index of diversity (a measure of how the individuals are distributed among the species). The two bars on the far right of the graphs show results from Yaringa MNP (outlined in red). It is evident that values for Yaringa MNP generally lie in the upper ranges of those recorded.

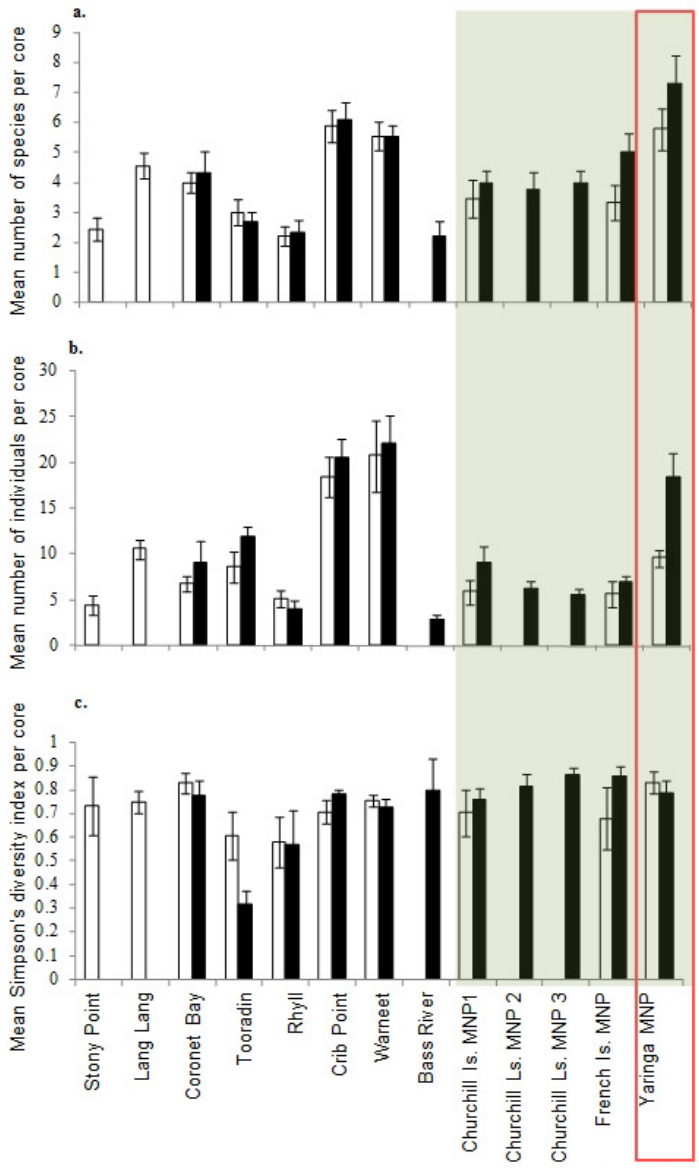


Figure 33 - The mean number of species a. the mean number of individuals b. and mean Simpson's diversity c. per core (15 cm diameter X 40 cm depth) collected at each site in Western Port, Victoria, in 2006 (open bars) and 2007 (filled bars). Sites within Marine National Parks are shaded. Error bars show one standard error.

10.3 Water Quality raw data

Phosphorus

The data presented in this report card are drawn from routine EPA water quality monitoring undertaken at three sites in Western Port. Site 716, off Barrallier Island, is the site nearest to Yaringa MNP.

The following chart plots the raw data for Total Phosphorus. The SEPP objective that the annual median be less than 25 ug/L[S10][S16] is indicated on the chart as the area below the dashed line. It can be seen that, in any year, the majority of the data points fall above the dashed line.

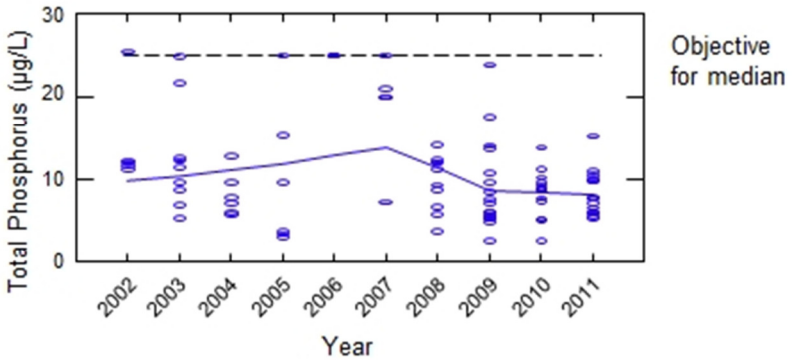


Figure 34 – Total Phosphorus in the water column

Nitrogen

The data presented in this report card are drawn from routine EPA water quality monitoring undertaken at three sites in Western Port. Site 716, off Barrallier Island, is the site nearest to Yaringa MNP.

The following chart plots the raw data for Total Nitrogen. The SEPP objective that the annual median be less than 120 ug/L[S10][S16] is indicated on the chart as the area below the dashed line. It can be seen that, in any year, the majority of the data points fall above the dashed line, leading to medians that fail to meet the objective.

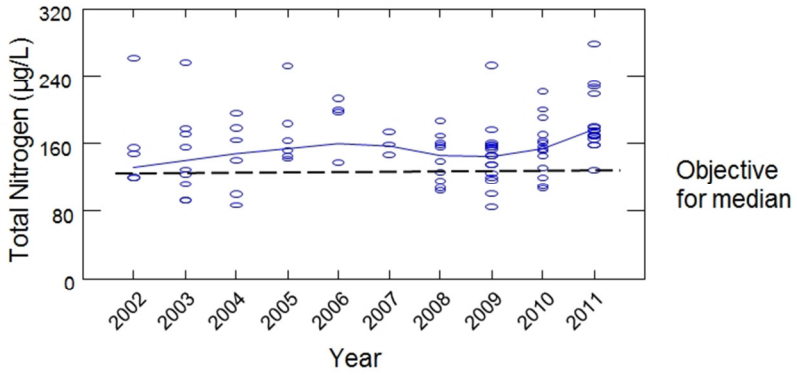


Figure 35 – Total Nitrogen in the water column

Chlorophyll

The data presented in this report card are drawn from routine EPA water quality monitoring undertaken at three sites in Western Port. The data used in this report is for Site 716, off Barrallier Island. This is the site nearest to Yaringa MNP.

The following chart plots the raw data for Chlorophyll a, with the SEPP objective for the median of less than 1.6 ug/L[S10] indicated by the dashed line. Less than half the data for each year lie above the dashed line, indicating the median for each year meets the SEPP objective.

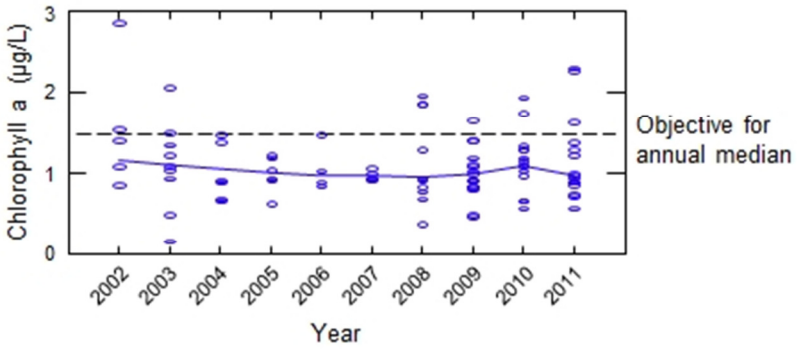


Figure 36 – Total Nitrogen in the water column

Dissolved oxygen

The data presented in this report card are drawn from routine EPA water quality monitoring undertaken at three sites in Western Port. The data used in this report is for Site 716, off Barrallier Island. This is the site nearest to Yaringa MNP.

The following chart plots the raw data for Dissolved Oxygen, with the SEPP objective that the annual minimum be greater than 90% saturation[S10] indicated by the dashed line. While the minimum DO fell below the objective for 5 of the 10 years reported, most of the individual data for those years were in fact higher than 90% saturation (higher values being better with this parameter).

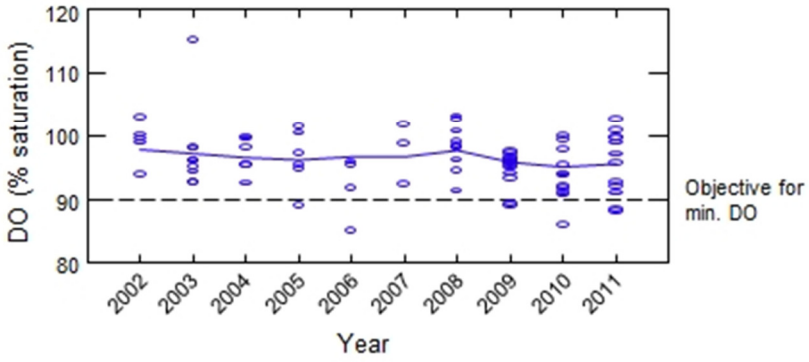


Figure 37 – Dissolved Oxygen (% saturation) in the water column

Water clarity

The data presented in this report card are drawn from routine EPA water quality monitoring undertaken at three sites in Western Port. Site 716, off Barrallier Island, is the site nearest to Yaringa MNP.

The following charts plot raw data for Secchi depth (a measure of water transparency) and suspended solids (SS). The relevant SEPP objectives[S10] are that the annual medians be

greater than 2.4 m for Secchi depth and less than 9 mg/L. The objectives for SS are marked on each chart with a dashed line.

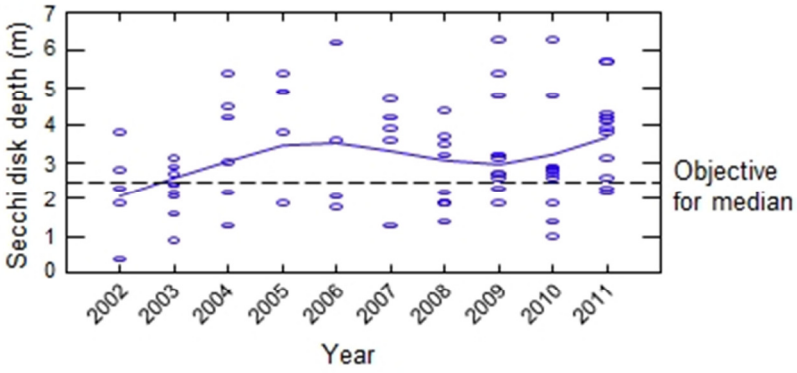


Figure 38 – Secchi disk depth in the water column

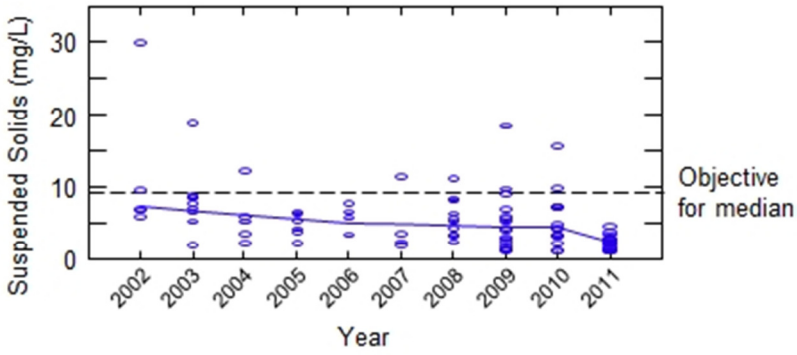


Figure 39 – Suspended solids in the water column

11. Appendix 4 - Conceptual map of general marine ecosystem in Victorian MPA

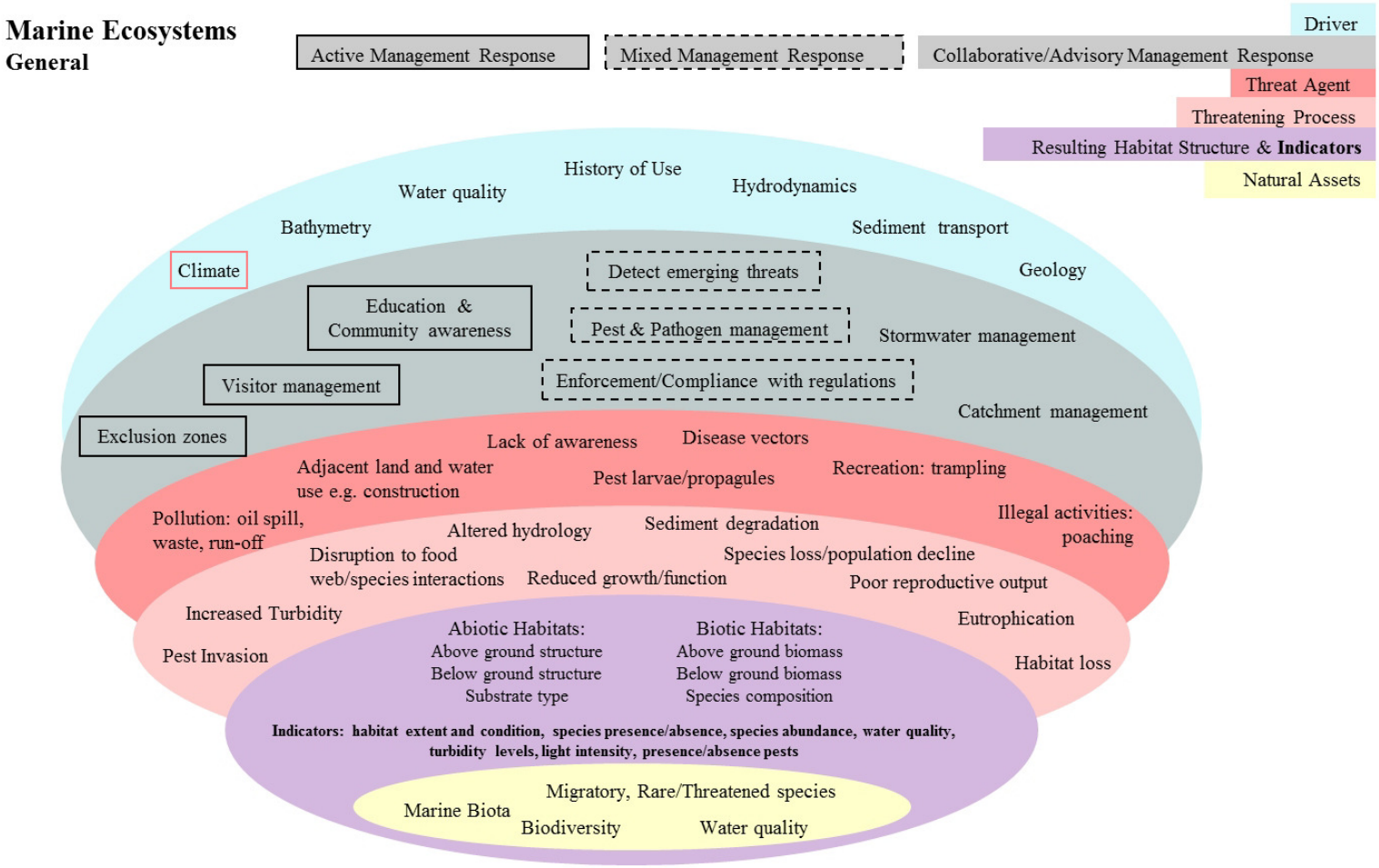


Figure 40 - Conceptual map of general marine ecosystem in Victorian marine Protected Areas (Fig. 1 from Pocklington *et al. (2012) Conceptual Models for Victorian Ecosystems: Marine and Estuarine Ecosystems.* Parks Victoria Technical Series No. 66. Parks Victoria, Melbourne)

12. Appendix 5 – Summary Level Report Card

2013 Natural Assets Report Card

Yaringa Marine National Park

Date established 2002 **Size** 980 Ha

IMCRA Marine Bioregion

Victorian embayments - Western Port

Traditional Owners

The park is part of the *Country* of the Boonwurrung People.

Conservation Vision

A future visitor to Yaringa MNP finds a wide range of marine ecosystems in a dynamic tidal environment. The complex interactions and biological processes that underpin and sustain the marine communities are healthy.

The park is protected from inappropriate visitor use and the pressures of increasing urban and maritime development by management that is integrated with that of the adjacent land, water and wider catchment, providing a model for other area managers.

Parks Victoria has developed a series of report cards to provide timely, accurate, and reliable information on the condition of natural assets, level of threats and management effectiveness. These report cards form part of Parks Victoria's State of the Parks evaluation.

Park Description

Yaringa MNP is heavily influenced by tidal flows which leave large areas of mudflats and seagrass beds exposed at low tide. Some of the park's natural values include highly diverse and extensive salt marsh communities, undisturbed mangroves, extensive sea grass meadows, rich mudflats, and deep channels.

The ecosystems in the park provide key roosting and feeding areas for a resident and migratory shorebirds, including many of conservation significance. In-water ecosystems provide habitat for a wide range of fish including juveniles of a number of species important to fishers.

The park is part of two internationally recognised special protection areas in Western Port including the Western Port Ramsar Site and Mornington Peninsula and Western Port UNESCO Biosphere Reserve. More than two thirds of the park is covered by a Special Protection Area for sensitive mangrove and saltmarsh.

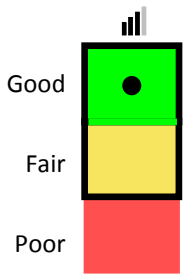
Poor water quality entering the park from Watson Creek, one of the region's most challenged waterways, represents a key concern for the park, along with the potential for marine pest introductions, and oil spills associated with adjacent port and catchment activity.

Status Summary

Overall the key natural assets in Yaringa Marine National Park (MNP) are in good condition. Seagrass, mangrove and saltmarsh ecosystems are all in good condition, while unvegetated soft sediments and the water column are in fair condition. Condition of the soft sediment ecosystem has declined.

Overall key threats have had a moderate impact on natural assets. Illegal fishing , oil and chemical spills have had a very low impact, while invasive species, and pollutants from the catchment have had a low to moderate impact. Sediments and nutrients from the catchment and stormwater have had the greatest impact on some key park values.

Park condition



Park threat level

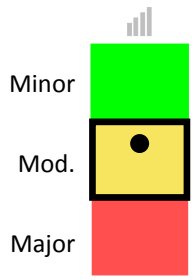
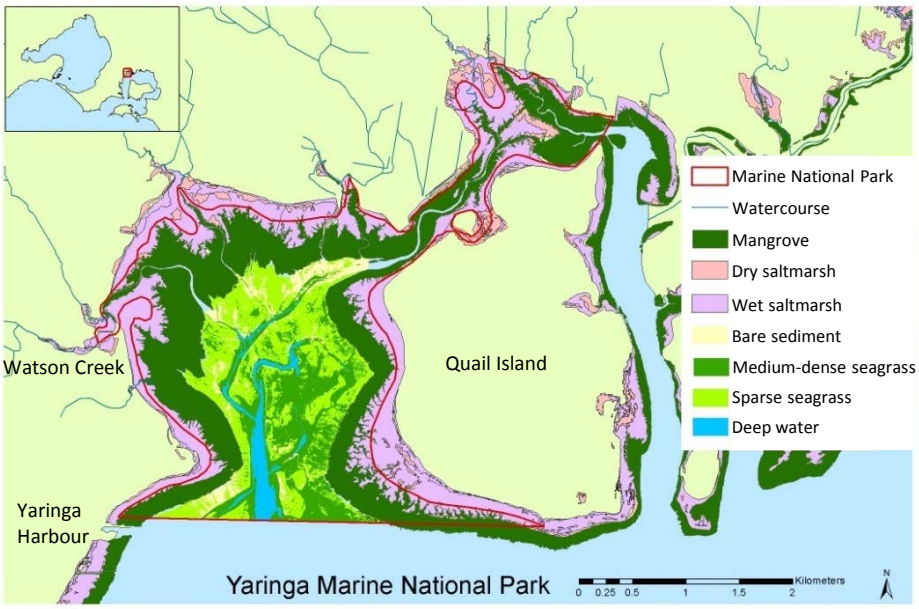
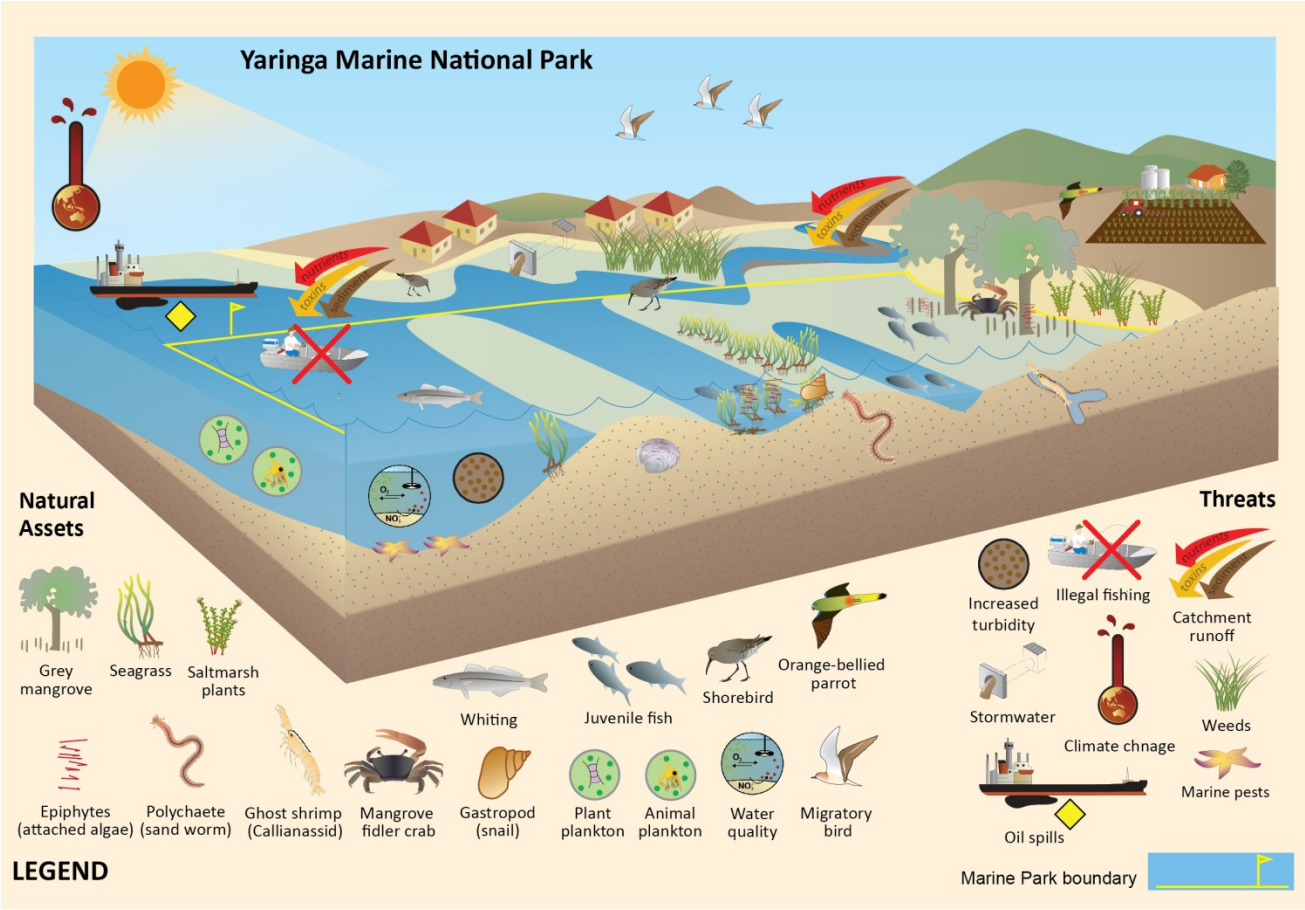


Image left (top): Seagrass and mangroves in Yaringa MNP. Photo by Jo James.
Image left (bottom): Parks Victoria Rangers on patrol. Photo by Parks Victoria.
Image right: Marine habitat map for Yaringa MNP.

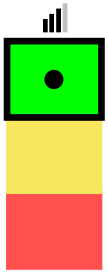




Natural Assets - *Ecosystems*

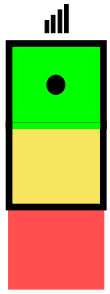
Seagrass Beds - Aim: *Maintain water quality and extent, cover and heterogeneity of intertidal and subtidal seagrass communities in order to support an abundant and diverse assemblage of invertebrate and fish communities.*

- Seagrasses provide critical habitat for many invertebrates and fish, including juveniles. They also help slow water movement, bind sediments together, and thus reduce erosion and improve water clarity.
- Sunlight trapped by seagrasses is a major source of energy for marine food chains.
- Expert opinion indicates that the seagrasses of Yaringa MNP have coped with conditions to which seagrasses in other parts of Western Port have succumbed.



Mangroves - Aim: *Maintain the extent, cover and heterogeneity of mangrove communities in order to support an abundant and diverse assemblage of invertebrate, bird and fish species along the coastline of Yaringa MNP.*

- Mangroves and their complex root systems provide important habitat for many invertebrates, fish and birds. They also trap and bind sediments and protect shorelines by reducing wave erosion.
- Falling mangrove leaves contribute large quantities of organic matter and energy to marine food chains.
- Mangroves in Yaringa MNP to be in fair to good condition due to the relative lack of human interference.



Condition rating

- Good condition
- Fair condition
- Poor condition
- ● / arrow — Mean or best estimate
- Condition range

Level of threat rating

- Minor threat
- Moderate threat
- Major threat
- ● / arrow — Mean or best estimate
- Level of threat range

Trend 2002-12

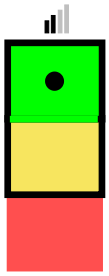
- Improving
- Steady
- Worsening
- Variable
- ● — Trend not available or uncertain

Confidence

- 76% - 100%
- 51% - 75%
- 26% - 50%
- 0% - 25%
- Confidence not available
- For condition only
- For condition & trend

Saltmarsh - Goal: *Maintain the extent, cover and heterogeneity of saltmarsh communities in order to support an abundant and diverse assemblage of bird communities, and habitat for rare and threatened species.*

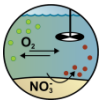
- Saltmarsh plant communities within the park are very diverse and are of state conservation significance.
- Yaringa's saltmarshes provide potential habitat for a range of rare and threatened species, including the endangered Orange Bellied Parrot .
- Mangroves in Yaringa MNP are believed to be in fair to good condition due to the relative lack of human interference.



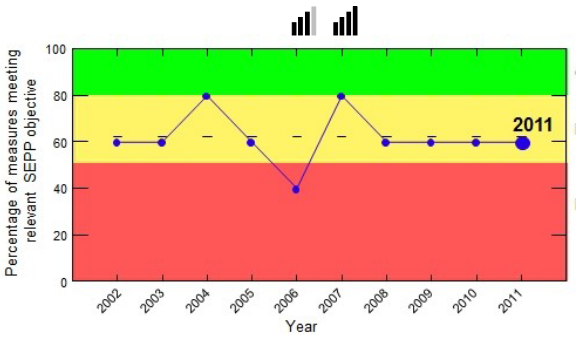
Unvegetated Soft Sediments - Aim: *Maintain natural sediment transport patterns and the structural integrity and composition of intertidal and subtidal soft sediments, in order to support an abundant and diverse assemblage of invertebrate and bird species.*

- Intertidal and subtidal soft sediments support an abundance of deposit feeding invertebrate communities, which play an important role in nutrient cycling. They are important feeding areas for significant resident and migratory shorebird populations.
- Macroscopic invertebrates are believed to be in good condition, with a high number of species relative to other sites in Western Port. Migratory shorebirds are believed to be faring worse (poor to fair, and declining) than the resident shorebirds (fair and steady).

Water Column - Aim: *Improve water quality to provide suitable habitat for water column communities.*



- The water column provides habitat for many species including fish and plankton communities.
- Water quality within the park is critical in the overall health of the park's ecosystems including seagrass and unvegetated soft sediments.
- Between 2002 and 2012, water quality recorded at a site near Yaringa MNP generally remained in fair condition, dipping to 'poor' in 2006 before returning to 'fair'.



Threats - *Across the whole park*

Sediments From Catchment - Objective: *Reduce the suspended sediment levels from catchment and stormwater inputs.*

- Increased sediment in the water column reduces light penetration and affects growth of seagrass and phytoplankton.
- High sediment loads smother seagrass beds, mangroves, and burrowing fauna.
- Sediments from the catchment are believed to have a major impact on seagrass plant communities and a moderate impact on the water column in Yaringa MNP.

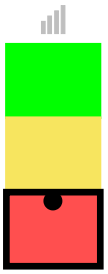
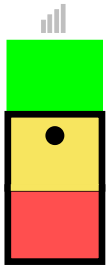


Image left: *Zostera nigricaulis* seagrass and Caulerpa spp.
Image centre: Ghost shrimp *Biffarius arenosus*. Photo by Michael Marmach, Museum Victoria.
Image right: High turbidity levels typical of Yaringa MNP and Western Port.

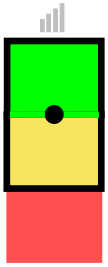
Nutrients From Catchment/Stormwater - Objective: *Reduce the nutrient levels from catchment and stormwater inputs.*

- Excessive nutrients result in increased growth of epiphytic algae on seagrass and mangroves which can eventually smother plants and cause dieback.
- Excessive nutrients in the water column also causes algal blooms leading to the eutrophication and loss of many species that require oxygen.
- Nutrients from the catchment are believed to have a major impact on both seagrass plant communities and the water column in Yaringa MNP.

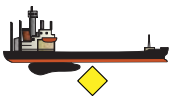


Pollutants From Catchment - Objective: *Reduce pollutant levels from catchment and stormwater inputs.*

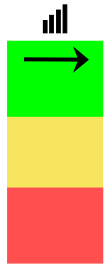
- Pollutants including pesticides, hormones, and heavy metals from industry, agriculture, or domestic sources have potential for harmful impacts on marine flora and fauna, but these have had limited impact on park values.



Oil & Chemical Spill or Leak - Objective: *Minimise the impact of potential oil/chemical spills.*

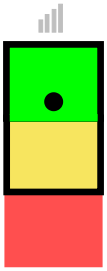


- Oil, from marine or terrestrial sources, smothers sensitive intertidal ecosystems such as mangroves, saltmarshes and seagrasses, and the species that live within them.
- Chemical spills can have toxic effects or cause physical damage to flora and fauna reducing health or causing death.
- There have been no oil or chemical spills in Yaringa MNP.



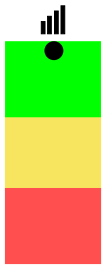
Invasive Species - Objective: *Prevent the establishment of marine pests and weeds and reduce the impact of existing infestations.*

- Marine pest species compete with other plants and animals for space or food resources, and lead to a decrease in the diversity and abundance of native species.
- The Asian Bag Mussel been recorded in the park with the Pacific Oyster also recorded at low densities. The highly invasive Northern Pacific Seastar and Cordgrass (*Spartina anglica*) are known in Western Port.



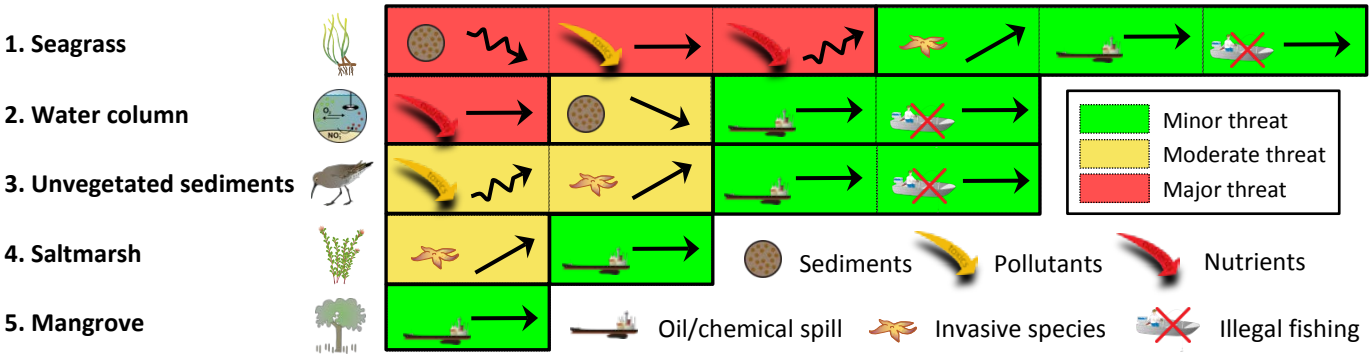
Illegal Fishing - Objective: *Minimise the incidence of illegal resource use and extraction within Yaringa MNP.*

- Illegal fishing in the MNP reduces the size and abundance of targeted species.
- Fish and other targeted species play an important ecological role in the park and their removal has flow on effects for the rest of the food web.
- Illegal fishing has minimal impact because of the remote location and relative inaccessibility of the park.



Interactions Between Ecosystems and Key Threats in Yaringa MNP

- Ecosystems are ranked in order from those most impacted by threats to those least impacted by threats.

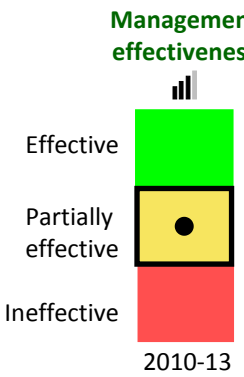


Management Focus and Effectiveness

Management of the park was considered 'partially' effective with management effort since the park was declared focusing on key threats to priority natural assets. Several emerging threats have also been identified. Future management will focus on addressing existing and emerging threats.

Since the declaration of the park in 2002, Parks Victoria's management priorities have included:

- Partnership building and stakeholder engagement to address water quality issues through improved agricultural, urban and land use practices within the park catchment, with a particular focus on Watson Creek.
- Compliance and enforcement patrols, maintenance of boundary markers, and removal of an illegal jetty in the park.
- Building community understanding and stewardship for the park's important values through community engagement and collection and use of high quality images and video footage.
- Improving knowledge of the park through marine habitat mapping, seagrass monitoring, marine pest surveys, and developing methods for monitoring soft sediment communities.



Emerging Threats

Many of the threats identified as high risk in the future overlap with the existing threats, however physical disturbance to sensitive seagrass, mangrove and saltmarsh habitats was identified as an additional threat.

Climate change is recognised as an important driver of change for the MNP in the medium to long term but other threats were considered more important over the next five years.

Future Management Response

Following the assessment of condition of key natural assets, level of threats and management effectiveness, the following management strategies have been identified as high priorities over the next five years:

- Work collaboratively with Port Phillip and Western Port CMA to reduce the impacts of land use and catchment management on the planning area and develop appropriate actions in the Regional Catchment Strategy.
- Work collaboratively with EPA and Melbourne Water to minimise impacts associated with discharge of waste into the environment, particularly from Watson Creek.
- Establish an ongoing program to minimise the risk of marine pest and weed introduction and subsequent spread. This should include improving the understanding of the potential means of introduction and spread and formalising arrangements for prevention, reporting, monitoring and response.
- Work collaboratively with Department of Transport Planning and Local Infrastructure on marine pollution incidents, and update contingency plans for marine pollution incidents as required, and communicate arrangements to staff, relevant agencies and interested parties.
- Work with Fisheries Victoria to undertake education, patrols and targeted compliance operations to ensure appropriate behaviours, and encourage visitors to assist with compliance management by reporting illegal fishing to the Fisheries Victoria hotline.
- Continue to implement the marine science program to fill remaining critical knowledge gaps and address key management challenges

For more information please see the detailed Report Cards and the Marine Natural Values reports on www.parks.vic.gov.au.

Image left: The oyster blennie *Omobranchus anolius*. Photo by Julian Finn, Museum Victoria.
Image right: Intertidal bare sediment and mangroves in Yaringa Marine National Park. Photo by Adam Pope, Deakin University.

13. Appendix 6: Example of expert opinion questionnaire

Eliciting expert knowledge about the condition of priority assets and impacts of priority threats for Parks Victoria's marine protected areas.

Comments by expert in blue italics

Questionnaire

The questions in this survey are specific and relevant to your area of expertise. In this survey you will be asked to assess one or more natural assets and the threats to these asset(s). The order of the survey will reflect the asset and the threats relevant to this asset, if you have been asked to assess multiple assets then they will be separated in the survey for clarity (e.g. asset 1, threat 1, threat 2; asset 2, threat 1, threat 2 etc.). The location, ecosystem, particular asset and the details about it will be listed at the start of each priority asset section as location habitat, asset, attribute(s) and indicator(s) so you know what to be considering when responding to each question.

Priority asset 1 of 3

LOCATION: Yaringa Marine National Park
NESTED ASSET: Saltmarsh vegetation
KEY ECOLOGICAL ATTRIBUTES: extent of saltmarsh habitat, condition of saltmarsh vegetation
INDICATOR(S): Total extent, proportion weed free/density of weed species, diversity of Ecological Vegetation Classes
We are interesting in understanding the condition of saltmarsh vegetation in Yaringa MNP. When you think about the condition of saltmarsh vegetation, we would like you to pay particular attention to their attributes and indicators listed above. Where the status of these different attributes and indicators varies, we would like you to first describe those variations, then average across them to provide a holistic assessment for the asset. On the map provided, could you indicate which areas of Yaringa MNP you are familiar with for seagrass.

Current condition of the asset (use Reference Table 1):

1) Can you give me a quick indication of what you consider to be the key elements of saltmarsh vegetation condition?

Example for shorebirds: Number of individual species, breeding success and recruitment, extent and quality of habitat

- *Percentage aerial vegetative cover compared with reference sites*

- *Plant vigour (and its converse, absence of any sort of dieback) compared with reference sites*
- *Floristic diversity compared with reference sites with similar climate, soil type and elevation (esp. seawater inundation patterns)*
- *Concordance with 'normal' phenology for particular species in that climate zone*
- *Any evidence of floristic or structural changes over time (i.e. over decadal time periods)*

2) When you judge condition, what is the benchmark or reference condition against which you compare current condition?

Example for shorebirds: Other sites in Victoria and southern Australia with high numbers of shorebirds and low levels of threats.

Yes: other sites in Victoria and southern Australia with low levels of threats and, presumed, little modification. For vegetation, the elevation (i.e. seawater inundation pattern) is also crucial in choosing appropriate reference sites, as it's not only the site per se but also the position within a site that's critical for plant performance.

3) In making an assessment of the current condition of saltmarsh vegetation we would like you to use the following categories (use assessment Table 1). We are hoping to get an indication of the estimate in which you believe the true condition lies. So in the condition assessment table below, could you please indicate:
   (i) the upper bound of your condition estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).
   We'd also like to understand your confidence that this interval contains the true value. So could you also please note in the column provided in assessment Table 1:
   (iv) your confidence rating (with 1% being not at all confident and 100% being totally confident).

Condition assessment (current)

Saltmarsh at Yaringa MNP

Condition category	Estimate	Confidence rating	Description
Good		80	The natural asset(s) is/are currently largely or entirely intact. There may be minor impacts of threatening processes but the natural asset(s) is/are not currently at risk.
Fair			The natural asset(s) is/are being moderately impacted by threatening processes and is/are at some risk.
Poor			The natural asset(s) is/are not intact and is/are at continuing risk without corrective action.
Unsure			Unable to make an accurate assessment of the current condition of the natural asset(s).

4) In a few words, could you give me a bit of a sense of what you are basing your judgement of condition on for saltmarsh vegetation?

Example for shorebirds: shorebird counts, awareness of studies, personal observation

Personal observation for plant condition, and mapping of northern Western Port region undertaken in the 2011 State-wide saltmarsh/mangrove study. This mapping indicates there are large areas of Wet Saltmarsh Shrubland, with smaller amounts of Wet Saltmarsh Herbland, fronted by an extensive band of mangroves on the seaward side: also some Juncus-dominated Estuarine Wetland on fresher parts to the landward side. In all, this is an extensive area of coastal saltmarsh that, with the exception of the nearby marina/harbour development, has probably not seen much human interference (well, in comparison with other parts of the State…).

5) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience.

Personal visits, although these are not as frequent as I would like (maybe twice per year). My more detailed experience with the area was a long time ago: back in the mid 1980s, when I was doing post-doctoral studies on the saltmarshes at Yaringa.

6) Are there any other people you know who would be knowledgeable about saltmarsh vegetation condition in Yaringa MNP?

Dr Birgita Hansen (Uni Ballarat) may have undertaken bird counts in the area.

Trend in condition of the asset (use Reference Table 2):

1) Over what time period have you been familiar with saltmarsh vegetation in Yaringa MNP?

Twenty years, on and off.

2) Which of the following categories would best describe how you believe condition has changed over time (2002-2012)? Please circle
   (i) Condition has improved
      a. steadily
      b. condition has varied considerably, overall showing net improvement
      c. unsure if steady or variable
   (ii) Condition has been steady
      a. without variation
      b. condition has varied considerably, but with no net change
      c. unsure if steady or variable
   (iii) Condition has declined
      a. steadily
      b. condition has varied considerably, overall showing net decline
      c. unsure if steady or variable
   (iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of change in condition over time?

NA – since I am unsure as to whether any changes have occurred at all; we simply don't have the data, nor I the recent on-ground experience.

Opportunity to comment or make suggestions regarding the attributes and indicators of this asset:

Please write anything you think is relevant.

As with almost all coastal wetlands, we simply do not have the monitoring data to make any firm statements about change in condition, let alone make inferences about current condition. Indeed, the problem is even bigger than that, because we do not have robust monitoring techniques to quantify condition. Let's be even more pessimistic: are we sure what 'good' condition really is, and what makes good reference sites for coastal wetlands?

Priority threats

1) Can you give me a quick indication of what you consider are the key threats to saltmarsh vegetation condition in Yaringa MNP?

Example for shorebirds: human disturbance, loss of roosting and foraging habitat (weed invasion, weather events), lack of knowledge, off-site nutrient and pollution inputs.

- *Clearing and infilling (i.e. complete loss of saltmarsh vegetation) by land claim. Whilst this is a State-wide threat to coastal wetlands, it is probably not relevant to Yaringa MNP because of the site's protected status*
- *Climate change (longer term impacts: i.e. over the coming decades)*
- *Modification to inundation regimes (shorter term, due for example to port development, dredging etc, likely to be seen within the decade)*

- *Two unknown/unquantified threats are*
  - *i. Oil spills and hydrocarbon pollution*
  - *ii. Exotic taxa, plants and animals (see Threat 3 below, ~ page 10-12). In an area like Yaringa, close to urban housing etc, I wonder whether cats and foxes might be problematic?*

2) What is the benchmark or reference condition against which you are judging the current impacts?

Example for shorebirds: other degraded saltmarsh/mangrove locations in southern Australia

Other degraded coastal saltmarsh sites in south-eastern Australia

THREAT 1 of 3

Oil/Chemical spill on saltmarsh vegetation in Yaringa MNP.

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current *likely* impact of a *future* oil and chemical spill on saltmarsh vegetation in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
   (i) the upper bound of your estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).

   We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
   (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Assessment is based on literature review of the effects of hydrocarbon pollution on coastal wetlands in our 2011 saltmarsh/mangrove study. Impacts can range from minor to severe, depending on volume of oil lost, types of dispersant used, tidal and wave conditions etc (and types of plant communities affected: annuals vs perennials etc). Recovery might be expected to take a decadal time frame; saltmarshes probably take longer to recover from an oil spill than most other coastal habitats.

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Scientific studies, although note that there are few studies of hydrocarbon pollution in south-eastern Australian coastal systems.

4) Are there any other people you know who would be knowledgeable about oil and chemical spill on saltmarsh vegetation

Perhaps Dr Peter Clarke, Uni of New England (Armidale, NSW).

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with oil and chemical spill on saltmarsh vegetation?

4 years (for literature review only: no on-ground experience at Yaringa MNP). But please note that I've never seen an oil spill in Western Port, so my analysis is, necessarily, rather theoretical.

2) Which of the following categories would best described how you believe the impacts of oil and chemical spill have changed over time? Please circle

(i) Impacts have decreased,
   a. steadily
   b. condition has varied considerably, overall showing net decrease
   c. unsure if steady or variable

(ii) Impacts are stable,
   a. Without variation
   b. condition has varied considerably, but with no net change
   c. unsure if steady or variable

(iii) Impacts have increased, or
   a. steadily
   b. condition has varied considerably, overall showing net increase
   c. unsure if steady or variable

(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

NA

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

As there seems not to have been an oil spill (or at least one big enough to get into the saltmarshes) at Western Port, I am unsure how to respond to Q2 above. It's not as if we have had yearly oil spills for the past three decades that covered all the coastal wetlands around the embayment! Similar response is applicable to mangroves at the very end of this questionnaire too.

THREAT 2 of 3.

Climate change (sea-level rise, climate-related changes e.g. temperature, increased sediment load etc.) **to 15 years**

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current ***and projected*** impact of climate change on saltmarsh vegetation in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
   (i) the upper bound of your estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).

   We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
   (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Climate change will have major impacts on coastal saltmarsh. The most direct effects will be via sea-level rise; but there will be other direct effects arising from a) higher air temperatures and b) higher C02 concentrations. The first will affect all aspects of plant phenology; the latter will modify competitive relationship between C4 and C3 plants. Then there are a host of indirect effects: altered freshwater run-off, altered patterns of nutrient and sediment loading, altered rates of sediment elevation with different river discharge and SS loads etc etc.

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Comprehensive scientific studies on this topic indicate the broad direct in which changes will occur: but details are less well understood (e.g. specific effects of altered CO2 on C3/C4 competitive interactions; details on effect of decrease in frost incidence on saltmarsh/mangrove interactions). This topic was covered in great detail in Chapter 1 of the 2011 saltmarsh/mangrove study. Some information specific to Western Port is available also in Boon et al. (2010):

Boon PI, White M & Sinclair S (2010). Climate change impacts on Victoria's coastal vegetation (mangroves and saltmarsh): Western Port case study. Institution of Engineers Australia: Practical responses to climate change 2010 conference. Melbourne, 29 September to 1 October 2010. (Full refereed paper: Paper 107: Presentation 107)

4) Are there any other people you know who would be knowledgeable about climate change on saltmarsh vegetation

Four people: Professor Paul Adam (Uni NSW, Sydney), Dr Neil Saintilan (NSW Dept Environment, Sydney), Dr Kerrylee Rogers (Wollongong Uni) and Prof Rod Connolly (Griffith Uni, Gold Coast)

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with climate change on saltmarsh vegetation?

4 years (for literature review only: no on-ground experience at Yaringa MNP)

2) Which of the following categories would best described how you believe the impacts of climate change have changed over time? Please circle
   (i) Impacts have decreased,
      a. steadily
      b. condition has varied considerably, overall showing net decrease
      c. unsure if steady or variable

(ii) Impacts are stable,
   a. Without variation
   b. condition has varied considerably, but with no net change
   c. unsure if steady or variable

(iii) Impacts have increased, or
   a. steadily
   b. condition has varied considerably, overall showing net increase
   c. unsure if steady or variable

(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

NA for Q2 above, but for the likely response for the Table/Graph on page 8 I'm very sure (i.e. 99%)

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

Left blank

THREAT 3 of 3.

Invasive exotic species (weeds and marine pests) to 15 years

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of invasive exotic species on saltmarsh vegetation in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
   (i) the upper bound of your estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).

   We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
   (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Coastal saltmarsh is subject to weed invasions both from the sea (e.g. Spartina) and from the land (e.g. Tall Wheat Grass). Spartina is found in Western Port, but it is limited in its distribution and is subject to a pretty successful control program by PV (and Melbourne Water too?). We did not find Spartina in the Yaringa-Hastings region, although it is found just to the north-east, in The Inlets around Tooradin. So we can probably dismiss it as a current problem. But a larger number of weed species can invade into the higher levels of saltmarsh, from the bordering terrestrial zones. We identify the 20 most threatening weed taxa in Chapter 1 of our 2011 report. To my knowledge, weed surveys have not been undertaken in Yaringa to determine the scale of any potential problem. At a first estimate, though, I would judge it to be a smaller threat than those posed by sea-level rise (and other climate-change associated issues) and the risk of hydrocarbon pollution.

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Mostly drawn from 2011 saltmarsh/mangrove study

4) Are there any other people you know who would be knowledgeable about invasive exotic species on saltmarsh vegetation

Geoff Carr (Ecology Australia) and Dr Jeff Yugovic (Biosis Research) are experts in this field; Dr Steve Sinclair (ARI, Heidelberg) might also be knowledgeable.

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with invasive exotic species on saltmarsh vegetation?

2) Which of the following categories would best described how you believe the impacts of invasive exotic species have changed over time? Please circle
   (i) Impacts have decreased,
      a. steadily
      b. condition has varied considerably, overall showing net decrease
      c. unsure if steady or variable
   (ii) Impacts are stable,
      a. Without variation
      b. condition has varied considerably, but with no net change
      c. unsure if steady or variable
   (iii) Impacts have increased, or
      a. steadily
      b. condition has varied considerably, overall showing net increase
      c. unsure if steady or variable
   (iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?
   NA

Opportunity to comment or make suggestions regarding this threat and indicators:
Please write anything you think is relevant.
Left blank

Priority asset 2 of 3
LOCATION: Yaringa Marine National Park
ASSET: Mangrove/Saltmarsh
NESTED ASSET: Rare species (rail, orange-bellied parrot, skink)
KEY ECOLOGICAL ATTRIBUTES: Minimum intact habitat area, presence of rare species
INDICATOR(S): Spatial extent of quality habitat, presence of rare species
Jacqui and Steffan: I probably can't help you here as the rare/endangered species are most likely to be birds. There may be some rare/endangered plant species in the coastal wetlands around Western Port, but it's not something that I've followed up.

The two people who might be in a better position to help with this section (esp for birds) are a) Dr Birgita Hansen (Uni Ballarat) and b) the bird specialist who attended our meetings at Docklands and at VU over the past 12-18 months. I forget his name – Steffan will know – but I recollect that he was based at Deakin Uni, Burwood. A lovely fellow.... we had coffee at VU one afternoon to discuss this project, after the big meeting at Docklands.

We are interesting in understanding the rare species in mangrove/saltmarsh habitat in Yaringa MNP. When you think about rare species, we would like you to pay particular attention to the attributes and indicators listed above. Where the status of these different attributes and indicators varies, we would like you to first describe those variations, then average across them to provide a holistic assessment for the asset. On the map provided, could you indicate which areas of Yaringa MNP you are familiar with for rare species.

Current condition of the asset (use Reference Table 1):

1) Can you give me a quick indication of what you consider to be the key elements of condition for rare species in mangrove/saltmarsh?

Example for shorebirds: Number of individual species, breeding success and recruitment, extent and quality of habitat

Left blank

2) When you judge condition, what is the benchmark or reference condition against which you compare current condition?

Left blank

Example for shorebirds: Other sites in Victoria and southern Australia with high numbers of shorebirds and low levels of threats.

3) In making an assessment of the condition of rare species in mangrove/saltmarsh we would like you to use the following categories (use assessment Table 1). We are hoping to get an indication of the estimate in which you believe the true condition lies. So in the condition assessment table below, could you please indicate:
   (i) the upper bound of your condition estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).

   We'd also like to understand your confidence that this interval contains the true value. So could you also please note in the column provided in assessment Table 1:
   (iv) your confidence rating (with 1% being not at all confident and 100% being totally confident).

   Condition assessment (current)

   Use Table 6 to see how to fill in – if you need more than one table (e.g. for shorebirds may have an answer for migratory and for resident) please use spare table at end of and write what it refers to.

Condition category	Estimate	Confidence rating	Description
Good			The natural asset(s) is/are currently largely or entirely intact. There may be minor impacts of threatening processes but the natural asset(s) is/are not currently at risk.
Fair			The natural asset(s) is/are being moderately impacted by threatening processes and is/are at some risk.
Poor			The natural asset(s) is/are not intact and is/are at continuing risk without corrective action.
Unsure			Unable to make an accurate assessment of the current condition of the natural asset(s).

4) In a few words, could you give me a bit of a sense of what you are basing your judgement of condition of rare species in mangrove/saltmarsh?

Example for shorebirds: shorebird counts, awareness of studies, personal observation

Left blank

5) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience.

Left blank

6) Are there any other people you know who would be knowledgeable about rare species in mangrove/saltmarsh in Yaringa MNP?

Left blank

Trend in condition of the asset (use Reference Table 2):

1) Over what time period have you been familiar with rare species in mangrove/saltmarsh in Yaringa MNP?

Left blank

2) Which of the following categories would best describe how you believe condition has changed over time (2002-2012)? Please circle
   (i) Condition has improved
      a. steadily
      b. condition has varied considerably, overall showing net improvement
      c. unsure if steady or variable
   (ii) Condition has been steady
      a. without variation
      b. condition has varied considerably, but with no net change
      c. unsure if steady or variable

(iii) Condition has declined

a. steadily
b. condition has varied considerably, overall showing net decline
c. unsure if steady or variable

(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the condition of rare species in mangrove/saltmarsh over time?

Left blank

Opportunity to comment or make suggestions regarding the attributes and indicators of this asset:

Please write anything you think is relevant.

Left blank

Priority threats

1) Can you give me a quick indication of what you consider are the key threats to rare species in mangrove/saltmarsh?

Example for shorebirds: human disturbance, loss of roosting and foraging habitat (weed invasion, weather events), lack of knowledge, off-site nutrient and pollution inputs.

Left blank

2) What is the benchmark or reference condition against which you are judging the current impacts?

Example for shorebirds: other degraded saltmarsh/mangrove locations in southern Australia

Left blank

THREAT 1 of 5.

Oil and Chemical Spills on rare species in mangrove/saltmarsh in Yaringa MNP.

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of oil and chemical spill on rare species in mangrove/saltmarsh in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
   (i) the upper bound of your estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).
   We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:

(iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for invasive exotic species impact on shorebirds: No increase of invasive exotic species in the area over past 10 years, shorebirds are not affected by invasive exotic species except where weeds encroach on roost sites.

Left blank

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Left blank

4) Are there any other people you know who would be knowledgeable about oil and chemical spill on rare species in mangrove/saltmarsh?

Left blank

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with oil and chemical spill on rare species in mangrove/saltmarsh?

Left blank

2) Which of the following categories would best described how you believe the impacts of oil and chemical spill have changed over time? Please circle

(i) Impacts have decreased,

a. steadily
b. condition has varied considerably, overall showing net decrease
c. unsure if steady or variable

(ii) Impacts are stable,
a. Without variation
b. condition has varied considerably, but with no net change
c. unsure if steady or variable

(iii) Impacts have increased, or
a. steadily
b. condition has varied considerably, overall showing net increase
c. unsure if steady or variable

(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Left blank

Opportunity to comment or make suggestions regarding this threat and indicators:
Please write anything you think is relevant.
Left blank

THREAT 2 of 5.
Pollutants from catchment run-off/stormwater (e.g. poisons, herbicides, hydrocarbons, septic tanks) on rare species in mangrove/saltmarsh in Yaringa MNP.

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of pollutants from catchments run-off/stormwater on rare species in mangrove/saltmarsh in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
(i) the upper bound of your estimate (U),
(ii) the lower bound of your estimate (L), and
(iii) what you believe the most likely value to be (M).

We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
(iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for invasive exotic species impact on shorebirds: No increase of invasive exotic species in the area over past 10 years, shorebirds are not affected by invasive exotic species except where weeds encroach on roost sites.

Left blank

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Left blank

4) Are there any other people you know who would be knowledgeable about pollutants from catchments run-off/stormwater on rare species in mangrove/saltmarsh?

Left blank

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with pollutants from catchments run off/stormwater on rare species in mangrove/saltmarsh?

Left blank

2) Which of the following categories would best described how you believe the impacts of pollutants from catchments run-off/stormwater have changed over time? Please circle

(i) Impacts have decreased,

a. steadily
b. condition has varied considerably, overall showing net decrease
c. unsure if steady or variable

(ii) Impacts are stable,
    a. Without variation
    b. condition has varied considerably, but with no net change
    c. unsure if steady or variable
(iii) Impacts have increased, or
    a. steadily
    b. condition has varied considerably, overall showing net increase
    c. unsure if steady or variable
(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Left blank

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

Left blank

THREAT 3 of 5.

Climate change (sea-level rise, climate-related changes e.g. temperature, increased sediment load etc.) on rare species in mangrove/saltmarsh, **to 15 years**

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of climate change on the rare species in mangrove/saltmarsh in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
    (i) the upper bound of your estimate (U),
    (ii) the lower bound of your estimate (L), and
    (iii) what you believe the most likely value to be (M).

    We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
    (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for invasive exotic species impact on shorebirds: No increase of invasive exotic species in the area over past 10 years, shorebirds are not affected by invasive exotic species except where weeds encroach on roost sites.

Left blank

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Left blank

4) Are there any other people you know who would be knowledgeable about climate change on rare species in mangrove/saltmarsh?

Left blank

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with climate change rare species in mangrove/saltmarsh?

Left blank

2) Which of the following categories would best described how you believe the impacts of climate change have changed over time? Please circle

   (i) Impacts have decreased,

      a. steadily
      b. condition has varied considerably, overall showing net decrease
      c. unsure if steady or variable

(ii) Impacts are stable,
    a. Without variation
    b. condition has varied considerably, but with no net change
    c. unsure if steady or variable
(iii) Impacts have increased, or
    a. steadily
    b. condition has varied considerably, overall showing net increase
    c. unsure if steady or variable
(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

Left blank

THREAT 4 of 5.

Invasive exotic species (weeds and marine pests).**to 1**

5 years

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of invasive exotic species on rare species in mangrove/saltmarsh in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
    (i) the upper bound of your estimate (U),
    (ii) the lower bound of your estimate (L), and
    (iii) what you believe the most likely value to be (M).

    We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
    (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for invasive exotic species impact on shorebirds: No increase of invasive exotic species in the area over past 10 years, shorebirds are not affected by invasive exotic species except where weeds encroach on roost sites.

Left blank

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Left blank

4) Are there any other people you know who would be knowledgeable about invasive exotic species on rare species in mangrove/saltmarsh?

Left blank

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with invasive exotic species on rare species in mangrove/saltmarsh?

Left blank

2) Which of the following categories would best described how you believe the impacts of invasive exotic species have changed over time? Please circle

   (i) Impacts have decreased,

      a. steadily
      b. condition has varied considerably, overall showing net decrease
      c. unsure if steady or variable

(ii) Impacts are stable,
    a. Without variation
    b. condition has varied considerably, but with no net change
    c. unsure if steady or variable
(iii) Impacts have increased, or
    a. steadily
    b. condition has varied considerably, overall showing net increase
    c. unsure if steady or variable
(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Left blank

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

Left Blank

THREAT 5 of 5.

Pest animals (feral cats and foxes) on rare species in mangroves/saltmarsh habitats.**to 15**

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of pest animals on rare species in mangrove/saltmarsh habitats in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
    (i) the upper bound of your estimate (U),
    (ii) the lower bound of your estimate (L), and
    (iii) what you believe the most likely value to be (M).

    We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
    (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for invasive exotic species impact on shorebirds: No increase of invasive exotic species in the area over past 10 years, shorebirds are not affected by invasive exotic species except where weeds encroach on roost sites.

Left blank

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Left blank

4) Are there any other people you know who would be knowledgeable about pest animals on rare species in mangrove/saltmarsh habitats?

Left blank

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with pest animals on rare species in mangrove/saltmarsh habitats?

Left blank

2) Which of the following categories would best described how you believe the impacts of pest animals have changed over time? Please circle

(i) Impacts have decreased,

d. steadily
e. condition has varied considerably, overall showing net decrease
f. unsure if steady or variable

(ii) Impacts are stable,
    a. Without variation
    b. condition has varied considerably, but with no net change
    c. unsure if steady or variable
(iii) Impacts have increased, or
    a. steadily
    b. condition has varied considerably, overall showing net increase
    c. unsure if steady or variable
(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Left blank

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

Left blank

Priority asset 3 of 3

LOCATION: Yaringa Marine National Park
ASSET: Mangrove/Saltmarsh
NESTED ASSET: Mangrove Vegetation
KEY ECOLOGICAL ATTRIBUTES: Extent of mangrove habitat, recruitment of mangrove seedlings
INDICATOR(S): Total mangrove extent, density of seedlings/saplings

We are interesting in understanding the condition of mangrove vegetation in Yaringa MNP. When you think about the condition of mangrove vegetation, we would like you to pay particular attention to their attributes and indicators listed above. Where the status of these different attributes and indicators varies, we would like you to first describe those variations, then average across them to provide a holistic assessment for the asset. On the map provided, could you indicate which areas of Yaringa MNP you are familiar with for mangrove vegetation.

Current condition of the asset (use Reference Table 1):

1) Can you give me a quick indication of what you consider to be the key elements of condition for mangrove vegetation?

Example for shorebirds: Number of individual species, breeding success and recruitment, extent and quality of habitat

- Percentage aerial vegetative cover compared with reference sites
- Plant vigour (and its converse, absence of any sort of dieback) compared with reference sites

- Concordance with 'normal' phenology for Avicennia in this climate zone
- Work is needed on this matter, but I think information on non-vascular plants in mangroves might also be a valuable condition tool too. This might apply to saltmarshes too, but it their case at least we have >100 vascular plant species from which to infer plant biodiversity - in the case of mangroves, we have only one: Avicennia marina.
- Note that there are a number of 'condition assessment' protocols that purport to measure mangrove condition: not sure that they are worth much. Marta Slawuta is comparing them as part of her PhD with me: results should be out in 12 months or so.

2) When you judge condition, what is the benchmark or reference condition against which you compare current condition?

Example for shorebirds: Other sites in Victoria and southern Australia with high numbers of shorebirds and low levels of threats.

As for saltmarshes in Priority Asset 1

i.e. Yes: other sites in Victoria and southern Australia with low levels of threats and, presumed, little modification. For vegetation, the elevation (i.e. seawater inundation pattern) is also crucial in choosing appropriate reference sites, as it's not only the site per se but also the position within a site that's critical for plant performance.

(copied to here from earlier in doc by JMC)

3) In making an assessment of the current condition of mangrove vegetation we would like you to use the following categories (use assessment Table 1). We are hoping to get an indication of the estimate in which you believe the true condition lies. So in the condition assessment table below, could you please indicate:
   (i) the upper bound of your condition estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).

   We'd also like to understand your confidence that this interval contains the true value. So could you also please note in the column provided in assessment Table 1:
   (iv) your confidence rating (with 1% being not at all confident and 100% being totally confident).

   <u>Condition assessment (current)</u>

   Use Table 6 to see how to fill in – if you need more than one table (e.g. for shorebirds may have an answer for migratory and for resident) please use spare table at end of and write what it refers to.

Condition Category	Estimate	Confidence rating	Description
Good			The natural asset(s) is/are currently largely or entirely intact. There may be minor impacts of threatening processes but the natural asset(s) is/are not currently at risk.
Fair			The natural asset(s) is/are being moderately impacted by threatening processes and is/are at some risk.
Poor			The natural asset(s) is/are not intact and is/are at continuing risk without corrective action.
Unsure			Unable to make an accurate assessment of the current condition of the natural asset(s).

4) In a few words, could you give me a bit of a sense of what you are basing your judgement of condition on for mangrove vegetation?

Example for shorebirds: shorebird counts, awareness of studies, personal observation

As for saltmarshes in Priority Asset 1

i.e. Personal observation for plant condition, and mapping of northern Western Port region undertaken in the 2011 State-wide saltmarsh/mangrove study. This mapping indicates there are large areas of Wet Saltmarsh Shrubland, with smaller amounts of Wet Saltmarsh Herbland, fronted by an extensive band of mangroves on the seaward side: also some Juncus-dominated Estuarine Wetland on fresher parts to the landward side. In all, this is an extensive area of coastal saltmarsh that, with the exception of the nearby marina/harbour development, has probably not seen much human interference (well, in comparison with other parts of the State…).

(copied to here from earlier in doc by JMC)

5) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience.

As for saltmarshes in Priority Asset 1

i.e. Personal visits, although these are not as frequent as I would like (maybe twice per year). My more detailed experience with the area was a long time ago: back in the mid 1980s, when I was doing post-doctoral studies on the saltmarshes at Yaringa.

(copied to here from earlier in doc by JMC)

6) Are there any other people you know who would be knowledgeable about the condition of mangrove vegetation in Yaringa MNP?

Possibly Dr Jeff Yugovic, Biosis Research

Trend in condition of the asset (use Reference Table 2):

1) Over what time period have you been familiar with mangrove vegetation in Yaringa MNP?

As for saltmarshes in Priority Asset 1

2) Which of the following categories would best describe how you believe condition has changed over time (2002-2012)? Please circle
   (i) Condition has improved
      a. steadily
      b. condition has varied considerably, overall showing net improvement
      c. unsure if steady or variable
   (ii) Condition has been steady
      a. without variation
      b. condition has varied considerably, but with no net change
      c. unsure if steady or variable
   (iii) Condition has declined
      a. steadily
      b. condition has varied considerably, overall showing net decline
      c. unsure if steady or variable
   (iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of change in condition over time?

Caveats raised for saltmarshes (Asset 1) apply here as well

i.e. NA – since I am unsure as to whether any changes have occurred at all; we simply don't have the data, nor I the recent on-ground experience.

Opportunity to comment or make suggestions regarding the attributes and indicators of this asset:

Please write anything you think is relevant.

Left blank

Priority threats

1) Can you give me a quick indication of what you consider are the key threats to the condition of mangrove vegetation in Yaringa MNP?

Example for shorebirds: human disturbance, loss of roosting and foraging habitat (weed invasion, weather events), lack of knowledge, off-site nutrient and pollution inputs.

- *Clearing and infilling (i.e. complete loss of mangrove vegetation) by land claim. Whilst this is a State-wide threat to mangroves, it is probably not relevant to Yaringa MNP because of the site's protected status. But it is a problem elsewhere in Western Port*

- *Climate change (longer term impacts: i.e. over the coming decades)*
- *Altered patterns of sedimentation and sediment elevation*
- *Two unknown/unquantified threats are*
  - *i. Oil spills and hydrocarbon pollution*
  - *ii. Exotic taxa, plants and animals (see Threat 3 for saltmarshes above, ~ page 10-12)*

2) What is the benchmark or reference condition against which you are judging the current impacts?

Example for shorebirds: other degraded saltmarsh/mangrove locations in southern Australia

As for saltmarshes in Priority Asset 1

THREAT 1 of 3.

Sediments from catchment run-off on mangrove vegetation condition in Yaringa MNP.

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of sediments from catchment run-off we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
   (i) the upper bound of your estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).

   We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
   (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate	**NA**		Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for impact of oil and chemical spills on shorebirds: no knowledge of any significant spills in last 10 years.

High sediment loads in run-off from the catchment are likely to be a good thing for mangroves in Western Port, and that is why I've given a NA in the box above. Relatively high rates of sedimentation will allow mangroves to keep track with sea-level rise: if there is no sedimentation, the only mechanism for them to keep their heads above water is via biogenic sediment expansion, and that might not be fast enough. So, unlike the case for seagrasses (where high sediment loads are a BAD thing), they are probably a good thing for mangroves!

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Data from Neil Saintilan's and Kerrylee Rogers SET apparatus in Western Port. (SET = Sediment Elevation Tables)

4) Are there any other people you know who would be knowledgeable about the threat of sediments from catchment run-off on mangrove vegetation condition in Yaringa MNP?

Yes: Neil and Kerrylee as noted above. At an international scale, the world expert is Don Cahoon from the UGS in the USA; but Neil and Kerrylee have more than enough local information too.

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with sediments from catchment run-off on mangrove vegetation condition?

Left blank

2) Which of the following categories would best described how you believe the impacts of sediments from catchment run-off on mangrove vegetation condition have changed over time? Please circle

(i) Impacts have decreased,
   a. steadily
   b. condition has varied considerably, overall showing net decrease
   c. unsure if steady or variable

(ii) Impacts are stable,
   a. Without variation
   b. condition has varied considerably, but with no net change
   c. unsure if steady or variable

(iii) Impacts have increased, or
   a. steadily
   b. condition has varied considerably, overall showing net increase

c. unsure if steady or variable

(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Left blank

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

As a matter of urgency, we need to maintain the SET apparatus established 10 years ago by Neil and Kerrylee across Western Port. Without this, we can say nothing about the ability of mangroves to withstand sea-level rise.

THREAT 2 of 3.

Sediment movement and transport from changes to coastal hydrology on mangrove vegetation condition in Yaringa MNP.

Current impact of Threats (use Reference Table 3)

1) In making an assessment of the current impact of sediment movement and transport from changes to coastal hydrology on mangrove vegetation condition we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:
   (i) the upper bound of your estimate (U),
   (ii) the lower bound of your estimate (L), and
   (iii) what you believe the most likely value to be (M).

   We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:
   (iv) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate	**???**		Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

2) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for impact of climate change on shorebirds: Knowledge of current climate change projections and vulnerability of shorebird foraging and roosting sites to climate change impacts

Left blank

3) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Left blank

4) Are there any other people you know who would be knowledgeable about sediment movement and transport from changes to coastal hydrology on mangrove vegetation condition in Yaringa MNP?

Left blank

Trend in impacts 2002-2012 (use Reference Table 5):

1) What sort of time period have you been familiar with sediment movement and transport from changes to coastal hydrology?

Left blank

2) Which of the following categories would best described how you believe the impacts of sediment movement and transport from changes to coastal hydrology have changed over time? Please circle

(i) Impacts have decreased,

a. steadily

b. condition has varied considerably, overall showing net decrease
c. unsure if steady or variable

(ii) Impacts are stable,
a. Without variation
b. condition has varied considerably, but with no net change
c. unsure if steady or variable

(iii) Impacts have increased, or
a. steadily
b. condition has varied considerably, overall showing net increase
c. unsure if steady or variable

(iv) Are you unsure?

3) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Left blank

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

Jacqui and Steffan: not quite sure what this threat is meant to be. Is it erosion-like processes such as those that operate along the Lang Lang shore of eastern Western Port? For this reason, I've shown a **???** in the table above.

THREAT 3 of 3.

Oil and Chemical Spills on mangrove vegetation condition in Yaringa MNP.

Current impact of Threats (use Reference Table 3)

5) In making an assessment of the ***possible future not current*** impact of oil and chemical spill on mangrove vegetation condition in Yaringa MNP we would like you to use the following categories (whilst using Reference Table 3). We are hoping to get an indication of the estimate in which you believe the true impact lies. So, on the table below, could you please indicate:

(v) the upper bound of your estimate (U),
(vi) the lower bound of your estimate (L), and
(vii) what you believe the most likely value to be (M).

We'd also like to understand your confidence that the interval you provided contains the true value. So could you also please note:

(viii) your level of confidence (with 1% being not at all confident and 100% being totally confident).

Threat assessment (current) (use Reference Table 4)

Use Table 6 to see how to fill in

Category	Estimate	Confidence rating	Description
Impacts major			Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate			Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.

6) In a few words, could you give me a bit of a sense of what you are basing your judgement of these impacts on?

Example for invasive exotic species impact on shorebirds: No increase of invasive exotic species in the area over past 10 years, shorebirds are not affected by invasive exotic species except where weeds encroach on roost sites.

Note that, like to one for saltmarshes in Asset 1, the assessment above is for the likely impact of a future oil spill – to my knowledge, we have not had oil spills big or often enough to allow me to comment on the question as it stands in Q5. That's why I've revised the question to reflect possible/likely impacts from future spills.

The assessment above (on likely future impacts) is based on literature review of the effects of hydrocarbon pollution on coastal wetlands in our 2011 saltmarsh/mangrove study. Impacts can range from minor to severe, depending on volume of oil lost, types of dispersant used, tidal and wave conditions etc (and types of plant communities affected: annuals vs perennials etc). Recovery might be expected to take a decadal time frame; saltmarshes probably take longer to recover from an oil spill than most other coastal habitats – mangroves are probably in this situation as well. On the one hand, they will receive the brunt of any oil-spill exposure since they are so close to the water.

7) What sort of information helped you to form your judgement? E.g. scientific studies, monitoring data, field trips, number of years of experience etc.

Scientific studies, although note that there are few studies of hydrocarbon pollution in south-eastern Australian coastal systems. There is a little bit on mangrove responses, but generally very few studies are available (maybe this is because there have been few oil spills – a good thing!)

8) Are there any other people you know who would be knowledgeable about oil and chemical spill on mangrove vegetation condition

Professor Bill Allaway (Uni Sydney) – even though Bill is retired, he would still be the person with expertise in this field. If he didn't have the specific expertise, he would know who had.

Trend in impacts 2002-2012 (use Reference Table 5):

4) What sort of time period have you been familiar with oil and chemical spill on mangrove vegetation condition?

Never had any experience of this at all

5) Which of the following categories would best described how you believe the impacts of oil and chemical spill have changed over time? Please circle

(v) Impacts have decreased,

d. steadily
e. condition has varied considerably, overall showing net decrease
f. unsure if steady or variable

(vi) Impacts are stable,

a. Without variation
b. condition has varied considerably, but with no net change
c. unsure if steady or variable

(vii) Impacts have increased, or

a. steadily
b. condition has varied considerably, overall showing net increase
c. unsure if steady or variable

(viii) Are you unsure?

6) On a scale of 1-100, how confident are you in your assessment of the change in impacts over time?

Left blank

Opportunity to comment or make suggestions regarding this threat and indicators:

Please write anything you think is relevant.

Questions 5 and 6 are not relevant, as I'm not aware of any sizeable oils spills having taken place in Western Port in recent years. There have undoubtedly been spills, but they are all probably small (some very small, e.g. from refuelling pleasure craft rather than from commercial ships or tankers etc) and of very limited spatial impact.

REFERENCE TABLES TO BE USED BY EXPERT

Table 1. **Current condition categories for natural assets**

Condition	*Description*
Good	The natural asset(s) is/are currently largely or entirely intact. There may be minor impacts of threatening processes but the natural asset(s) are not currently at risk
Fair	The natural asset(s) is/are being moderately impacted by threatening processes and are at some at risk
Poor	The natural asset(s) is/are not intact and are at continuing risk without corrective action
Unknown	The current condition of natural assets is unknown

Table 2. **Trend in condition categories**

Trend in condition	Description	Symbol
Condition improved	The condition of the natural asset(s) improved between 2002 – 2012*, due to management or external influences	⇧
Condition was maintained	The condition of the natural asset(s) has generally been maintained between 2002 - 2012.	⇔
Condition declined	The condition of the natural asset(s) declined between 2002 - 2012, due to management or external influences	⇩
Trend in condition unknown	It is not known if the condition of the value has changed between 2002 - 2012	?

** This time frame to be used for initial assessments. Once current condition is established for a given park, condition will be noted with respect to the previous assessment.*

Table 3. **Consequence (level of impact) categories of Threatening Processes and Agents**

Category	Definition
Major	Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Moderate	Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Minor/ Insignificant	Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Level of threat unknown	The level of the threat to natural assets is unknown.

Table 4. **Current impact (consequence) of the threat categories**

Category	*Definition*
Impacts major	Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate	Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant	Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown	Impact of threat on natural assets unknown

Table 5. **Trend in impact (2002-2012) of threat categories**

Trend in impact	*Description*	*Symbol*
Impacts decreased	The impact of the threat on natural assets decreased between 2002 - 2012.	⇩
Impacts were stable	The impact of the threat on natural assets did not change between 2002 - 2012.	⇔
Impacts increased	The impact of the threat on natural assets increased between 2002 - 2012.	⇧
Trend in impact unknown	The trend in the impact of the threat between 2002 - 2012 was unknown, due to either lack of information or undetectable effects.	?

Table 6. EXAMPLE ASSESSMENT TABLES

Please fill in using central dot and line error bars on printed surveys or using U (upper bound), M (most likely) and L (lower bound) for electronic survey.

CONDITION

Condition category	Estimate	Confidence rating	Description
Good	U M L	90%	The natural asset(s) is/are currently largely or entirely intact. There may be minor impacts of threatening processes but the natural asset(s) is/are not currently at risk.
Fair			The natural asset(s) is/are being moderately impacted by threatening processes and is/are at some risk.
Poor			The natural asset(s) is/are not intact and is/are at continuing risk without corrective action.
Unsure			Unable to make an accurate assessment of the current condition of the natural asset(s).

THREAT

Category	Estimate	Confidence rating	Description
Impacts major	U M		Major *medium- to long-term impact* on natural assets. Slow recovery with substantial management intervention required.
Impacts moderate	L		Considerable and *short to medium-term impact* on natural assets. Natural asset(s) unlikely to be lost without intervention but quality/quantity may be reduced. Recovery will be slow with minor management intervention.
Impacts minor/ insignificant			Minor *short-term or minimal impact* on natural assets. Relatively quick recovery with no (or little) direct management intervention required.
Impacts unknown			The level of the threat to natural assets is unknown.