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Western Port
Ramsar Wetland
Ecological Character Description

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This report is not a substitute for professional advice rather it is intended to inform professional opinion by providing the authors' assessment of available evidence on change in ecological character. This information is provided without prejudice to any final decision by the Administrative Authority for Ramsar in Australia on change in ecological character in accordance with the requirements of Article 3.2 of the Ramsar Convention. Users should obtain any appropriate professional advice relevant to their particular circumstances.

SUMMARY viii

1 INTRODUCTION

1.1 Site location 1-1
1.2 Land tenure and management responsibilities 1-6
1.3 Ramsar criteria 1-8
1.4 Wetland types 1-13
1.5 Site details 1-14
1.6 Statement of purpose 1-15
1.7 Relevant treaties, legislation or regulations 1-16

2 CRITICAL COMPONENTS, PROCESSES, BENEFITS AND SERVICES

2.1 Essential elements 2-1
2.2 Critical ecosystem elements 2-10
2.3 Ecosystem components and processes 2-10
2.4 Ecosystem benefits and services 2-50

3 LIMITS OF ACCEPTABLE CHANGE

3.1 Wetland bathymetry 3-4
3.2 Geomorphology and sedimentation 3-4
3.3 Flora—Seagrass 3-5
3.4 Flora—Saltmarsh and mangrove 3-5
3.5 Fauna—Waterbirds 3-6
3.6 Fauna—Marine invertebrates 3-6
3.7 Fauna—Fish 3-6

4 THREATS TO THE ECOLOGICAL CHARACTER OF THE RAMSAR SITE

4.1 Historical site and catchment alterations 4-2
4.2 Catchment and coastal erosion 4-3
4.3 Deteriorating water quality 4-4
4.4 Shipping 4-6
4.5 Recreational activities 4-7
4.6 Pest plants and animals 4-7
4.7 Climate change 4-9
4.8 Urban development 4-10
4.9 Grazing 4-11
4.10 Recreational and commercial fishing 4-11

5 CHANGES TO ECOLOGICAL CHARACTER SINCE THE TIME OF LISTING

5.1 Wetland bathymetry 5-1
5.2 Water quality 5-1
5.3 Geomorphology and sedimentation 5-4
5.4 Tidal regime, hydrodynamics and catchment inflows 5-6
5.5 Climate 5-7
5.6 Flora 5-7
5.7 Fauna 5-14

6 KNOWLEDGE GAPS

7 MONITORING REQUIREMENTS

8 COMMUNICATION, EDUCATION AND PUBLIC AWARENESS

9 REFERENCES

APPENDICES

A Methods used in preparing the description
B Curriculum vitae of authors of the description
C Ramsar Information Sheet
D Non-pelagic waterbird species that occur at the Ramsar site classified by guild (Based on BOCA survey data)
E Common invertebrates found in marine habitats
F Common fish assemblages found in Western Port
G Atlas of Victorian Wildlife Records threatened fauna species historically recorded within the Western Port Ramsar site
H Pest species known to occur within the Ramsar site
I Total seasonal count separated by species

Glossary

Australian height datum (AHD)	The datum used to determine elevations in Australia. The AHD is based on mean sea level being zero elevation.
East Asian–Australasian Flyway	The East Asian–Australasian Flyway (the Flyway) stretches from the Russian Far East and Alaska, southwards through East Asia and South-east Asia, to Australia and New Zealand and encompasses 22 countries. The East Asian–Australasian Flyway is home to over 50 million migratory waterbirds from over 250 different populations, including 28 globally threatened species. (DEWHA, not dated).
Benchmark	A standard or point of reference (ANZECC and ARMCANZ 2000b). A predetermined state (based on the values that are sought to be protected) to be achieved or maintained (Lambert and Elix 2006). In this ECD, benchmarks are related to the baseline description at the time of listing of a Ramsar site.
Benefits	Benefits here refer to the economic, social and cultural benefits that people receive from ecosystems (Ramsar Convention 2005a, Resolution IX.1 Annex A). These benefits often rely on the underlying ecological components and processes in the wetland. See also 'Ecosystem services'.
Bioregion or Biogeographic region	A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc. (Ramsar Convention 2005b).
Catchment	The total area draining into a river, reservoir, or other body of water (ANZECC and ARMCANZ 2000a).
Change in ecological character	Human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention 2005a, Resolution IX.1 Annex A).
Community	An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (ANZECC and ARMCANZ 2000a).
Diversity (biological)	The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes. This definition is based largely on the one contained in Article 2 of the Convention on Biological Diversity (Ramsar Convention 2005b).
Ecological character	The combination of the ecosystem components, processes, and benefits and services that characterise the wetland at a given point in time. Within this context, ecosystem benefits are defined in accordance with the variety of benefits to people (ecosystem services). The phrase 'at a given point in time' refers to Resolution VI.1 paragraph 2.1, which states that 'It is essential that the ecological character of a site be described by the Contracting Party concerned at the time of designation for the Ramsar List, by completion of the Information Sheet on Ramsar Wetlands (as adopted by Recommendation IV. 7).'
Ecological communities	Any naturally occurring group of species inhabiting a common environment that interacts with each other, especially through food relationships, and that is relatively independent of other groups. Ecological communities may be of varying sizes, and larger ones may contain smaller ones (Ramsar Convention 2005b).
Ecosystems	Within the Millennium Ecosystem Assessment, ecosystems are described as the complex of living communities (including human communities) and non-living environment (ecosystem components) interacting (through ecological processes) as a functional unit, which provides, inter alia, a variety of benefits to people (ecosystem services) (Ramsar Convention 2005a, Resolution IX.1 Annex A).
Ecosystem components	Include the physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes) (Ramsar Convention 2005a, Resolution IX.1 Annex A).

Glossary (continued)

Ecosystem processes	Dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment, that result in existing ecosystems and that bring about changes in ecosystems over time (Australian *Heritage Commission 2002)*. They may be physical, chemical or biological.
Ecosystem services	Benefits that people receive or obtain from an ecosystem (Ramsar Convention 2005a, Resolution IX.1 Annex A). The components of ecosystem services include (Millennium Ecosystem Assessment 2005): • provisioning services—such as food, fuel and fresh water • regulating services—the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation • cultural services—the benefits people obtain through spiritual enrichment, recreation, education and aesthetics • supporting services—the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit in the long-term. See also ‘Benefits’.
Ecological vegetation class (EVC)	An EVC is a native vegetation classification based on a combination of its floristics, life form and ecological characteristics, and through an inferred fidelity to particular environment attributes (DSE 2004).
Epifauna	Fauna that live on the surface of a substrate, such as rocks, pilings, marine vegetation, or the sea or lake floor itself.
Essential element	An essential element is a component or process that has an essential influence on the critical components, processes and services/benefits of the wetland. Should the essential element cease, reduce, or is lost, it would result in a detrimental impact on one or more critical component, process and services/benefits. Critical components, processes and services/benefits depend in part or fully on an essential element, but an essential element is not in itself critical for defining the ecological character of the site.
Eutrophication	Waters that are characterised as having high nutrient levels that promote a proliferation of plant life especially algae which reduces the dissolved oxygen content.
Flyway	Global waterbird migration systems that directly link sites and ecosystems in different countries and continents. The geographical routes that migratory waterbirds traverse on an annual basis are known as ‘flyways’. There are eight major flyways around the world (DEWHA not dated).
Infauna	Fauna that burrow into and live in the bottom deposits of the ocean.
Limits of acceptable change	Variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (modified from definition adopted by Phillips 2006).
Pelagic	Of open seas or oceans.
Pneumatophores	An air-filled root (submerged or exposed) that can function as a respiratory organ of a mangrove, marsh or swamp plant.
Ramsar	City in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Convention’s short title, ‘Ramsar Convention on Wetlands’ http://www.ramsar.org/about/about_glossary.htm

Glossary (continued)

Ramsar criteria	Criteria for identifying wetlands of international importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values. http://www.ramsar.org/about/about_glossary.htm
Ramsar convention	Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names 'Convention on Wetlands (Ramsar, Iran, 1971)' or 'Ramsar Convention' are used more commonly. http://www.ramsar.org/index_very_key_docs.htm
Ramsar Information Sheet (RIS)	Form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed. http://www.ramsar.org/about/about_glossary.htm
Ramsar site	The area of Western Port situated within the Ramsar boundary
Western Port	The entire Western Port embayment
Wetlands	Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 m (Ramsar Convention 1987).
Wetland types	As defined by the Victorian classification system of Corrick and Norman (1980).

Abbreviations

AAV	Aboriginal Affairs Victoria
ARI	Arthur Rylah Institute
AVW	Atlas of Victorian Wildlife
BOCA	Bird Observation and Conservation Australia
CAMBA	China-Australia Migratory Bird Agreement
CCB	Central Coastal Board
CEPA	Communication, Education and Public Awareness
CMA	Catchment Management Authority
COM	Committee of Management
DEWHA	Department of the Environment, Water, Heritage and the Arts
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
DIWA	Directory of Important Wetlands in Australia
DPI	Department of Primary Industries
DRI	Dolphin Research Institute
DSE	Department of Sustainability and Environment
ECD	Ecological Character Description
EPA	Environment Protection Authority
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
FFG	*Flora and Fauna Guarantee Act 1988*
FIS	Flora Information System
IMCRA	Interim Marine and Coastal Regionalisation for Australia
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
KBR	Kellogg, Brown & Root Pty Ltd
MAFFRI	Marine and Freshwater Fisheries Research Institute
PPWCMA	Port Phillip and Western Port Catchment Management Authority
RIS	Ramsar Information Sheet
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SEPP	State Environment Protection Policy
UNESCO	United Nations Educational, Scientific and Cultural Organisation
VRHS	Victorian River Health Strategy
WPSP	Western Port Seagrass Partnership

Summary

Western Port is situated in south-eastern Australia, approximately 60 km south-east of Melbourne, Victoria. It is situated within Drainage Division 2: South East Coast identified by Australian Water Resources Council, and Bass Strait Province of the Interim Marine and Coastal Regionalisation for Australia.

In 1982, a large portion of Western Port was designated as a wetland of international importance under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention). The site occupies approximately 59 950 ha[1] and consists of large shallow intertidal areas dissected by deeper channels, and a narrow strip of adjacent coastal land in some areas. Australia has a number of obligations pertinent to the management of wetlands of international importance under the Ramsar Convention. Australia is expected to manage Ramsar wetlands so as to maintain their ecological character, remain informed of any changes to their character, and notify the Ramsar Secretariat of any changes at the earliest opportunity (DEWHA 2008).

Preparing a detailed description of the ecological character of a Ramsar wetland is critical to maintaining and protecting wetland values and establishes a benchmark at a given point in time from which change can be assessed and monitoring can be effectively planned and implemented. This report forms an ecological character description for the Western Port Ramsar site (hereafter referred to as the Ramsar site) at the time it was listed in 1982. The main objectives of this description are to:

- describe essential elements, critical ecosystem components, processes, benefits and services of the Ramsar site
- set limits of acceptable change for critical ecosystem components and processes, where practical, so as to ensure a benchmark from which change can be detected is established
- describe threats to the ecological character of the Ramsar site
- describe the current status and any evident change to critical components and processes within the site
- describe knowledge gaps and monitoring requirements to adequately assess and detect change.

[1] To be updated with more accurate mapping - see Ramsar Information Sheet (RIS) for a more recent area measurement.

The Ramsar site has long been recognised for its diversity of native flora and fauna, particularly for its ability to support diverse assemblages of waterbirds and wetland vegetation, including seagrass, saltmarsh and mangroves. As such, when the site was listed in 1982 it satisfied the following original criteria which have subsequently been re-defined:

- Criterion 1(a): the wetland is a particularly good representative example of a natural or near-natural wetland characteristic of the appropriate biogeographical region
- Criterion 1(b): the wetland is a particularly good representative example of a natural or near-natural wetland common to more than one biogeographical region
- Criterion 3(a): regularly supports 20 000 waterfowl
- Criterion 3(b): regularly supports substantial numbers of waterfowl from particular groups
- Criterion 3(c): regularly supports 1 per cent of the individuals in a population of one species or subspecies.

Following preparation of this description it has been determined that the site also satisfies the following current criteria:

- Criterion 2: a wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities
- Criterion 4: a wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions
- Criterion 8: a wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Essential elements which support the critical components and processes of the site are water quality, tidal regime and climate. These elements are described further in Section 2 of this report. A summary of the critical components and processes that constitute the ecological character of the site and a description for each from, or around, 1982 are provided in Table 1. The components and processes identified as critical are either important in maintaining the site's unique character or are important for supporting the criteria under which the site was listed.

Table 1 Summary of critical components and processes for the Ramsar site in 1982

Element	Summary description
Wetland bathymetry	Deepwater coastal inlet.
	Extensive intertidal mudflats (270 km^2) intersected by deep channels.
Geomorphology and sedimentation	Total sediment load in 1982 40 000 t/a; however estimates of total sediment input loads following European settlement have varied between approximately 40 000 and 100 000 t/a.
	Coarse and medium sand was concentrated towards the western entrance, encircled by French Island and along inshore areas and channel margin banks. Depositional fans were reported near the mouths of river inlets. Finer sediments deposited on intertidal areas.
Flora—seagrass	72 km^2 of seagrass and macroalgae in Western Port in 1983.
Flora—mangrove and saltmarsh	31 000 ha of saltmarsh vegetation in 1984.
	13 700 ha of mangrove vegetation in 1984.
	Near continuous coverage along the western and northern shoreline, and along the northern shoreline of French Island. Scattered vegetation along the eastern shoreline.
Flora—significant species	The site supports a number of species of Victorian conservation significance considered critical in maintaining its character. White Mangrove (*Avicennia marina* subsp. *australasica*) are listed as rare within Victoria and are characteristic of the mangrove fringe within the site.
	Creeping Rush (*Juncus revolutus*), Marsh Saltbush (*Atriplex paludosa* subsp. *paludosa*), and Salt Lawrencia (*Lawrencia spictata*) which are characteristic species of saltmarsh vegetation.
Fauna—waterbirds	115 waterbird species considered critical to the site's character have been recorded within the Ramsar site.
	Total numbers of waders and other non-pelagic waterbirds have exceeded 20,000 in all years of the BOCA survey (1973 until present). Typically these include 10 000 to 15 000 waders, 5000 to 10 000 swans and a few thousand ducks, gulls and other species. Nine wader species breed locally in or near the Ramsar site.
	The Ramsar site regularly supports more than 1 per cent of the estimated flyway population of five wader species, and three other non-pelagic waterbird species.
	The site supports a number of seabirds, most of which use the site opportunistically. Small numbers of Little Penguins (*Eudyptula minor*) and Short-tailed Shearwaters (*Puffinus tenuirostris*) nest within the Ramsar site on Barralliar Island and Tortoise Head, respectively. In addition, thousands of Short-tailed Shearwaters gather in the Ramsar site in autumn before embarking on their annual pan-Pacific migration: estimates of up to 250,000 birds have been made (Loyn 1978).
	The site also supports the following numbers of non-pelagic waterbird species protected by bilateral agreements: 36 species listed under CAMBA, 38 species listed under JAMBA and 34 species listed under ROKAMBA.
Fauna—marine invertebrates	In 1974, surveys of Western Port benthos reported 19 853 individuals recorded from 14 phyla.
Fauna—fish	Diverse assemblages of fish species, including a number of commercially significant species, characteristic of various marine habitats.
Fauna—significant species	Eighteen fauna species of national significance were recorded within the site prior to 1982. Of these the Orange-bellied Parrot (*Neophema chrysogaster*) is considered critical in maintaining the site's character as saltmarsh vegetation provides important overwintering habitat for the species.

Critical elements of the Ramsar site have been subject to change since 1982 (as summarised in Table 2). These have resulted from a variety of causes, including historical and current activities that threaten the character of the site, and are anticipated to continue threatening the site in the future, including:

- historical catchment alterations such as large scale vegetation clearance, channelisation and construction of levees
- catchment and coastal erosion
- deteriorating water quality
- shipping
- recreational activities
- pest plants and animals
- climate change
- urban development
- grazing
- recreational and commercial fishing.

Table 2 Summary of changes to critical components and processes for the Ramsar site

Element	Summary of change since listing	Change in character
Wetland bathymetry	Extensive intertidal mudflats: 270 km^2, channels maintained by dredging, sediment re-distribution Level of change largely unquantified	No change to the ecological character
Geomorphology and sedimentation	Total sediment load of 62 000 t/a discharging directly into the Ramsar site Fine sediment has been removed from the northern arm, French Island and from Bunyip and Cardinia Creek. Significant sediment distribution and accumulation in the eastern and south-eastern segments	Unable to be determined
Flora—seagrass	Seagrass beds within the site suffered a loss of up to 70 per cent in area between 1971 and 1985 Seagrass has increased from 72 km^2 in 1983/84, to 113 km^2 in 1994, and 154.5 km^2 in 1999. Regrowth since this time has occurred mainly in the north arm and entrances with little in the eastern arm. No current information on the distribution and health of seagrass within the site is available.	Unable to be determined
Flora—saltmarsh and mangrove	Between 1973 and 1999, saltmarsh vegetation has retreated in distribution while mangrove vegetation has increased, particularly along tidal creeks No current bay-wide information is available for the distribution or health of saltmarsh or mangrove vegetation	Unable to be determined

Table 2 Continued

Element	Summary of change since listing	Change in character
Flora—significant species	As above for saltmarsh and mangrove vegetation	Unable to be determined
Fauna—waterbirds	Waterbirds were impacted by seagrass dieback and partial recovery in the 1970s and 1980s. Black Swans (*Cygnus atratus*) and fish-eating birds were impacted significantly. Black Swans have returned in large numbers; however fish eating birds remain lower than earlier years. Three wader species have shown evidence of declining numbers in recent years, in parallel with global declines for these species. More marked changes over time are evident for some other wader species that did not meet the Ramsar criteria. Alternatively, some species have increased over time, notably Red-necked Avocet (*Recurvirostra novaehollandiae*) which became regular spring visitors to the sheltered mudflats between Jam Jerrup and Grantville in the east. Increases have also been observed in numbers of Pied Oystercatcher (*Haematopus longirostris*), Bar-tailed Godwit (*Limosa lapponica*) and Whimbrel (*Numenius phaeopus*) Total counts of waders have remained remarkably consistent in the Ramsar site over the years	No change to the ecological character A decline in the mean counts of the following guilds has been observed ducks, fishers, grebes, large wading birds and swans. This is likely to be due to drought conditions
Fauna—marine invertebrates	Diversity of marine invertebrates is reported to have been similar in 1973/74 and 1992/93 surveys. Anecdotal evidence suggests that the general composition of marine invertebrates in reef and rocky substrate habitats have generally remained unchanged since 1975 Increases in the total density of infauna and an apparent change in community structure over 20 years within a swing basin associated with the BHP International Steel Coated Products Plant in the north arm of the site	Unable to be determined
Fauna—fish	Since 1982 there have been changes to the assemblages that are characteristic of various habitat types A catch approximately 20 per cent of the size of the commercial catch of 1982/83 was recorded in 2007/08. In comparison, the commercial catch taken from Gippsland Lakes and Lake Tyers, and Port Phillip has reportedly fallen by 50 per cent from 1982/83 to 2007/08 (DPI 2008)	Unable to be determined

Limits of acceptable change acknowledge the natural variability exhibited by elements within the wetland ecosystem and establish guidelines that facilitate the assessment of change (either positive or negative) to the ecological character resulting from human activities.

Where possible, limits of acceptable change have been set with associated confidence levels for the critical ecosystem component and processes identified in preparing this description. It is envisaged that the limits of acceptable change identified are regularly updated in light of monitoring and further investigations undertaken to enhance ecosystem understanding.

A number of knowledge gaps pertaining to the critical ecosystem components and processes have been identified (Table 3). While it is acknowledged that many of the data deficiencies from 1982 cannot be resolved, additional investigations and monitoring requirements have been recommended (Table 4). In addition, it is recognised that although the Westernport Bay Environmental Study has been paramount in the early understanding of a complex system, a new comprehensive and integrated study of Western Port, its values, threats, and challenges, is required. Population growth, port development and land use changes present Western Port with an uncertain future. A comprehensive study to update earlier work is recommended in order to enhance our understanding of, and maintain, the values of the Ramsar site.

Table 3 Summary of knowledge gaps identified in preparing the description

Component/process	Identified knowledge gap
Wetland bathymetry	Quantitative information on the depths and location of each habitat type or morphological unit (from 1982 and current).
	Definitive associations in ecological response to changes in habitat availability.
	Extensive marine habitat mapping.
	Quantitative information on representativeness of wetland types within Drainage Division 2: South East Coast.
Water quality	Quantitative information on water quality within the site in 1982.
	Quantitative information on current water quality within the site.
Geomorphology and sedimentation	Graphical representation of sediment distribution within the site in 1982.
	Definitive associations in ecological response/causal links to changes in turbidity and sediment distribution.
	Extensive marine habitat mapping.
	Required reduction of sediment loads to protect environmental values.
Tidal regime, hydrodynamics and catchment inflows	Predictions of habitat loss as a result of sea level rise and storm surges.
	Extensive marine habitat mapping.
	Ecological response to climate change.
Climate	Predictions of habitat loss as a result of sea level rise, storm surges, and temperature fluctuations.
	Extensive marine habitat mapping.
	Ecological response to climate change.
	Water quality changes as a result of climate change causing reduced catchment inflows.
Flora—seagrass	Current distribution and health.
	Definitive associations in ecological response to changes in seagrass distribution and health.
	Extensive marine habitat mapping.
Flora—mangroves	Current distribution and health.
	Definitive associations in ecological response to changes in mangrove distribution and health.
	Extensive marine habitat mapping.

Table 3 Continued

Component/process	Identified knowledge gap
Flora—saltmarsh	Mapped distribution of saltmarsh vegetation in 1982 or 1984.
	Current distribution and health.
	Definitive associations in ecological response to changes in mangrove distribution and health.
	Extensive marine habitat mapping.
Component/process	Identified knowledge gap
Fauna—waterbirds	Clear relationships between waterbird numbers in relation to habitat availability, e.g. Orange-bellied Parrot (*Neophema chrysogaster*) and saltmarsh distribution.
	Quantitative information on representativeness within Drainage Division 2: South East Coast.
Fauna—marine invertebrates	Quantitative information on marine invertebrates within the site in 1982.
	Quantitative information on marine invertebrates currently within the site.
	Definitive associations in ecological response to changes in marine invertebrate diversity and abundance.
Fauna—fish	Quantitative information on fish (other than commercial species) within the site in 1982. Species lists used within the Westernport Bay Environmental Study were not available in preparing this description.
	Quantitative information on non-commercial fish species currently within the site, particularly those known to occur at beaches, rocky reefs, and mangroves.
	Quantitative information on the recreational fish catch from 1982 and currently.
	Definitive associations in ecological response to changes in fish diversity and abundance.

In order to address these gaps and measure future change to the character of the site, elements of the Ramsar site or threats that require monitoring have been identified (Table 4). It is not the intention of the description to provide a detailed monitoring program as it is envisaged that this will form an integral component of the management plan for the Ramsar site.

Table 4 Summary of monitoring requirements

Ecosystem element	Objective of monitoring	Indicator/measure	Suggested frequency of reporting
Bathymetry	Establish benchmarks and limits of change	Depth Dredging Habitat availability (i.e. habitat mapping)	Every 5 years Conduct habitat mapping every 5 years rather than review nautical maps every 5 years
Water quality	Ongoing condition and detection of change	EPA currently monitors water quality under their fixed site program and water quality improvement program Main parameters: chlorophyll-a, nitrogen, phosphorus, suspended solids, and turbidity, pathogens (Enterococci, *E. coli*), and litter	Monthly Report on trends every 5–10 years
Geomorphology and sedimentation	Establish limits, detection of change and ongoing condition	Sediment load Sediment distribution Habitat availability (i.e. habitat mapping)	Every 5 years Sediment grain size mapping could reviewed every 5–10 years
Tidal influences	Detection of change and ongoing condition	Tides are measured and reported constantly Habitat availability (i.e. habitat mapping)	Current frequency. Report on trends every 5 years
Climate	Detection of change and ongoing condition	The Bureau of Meteorology comprehensively monitors climate within the region Habitat availability (i.e. habitat mapping)	Current frequency. Report on trends every 5 years
Flora—seagrass	Establish limits, detection of change and ongoing condition	Distribution Health Habitat availability (i.e. habitat mapping)	At least every 2 years (EPA 1995)
Flora—mangroves	Establish limits, detection of change and ongoing condition	Distribution Health Habitat availability (i.e. habitat mapping)	At least every 5 years

1 Introduction

This report provides a description of the ecological character of the Western Port Ramsar site, which occupies the majority of Western Port excluding the western entrance. Throughout the report ‘Western Port’ refers to the entire embayment while ‘Ramsar site’ refers only to the area designated under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar convention).

1.1 SITE LOCATION

The Ramsar site consists of a large coastal bay situated approximately 60 km south-east of Melbourne, Victoria (DSE 2003). The site occupies approximately 59 950 ha[2] and includes large shallow areas dissected by deeper channels and, in some places, a narrow strip of adjacent coastal land. Western Port is connected to Bass Strait by a wide channel between Flinders and Phillip Island and a narrow channel between San Remo and Phillip Island (DSE 2003) (Figure 1.1). The southern boundary of the Ramsar site is therefore delineated by a line running east-west between Point Leo (145º4`42.71” and -38º25`25.4) and the western boundary of the Phillip Island Nature Park land situated at Observation Point (145º16`0.68” and -38º27`36.6”) and between New Haven and San Remo. French Island lies in the middle of Western Port but is not within the Ramsar site. However, a number of smaller islands are within the site boundaries. These include:

- Reef Island
- Elizabeth Island
- Churchill Island
- Crawfish Rock
- Barrallier Island
- Joes Island
- Quail Island
- Chinamans Island
- Schnapper Rock
- Pelican Island
- Sandstone Island
- Ram Island
- Eagle Rock.

[2] To be updated with more accurate mapping – see Ramsar Information Sheet (RIS) for a more recent area measurement

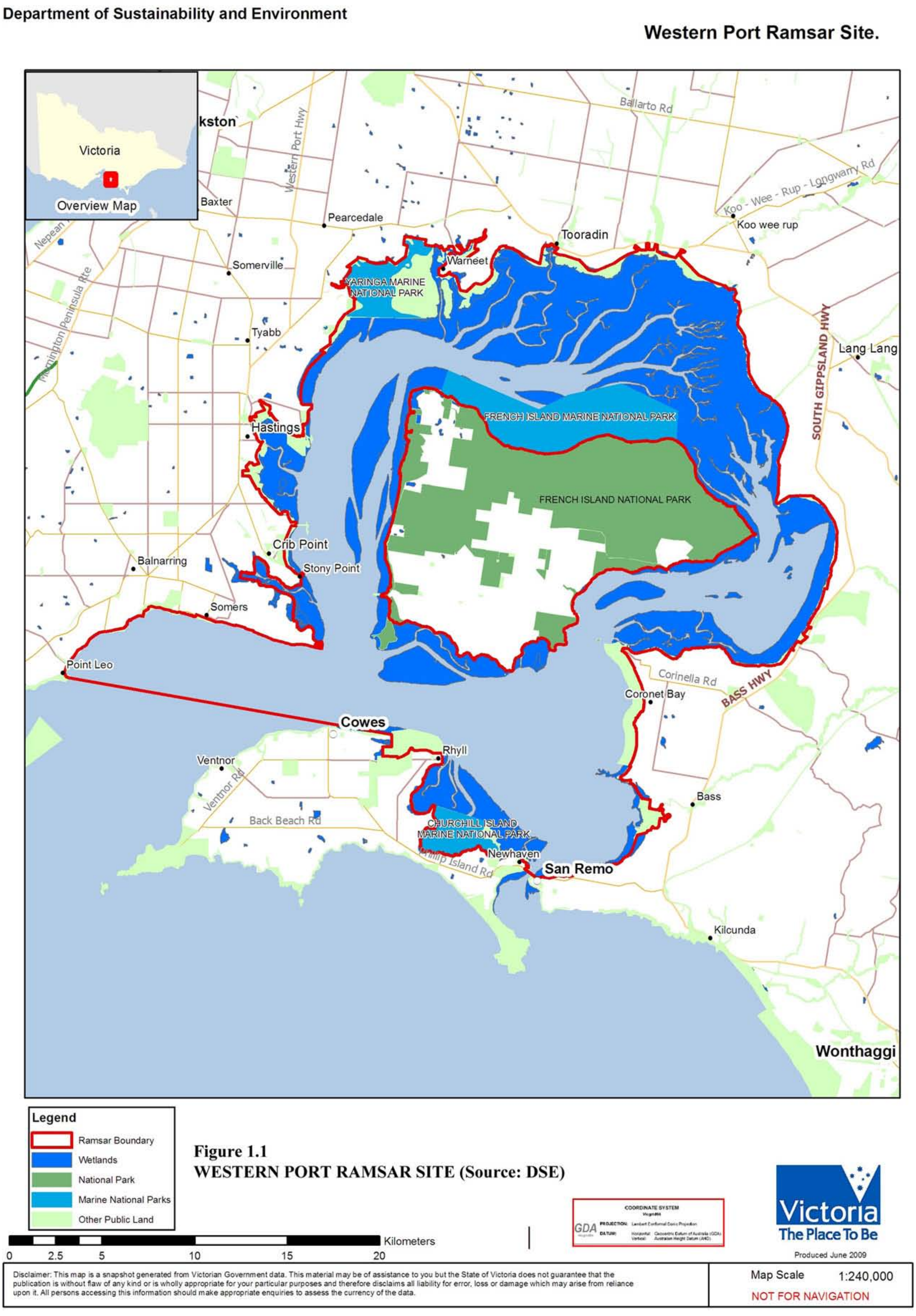

Figure 1.1
WESTERN PORT RAMSAR SITE (Source: DSE)

Adjoining land and French Island are situated within the Gippsland Plain Bioregion of Victoria (KBR 2007). At a national level, the adjoining land is situated within Drainage Division 2: South East Coast identified by Australia's River Basins by Australian Water Resources Council. Western Port itself also comprises one of the Victorian Embayments of the meso-scale bioregions defined by the Interim Marine and Coastal Regionalisation for Australia (IMCRA) within the larger Bass Strait IMCRA Province (Commonwealth of Australia 2006).

Western Port forms a component of the Mornington Peninsula and Western Port Biosphere Reserve, declared by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 2002.

The Ramsar site has a coastline of 263 km (CCB 2003), including islands, and traverses the following four local government jurisdictions:

- Mornington Peninsula Shire Council
- City of Casey
- Shire of Cardinia
- Shire of Bass Coast.

The Western Port catchment is within the jurisdiction of the Port Phillip and Western Port Catchment Management Authority (PPWCMA 2004). The catchment is bounded by the Strzelecki Ranges to the east, the Yarra Ranges to the north and the Mornington Peninsula to the west (EPA undated). The catchment has an area of 343 000 ha and comprises a mixture of land uses with agriculture, consisting predominantly of dairying, grazing and horticulture, occupying approximately 70 per cent of the catchment (PPWCMA 2004; Wallbrink and Hancock 2003a). Twenty per cent of the catchment consists of crown land, including French Island National Park, Phillip Island Nature Park and various conservation reserves. In 2003, 5 per cent of the catchment was urban; however this is rapidly increasing. Indigenous vegetation is said to occupy 22 per cent of the catchment (PPWCMA 2004). The catchment also supports major industry, including an oil refinery and steel works (CCB 2003). A population of 225 000 people is supported by the catchment across a number of urban and rural centres.

Western Port sustains a range of other human activities. These include commercial and recreational activities such as international and domestic shipping, fishing, tourism, aquaculture, recreational boating and aesthetic appreciation (CCB 2003).

Seventeen waterways enter Western Port in a radial fashion (CCB 2003). Major rivers include: the Bunyip, Tarago, Cardinia, Yallock, Lang Lang and Bass River networks, all of which discharge directly into the Ramsar site (Wallbrink and Hancock 2003a; EPA undated). The Koo-Wee-Rup Swamp once occupied extensive areas in the Western Port hinterland; however the swamp was drained to allow for agricultural development and to improve the transport link to Gippsland. As such, several watercourses within the lower catchment are now characterised as channelised drains. The waterways entering Western Port flow through urban and agricultural land. In addition, the catchment contains seven water supply catchments providing 73 900 ML annually for domestic, industrial and agricultural use (Parks Victoria 2007).

Groundwater also provides a significant water supply across the catchment with 18 830 ML licensed annually for both domestic and agricultural use (Parks Victoria 2007).

Western Port experiences the maximum tidal range along the Victorian coast (DSE 2003). As such, much of the northern and eastern sections of the Ramsar site consist of shallow intertidal areas. Specifically, Western Port occupies an area of 680 km^2 of which 40 per cent (or 270 km^2) is exposed as mudflats at low tide (Shapiro 1975; CCB 2003). The intertidal areas support mangrove, saltmarsh and seagrass communities and unvegetated mudflats, and are of great importance as shorebird habitat. In addition the saltmarsh and mangrove communities filter pollutants, stabilise sediments, trap and process nutrients, and protect the shoreline from erosion (DSE 2003). The adjacent coastal areas within the site support areas of native terrestrial vegetation.

The Ramsar site is valued for its terrestrial and marine flora and fauna, cultural heritage, recreational opportunities and its scenic values. As such, within the Ramsar site, there are three Marine National Parks, including Yaringa, French Island and Churchill Island Marine National Parks. Refer to Figure 1.2.

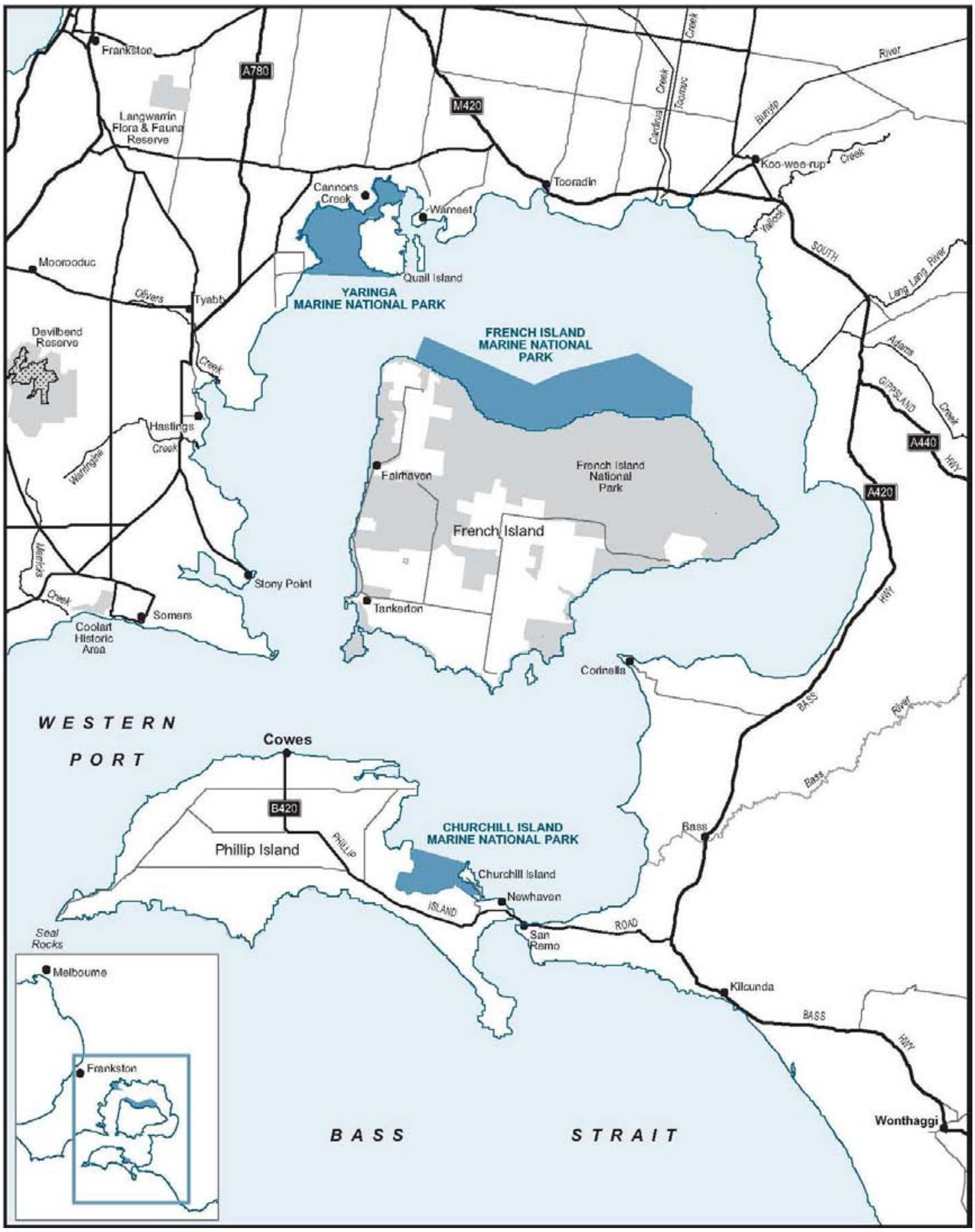

Figure 1.1
MAP SHOWING THE THREE MARINE NATIONAL PARKS WITHIN THE RAMSAR SITE
(Source: adapted from Parks Victoria 2007)

1.2 LAND TENURE AND MANAGEMENT RESPONSIBILITIES

Management of the Ramsar site is currently divided across:

- the Department of Sustainability and Environment (DSE)
  - responsible for the management of Crown Land and for waters of coastal embayments that overlie Crown Land (DSE 2003)
- Parks Victoria
  - manages specified coastal areas for DSE as Committees of Management under the *Crown Lands (Reserves) Act 1978*
  - responsible for the management of Western Port with respect to conservation and recreation in parks and reserves
  - responsible for the management of the three Marine National Parks situated within the Ramsar site
  - is a local authority of designated ports under Section 112(2) of the Victorian *Marine Act 1988* responsible for managing the port and its operations in a safe, effective manner; provide and maintain certain navigation aids and certain piers, jetties and facilities; and to determine and collect fees and other charges (DSE 2003)
- the Victorian Channels Authority
  - is responsible for the maintenance of designated commercial shipping lanes and for navigation within these lanes (DSE 2003)
- the Phillip Island Nature Park
  - manages specified coastal areas for DSE as a Committee of Management under the *Crown Lands (Reserves) Act 1978*
- Department of Defence
  - manages land occupied and utilised by HMAS Cerberus and naval waters (including Hanns Inlet) (DSE 2003; A. Delaney [Department of Defence] 2009, pers. comm., 10 June)
- Committees of Management under *Crown Lands (Reserves) Act 1978* (Table 1.1).

The site also encompasses two privately owned islands, Elizabeth and Sandstone Islands (DSE 2003).

Table 1.2 details the land tenure and responsible agencies within the Ramsar site.

Table 1.1 Committees of management within the Ramsar site (Source: DSE)

Reserve name	Type of reserve	Committee of Management (COM)
Flinders–Somers Coastal Reserve	Coastal reserve	Information not available
Western Port Coastal Reserve	Coastal reserve	Information not available
Hastings Pier	Port and coastal facility	Parks Victoria as COM
Warneet South Jetty	Port and coastal facility	Parks Victoria as COM
Lang Lang Jetty	Port and coastal facility	Parks Victoria as COM
Corinella Pier	Port and coastal facility	Parks Victoria as COM
San Remo Coastal Reserve	Coastal reserve	Information not available
Newhaven Jetty	Port and coastal facility	Parks Victoria as COM
Phillip Island Nature Park	Nature park	Phillip Island Nature Park Management Committee
Phillip Island Coastal Reserve	Coastal reserve	Information not available
Rhyll Jetty	Port and coastal facility	Parks Victoria as COM
Cowes Jetty	Port and coastal facility	Parks Victoria as COM

Table 1.2 Land tenure and management agencies within the Ramsar site (Source: DSE 2003)

Area	Land tenure	Legal status	Management agency
Yaringa, French Island and Churchill Island Marine National Parks	Marine National Park	*National Parks Act 1975*	Parks Victoria
Waters and seabed	Unreserved Crown Land	*Land Act 1958*	DSE
Waters—recreation and navigation	Unreserved Crown Land	*Marine Act 1988*	Parks Victoria
Port Waters of the Port of Hastings—commercial shipping channels	Unreserved Crown Land	*Port Services Act 1995*	Victorian Channels Authority (Toll Western Port)
150 m seawards of high water mark around French Island	French Island National Park	*National Parks Act 1975*	Parks Victoria
Hanns Inlet	Declared naval waters	*Control of Naval Waters Act 1918*	Department of Defence
Shoreline near Somers	Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
	Public Purpose Reserves	*Crown Land (Reserves) Act 1978*	Committee of Management—information not available
Shoreline from Stony Point to Jacks Beach	Coastal Reserve	*Crown Land (Reserves) Act 1978*	Stony Point–Crib Point Committee of Management
Jacks Beach to Hastings (Bittern Wetlands)	Unreserved Crown Land	*Land Act 1958*	Information not available
Shoreline from east of Tyabb to Tooradin	Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
	Nature Conservation Reserve	*Wildlife Act 1975 and Land Act 1958*	Parks Victoria
North-eastern shoreline	Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
	Nature Conservation Reserve	*Land Act 1958*	Parks Victoria

Table 1.2 Continued

Area	Land tenure	Legal status	Management agency
Shoreline near Corinella	Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Shoreline near Bass River	Nature Conservation Reserve	*Land Act 1958*	Parks Victoria
Churchill Island	Nature Park	*Crown Land (Reserves) Act 1978*	Phillip Island Nature Park
Shoreline near Rhyll	Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
	Nature Park	*Crown Land (Reserves) Act 1978*	Phillip Island Nature Park
French Island Shoreline	National Park	*National Parks Act 1975*	Parks Victoria
Elizabeth and Sandstone Islands	Freehold	*Private Land*	Private
Adjacent to Quail Island Nature Conservation Reserve	Yaringa Marine National Park	*National Parks Act 1975*	Parks Victoria
Waters adjacent to the northern shore of French Island National Park	French Island Marine National Park	*National Parks Act 1975*	Parks Victoria
South of Rhyll, on the eastern shore of Phillip Island	Churchill Island Marine National Park	*National Parks Act 1975*	Parks Victoria

1.3 RAMSAR CRITERIA

At the time of listing in 1982, Western Port satisfied former Ramsar criteria 1a, 1b, 3a, 3b and 3c. Since listing, the criteria have been revised a number of times in 1990, 1996, 1999, and 2005, when the current criteria were adopted (DEWHA 2008). Those criteria met by Western Port at the time of listing equate to current criteria 1, 3, 5 and 6. Refer to Table 1.3 for the former and current criteria satisfied by the Ramsar site. A justification statement on how the site satisfied each of these criteria in 1982 is provided in Section 1.3.1. An attempt has also been made, where possible, to state how each of these criteria is currently satisfied in accordance with the Explanatory Note and Guidelines for Completing the Information Sheet on Ramsar Wetlands (RIS) (Ramsar 2009).

The Ramsar site is considered to satisfy additional criteria that were not considered at the time of listing (Table 1.4). Justification statements as to how these criteria are met are provided in Section 1.3.2.

Table 1.3 Criteria satisfied by the Ramsar site in 1982

Current criteria 2005	Criteria	Ramsar Criteria 1982	Criteria
1	A wetland should be considered internationally important if it contains a representative, rare or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region	1(a)	The wetland is a particularly good representative example of a natural or near-natural wetland characteristic of the appropriate biogeographical region
		1(b)	The wetland is a particularly good representative example of a natural or near-natural wetland common to more than one biogeographical region
3	A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	3(b)	Regularly supports substantial numbers of waterfowl from particular groups
5	A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds	3(a)	Regularly supports 20,000 waterfowl
6	A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird	3(c)	Regularly supports 1 per cent of the individuals in a population of one species or subspecies

Table 1.4 Additional current criteria satisfied by the Ramsar site

Criteria No.	Current criteria (Ramsar secretariat)
2	A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
4	A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
8	A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

1.3.1 Criteria met at the time of listing

Criterion 1

In 1982, the site was determined to satisfy original Criteria 1(a) and 1(b), which equate to the current Criterion 1, for the following reasons:

> ‘It is a particularly good example of a natural wetland marine embayment with extensive intertidal flats, mangroves, saltmarsh, seagrass beds within the South East Coastal Plain.’
>
> ‘Western Port is a very good example of a saltmarsh-mangrove-seagrass wetland system.’
>
> (Parks Victoria 1999).

Current Criterion 1 refers to the representativeness of wetland types within the appropriate biogeographic area. At the time of listing, the South East Coastal Plain, which extends from Tyrendarra in western Victoria to Lakes Entrance in the east, was the designated biogeographic area. However, the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) has recently adopted a new biogeographical regionalisation which will enable the systematic application of this criterion. The Ramsar site is situated within Drainage Division 2: South East Coast which extends across south eastern Australia, from northern New South Wales to the South Australian border. As such, the Ramsar site is now considered to be situated within a much larger biogeographic area than at the time of listing.

A comprehensive analysis of the representativeness of wetland types within Drainage Division 2: South East Coast is yet to be undertaken in accordance with the Explanatory Note and Guidelines for Completing the Information Sheet on Ramsar Wetlands (RIS) (Ramsar 2009). In the absence of such information, it is not possible to make an assessment of the whether the wetland types within the site are currently ‘representative, rare or unique’ within Drainage Division 2: South East Coast.

Criterion 3

At the time of listing Western Port satisfied original Criterion 3(b), which now equates to current Criterion 3, as:

> ‘It is one of the three most important areas for migratory waders in Victoria. Wader surveys indicate that Western Port supports about 10,000 waders (approximately 12 per cent the Victorian population).’
>
> (Parks Victoria 1999).

Although the original criterion referred directly to the large numbers of waterbirds supported by the site, current Criterion 3 relates more specifically to biodiversity, endemism, and adaptation (Ramsar 2009). The Ramsar site is one of the most important areas for migratory waders in south-east Australia. Wader surveys indicate that the site supports up to 39 species, and includes 10 000 to 15 000 summer migrants, which is approximately 12–16 per cent of the Victorian population. Hence it makes a significant contribution to the habitat for waders in Drainage Division 2: South East Coast (along with other sites from South Australia to southern Queensland). The site is also important in supporting a large number of other waterbird species (63 in addition to the 39 wader species) and pelagic seabird species (at least 28). In addition, the site provides breeding habitat for 45 waterbird species (two seabirds, eight waders and 35 other waterbird species). It is therefore a significant site on a state, regional, national and international level for maintaining waterbird diversity.

Criterion 5

In 1982, the Ramsar site was determined as meeting original Criterion 3(a), which equates to current Criterion 5, because:

> 'Western Port regularly supports about 10 000 migratory waders and periodically supports in excess of 10 000 ducks and Black Swans (*Cygnus atratus*).'
>
> (Parks Victoria 1999).

The Ramsar site continues to meet current Criterion 5. It regularly supports about 10 000 to 15 000 migratory waders and periodically supports 1000 to 3000 ducks and 5000 to 10 000 Black Swans. The latter groups may be underestimated as some congregate in sites that are not included on regular counts. The site also supports thousands of gulls and hundreds of terns, grebes, large wading birds (e.g. ibis and spoonbills) and Australasian waders. The Ramsar site is also known to support globally threatened species, including Fairy Tern (*Sterna nereis*) which is currently listed as vulnerable on the IUCN Red List of Threatened Species (IUCN 2009).

Criterion 6

At the time of listing, the Ramsar site satisfied original criterion 3(c), which now equates to current Criterion 6, as:

> 'It has supported more than 5 per cent of the Victorian population of the Whimbrel (*Numenius phaeopus*), Grey-tailed Tattler (*Tringa brevipes*) and Bar-tailed Godwit (*Limosa lapponica*) (Australian Nature Conservation Agency 1996). Western Port has also supported internationally significant numbers of several waterfowl species (Australian Nature Conservation Agency 1996).'
>
> (Parks Victoria 1999).

The Ramsar site regularly supports (i.e. based on Bird Observation Conservation Australia (BOCA) data single counts exceed the 1 per cent criterion more than 17 years out of 35; see Table 2.9) more than 1 per cent of the estimated flyway population of five wader species, including Eastern Curlew (*Numenius madagascariensis*), Red-necked Stint (*Calidris ruficollis*), Curlew Sandpiper (*Calidris ferruginea*), Australian Pied Oystercatcher (*Haematopus longirostris*), Double-banded Plover (*Charadrius bicinctus*). The site also regularly supports internationally significant numbers (see Table 2.9) of several non-wader species, including Black Swan, Chestnut Teal (*Anas castanea*), Musk Duck (*Biziura lobata*), Pacific Gull (*Larus pacificus*) and Fairy Tern.

1.3.2 Additional criteria currently satisfied by the Ramsar site

Criterion 2

The Ramsar site supports species of global conservation significance, namely the Fairy Tern which is currently listed as vulnerable under the IUCN Red List of Threatened Species (IUCN 2009). BOCA survey data indicates that the site supports more than 1 per cent of the estimated relevant population (Delaney and Scott 2006) of Fairy Tern. Table 2.9 indicates that the species has exceeded the 1 per cent threshold 24 of the 35 year survey. The Ramsar site is also known to provide breeding habitat for this listed species (Parks Victoria 1999).

The Ramsar site is also known to support flora and fauna species of national conservation significance. A single flora species, Dense Leek-orchid (*Prasophyllum spicatum*) recorded within the boundaries of the site prior to and following listing is currently listed as vulnerable under the national *EPBC Act 1999*. This species is dependent on coastal heath and sandhill habitat provided within the site (Walsh and Entwisle 1994). In addition, eleven flora species of regional or state significance are known to have occurred within the boundary of the Ramsar site prior to and following listing (Section 2.2.6).

Eighteen fauna species of national significance are known to have occurred within the Ramsar site prior to and following 1982 (Section 2.2.7). These include:

- Australian Painted Snipe (*Rostratula australis*)
- Black-browed Albatross *(Thalassarche melanophris*)
- Blue Petrel (*Halobaena caeulea*)
- Fairy Prion (*Pachyptila turbur*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Growling Grass Frog (*Litoria raniformis*)
- Helmeted Honeyeater (*Lichenostomus melanops cassidix*)
- Long-nosed Potoroo (*Potorous tridactylus*)
- Northern Giant-Petrel (*Macronectes halli*)
- Orange-bellied Parrot (*Neophema chrysogaster*)
- Royal Albatross (*Diomedea epomophora*)
- Shy Albatross (*Thalassarche cauta*)
- Southern Brown Bandicoot (*Isoodon obesulus obesulus*)
- Southern Giant-Petrel (*Macronectes giganteus*)
- Swift Parrot *(Lathamus discolor*)
- Wandering Albatross (*Diomedea exulans*)
- Yellow-nosed Albatross (*Thalassarche chlororhynchos*).

Each of these species depends on habitat provided by the site; however many are pelagic seabirds that enter the site opportunistically to feed in deeper areas, especially during rough weather. Saltmarsh vegetation within the site provides important overwintering habitat for the Orange-bellied Parrot.

Criterion 4

The Ramsar site is one of the three most important areas in south east Australia for migratory waders in total numbers and density. The site also provides important overwintering habitat for the Orange-bellied Parrot.

The Ramsar site provides a number of important high tide roosts, including Yallock Creek mouth, Jam Jerrup, Stockyard Point, Reef Island, Rams Island, Barrallier Island and Tooradin.

Breeding habitat exists within the site for a number of species, including Australian Shelduck (*Tardorna tadornoides*), Chestnut Teal, Black Swan, Australian Pelican (*Pelecanus conspicillatus*), Short-tailed Shearwaters (*Puffinus tenuirostris*), Caspian Tern (*Sterna caspia*), Fairy Tern, Pied Oystercatcher, White-bellied Sea-eagle (*Haliaeetus leucogaster*) (Parks Victoria 1999).

Criterion 8

Seagrass beds within the Ramsar site are known to provide important nursery habitat for a number of fish species, including Smooth Toadfish (*Tetractenos glaber*), pipefish (*Syngnathidae*), Yellow-eye Mullet (*Aldrichetta forsteri*), leatherjackets (*Monacanthidae*), King George and Blue Rock Whiting (*Sillaginodes punctatus* and *Haletta semifasciata*, respectively), and Rock Flathead (*Platycephalus laevigatus*) (Parks Victoria 2007). Several of these are commercially significant species which result in wetland products; namely a valuable commercial fishing industry.

1.4 WETLAND TYPES

The Ramsar site consists of four wetland types that are recognised under the classification system used by the Ramsar Convention. These include:

- marine sub-tidal aquatic beds (B)
- intertidal mud and sand flats (G)
- intertidal marshes (including saltmarsh) (H)
- intertidal forested wetlands (including mangroves) (I)
- rocky marine shores (D)
- estuarine waters (F).

Mapping of these wetland types has not been available during the preparation of this description and is not known to exist. However, more information on the components within these wetland types, such as saltmarsh, seagrass and mangrove vegetation, is provided in Sections 2 and 5.

1.5 SITE DETAILS

Table 1.5 provides a summary table of details for the Ramsar site.

Table 1.5 Site details for the Ramsar site

Site descriptor	Western Port Ramsar site, Victoria
Name	Western Port.
Location in coordinates	Latitude: 38º12´ to 38º31´. Longitude: 145º02´ to 145º32´.
General location	Western Port is located in the State of Victoria, approximately 60 km south-east of Melbourne. The coastline of the Ramsar Site traverses the Mornington Peninsula Shire Council, City of Casey, Shire of Cardinia and Shire of Bass Coast local government jurisdictions. Drainage Division 2: South East Coast. PB35, Bass Strait IMCRA Province.
Area	59 950 ha (To be updated with more accurate mapping – see Ramsar Information Sheet (RIS) for a more recent area measurement.)
Date of Ramsar designation	15 December 1982.
Ramsar criteria met	Former Ramsar criteria: 1a, 1b, 3a, 3b, 3c which equate to current criteria 1, 3, 5 and 6 (refer to Table 1.2). Additional current criteria met by the site include 2, 4, and 8.
Management authority	Department of Sustainability and Environment (DSE). Parks Victoria. Victorian Channels Authority (Toll Western Port). Phillip Island Nature Park. Department of Defence. Committees of Management. Private.
Date the ecological character description applies	The description is for the Ramsar Site at time of listing in 1982.
Status of description	This represents an amendment to an unpublished draft description of the ecological character of the Ramsar site prepared in 2008. Refer to Appendix A for an outline of methods used in preparing this ecological character description.
Name(s) of compiler	KBR Level 3, 441 St Kilda Road, Melbourne, Victoria 3004. On behalf of DSEWPAC. Refer to Appendix B for the curriculum vitae for the authors of the description.
Date of completion	October 2009
Reference for Ramsar Information Sheet (RIS)	RIS compiled by Parks Victoria in 1999 electronic version available http://www.dse.vic.gov.au/CA256F310024B628/0/ACFEA346990109C0CA257292001F3220/$File/Western+Port+Information+Sheet.pdf Updated by KBR on behalf of DSEWPAC 2009 (Appendix C).
Reference for management plan	Department of Sustainability and Environment (2003). Western Port Ramsar Site: Strategic Management Plan. East Melbourne, Victoria. Available on Department of Sustainability and Environment website: http://www.dse.vic.gov.au/CA256F310024B628/0/09F382A15F086F64CA257292001C500A/$File/Western+Port+Ramsar+Site+Strategic+Management+Plan.pdf

1.6 STATEMENT OF PURPOSE

Australia has a number of obligations pertinent to the management of wetlands of international importance indentified under the Ramsar Convention. Australia is expected to manage Ramsar wetlands so as to maintain their ecological character, remain informed of any changes to their character, and notify the Ramsar Secretariat of any changes at the earliest opportunity (DEWHA 2008). As such, preparing a detailed description of the ecological character of a Ramsar wetland is critical to maintaining and protecting wetland values and establishes a benchmark at a given point in time from which change can be assessed and monitoring can be effectively planned and implemented.

In 2008, DSEWPAC published a National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands. The National Framework endeavours to establish a systematic and strategic approach to the management of Ramsar wetlands across Australia (DEWHA 2008). This report forms an ecological character description (ECD) for the Ramsar site prepared in accordance with the new National Framework.

The National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands (DEWHA 2008) details the general purpose of an ECD as:

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the Environment Protection and Biodiversity Conservation Regulations 2000 (Cwlth):
    a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia
    b) to formulate and implement planning that promotes:
        i) conservation of the wetland
        ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem
2. To assist in fulfilling Australia's obligation under the Ramsar Convention, to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.
3. To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, to form an official record of the ecological character of the site.
4. To assist the administration of the *EPBC Act*, particularly:
    a) to determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of Sections 16 and 17B of the *EPBC Act*, or
    b) to assess the impacts that actions referred to the Minister under Part 7 of the *EPBC Act* have had, will have or are likely to have on a declared Ramsar wetland.

5. To assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the *EPBC Act* for assessment and approval.
6. To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

1.7 RELEVANT TREATIES, LEGISLATION OR REGULATIONS

This section provides a list of any legislation or treaties that are relevant to the site or to species or communities that are present at the site.

1.7.1 International

Ramsar convention

The Convention on Wetlands of International Importance, especially as waterfowl habitat, otherwise known as the Ramsar Convention, came into being in Ramsar, Iran in 1971 and was ratified in 1975. The convention provides the framework for local, regional and national actions, and international cooperation, for the conservation and wise use of wetlands. Wetlands of international importance are selected on the basis of their international significance in terms of ecology, botany, zoology, limnology and or hydrology.

Migratory bird bilateral agreements and conventions

Australia is a signatory to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds which are relevant to the Western Port Ramsar site. These include:

- Japan-Australia Migratory Bird Agreement (JAMBA)—the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment, 1974
- China-Australia Migratory Bird Agreement (CAMBA)—the Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment, 1986
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)—the Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment, 2006
- Convention on Migratory Species of Wild Animals (also known as CMS or Bonn Convention)—the Bonn Convention adopts a framework in which countries with jurisdiction over any part of the range of a particular species cooperate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

1.7.2 National legislation

Environment Protection and Biodiversity Conservation (EPBC) Act 1999

The *EPBC Act 1999* provides a framework to facilitate the protection and management of nationally and internationally important flora, fauna, ecological communities and places of heritage (matters of national environmental significance) (DEWHA 2009a). Eight matters of national environmental significance have been identified under the Act and include Ramsar wetlands. Actions that will or are likely to have a significant impact on a matter of national environmental significance, including Ramsar wetland are subject to environmental assessment and approval under the Act. Actions, as defined by the Act, may be a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these (DEWHA 2009a).

The Australian Ramsar Management Principles are identified in Schedule 6 of the Environment Protection and Biodiversity Conservation Regulations 2000. These principles provide a framework for the management of Ramsar wetlands within Australia in a way that is consistent with Australia's obligations under the Ramsar Convention (DEWHA 2009a).

Australian Heritage Council Act 2003

Western Port was listed on the Register of the National Estate in 2001. The Register comprises a list of natural, Indigenous and historic heritage places throughout Australia (DEWHA 2009b). The Australian Heritage Council has the responsibility for maintaining items listed on the Register under the *Australian Heritage Council Act 2003*.

Native Title Act 1993

An Act about native title in relation to land or waters, and for related purposes.

> The main objects of this Act are:
>
> a) To provide for the recognition and protection of native title
>
> b) To establish ways in which future dealings affecting native title may proceed and to set standards for those dealings
>
> c) To establish a mechanism for determining claims to native title
>
> d) To provide for, or permit, the validation of past acts, and intermediate period acts, invalidated because of the existence of native title (Section 3 *Native Titles Act 1993* (Cwlth)).

The *Native Title Act 1993* applies to the management of the Ramsar site and the Marine National Parks within the site.

1.7.3 Victorian policy and legislation

Environment Protection Act 1970

The Act provides a regulatory framework for protection of environmental assets particularly water quality.

Wildlife Act 1975

The *Wildlife Act 1975* provides for the protection of native wildlife and habitat.

National Parks Act 1975

Thirteen marine national parks and eleven marine sanctuaries were created under the *National Parks (Marine National Parks and Marine Sanctuaries) Act 2002*, an amendment to the *National Parks Act 1975*. These parks and sanctuaries were created with the objective of protecting representative samples of Victoria's distinctive and diverse underwater environments. The Ramsar site includes three marine national parks created under this Act. They are Yaringa, French Island and Churchill Island Marine National Parks (Figure 1.2).

Environmental Effects Act 1978

Allows for the development of environmental effects statements in order to assess the potential impacts of proposed developments.

Crown Land (Reserves) Act 1978

Under this Act, land is reserved for a variety of public uses, managed either by the DSE or another land manager on their behalf as a Committee of Management.

Planning and Environment Act 1987

Establishes objectives for planning in Victoria and outlines the planning process and requirements for planning schemes. Of particular relevance, the Act provides for the assessment of proposals to disturb or remove native vegetation.

Flora and Fauna Guarantee (FFG) Act 1988

The *FFG Act 1988* is Victoria's key piece of legislation promoting the conservation of threatened species and communities and for the management of potentially threatening processes (DSE 2009a).

Catchment and Land Protection Act 1994

The Act provides an integrated catchment management framework and facilitates the wise management of land and water resources in a whole of catchment framework. Catchment management authorities (CMAs) are established under this Act to develop and implement a regional catchment strategy, which sets out how the catchments in a region are to be managed. It identifies objectives for the quality of the land and water resources of the catchments in the region and sets a program of measures to promote improved use of land and water resources and to treat land degradation.

Coastal Management Act 1995

The Victorian Coastal Strategy is developed under the Coastal Management Act 1995. This document provides a long-term vision for the planning, management and sustainable use of the Victorian coast (VCC 2008). The strategy facilitates the implementation of key provisions of the Act relating to the protection of Victoria's coastlines. Dredging within the site, for example, requires consent under the Act.

Fisheries Act 1995

The *Fisheries Act 1995* provides for the regulation, management, and conservation of fisheries and aquatic habitats, together with the reform of law relating to fisheries.

Heritage Act 1995

The *Heritage Act 1995* provides for the protection and conservation of places and objects of cultural heritage significance and the registration of such places and objects on the Victorian Heritage Register. The Act serves to protect all categories of historic cultural heritage relating to the non-Aboriginal settlement of Victoria, including historic buildings, shipwrecks and archaeological sites. It is an offence to excavate, damage or disturb relics and sites without a permit or unless consent has been issued under Section 129 of the Act.

Parks Victoria Act 1998

Enables Parks Victoria to provide, on behalf of the Secretary to DSE, management services for the parks (Parks Victoria 2007).

Aboriginal Heritage Act 2006

All Aboriginal places, objects and human remains are protected under the Victorian *Aboriginal Heritage Act 2006*. This Act replaces the former Victorian *Archaeological and Aboriginal Relics Preservation Act 1972* and Part IIA of the Federal *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (DPCD 2007).

Victorian Coastal Strategy 2008

The Victorian Coastal Strategy provides a long-term vision for the planning, management and sustainable use of the coast (VCC 2008). The strategy also identifies a number of actions required over a five year period in order to achieve the vision.

Victorian Biodiversity Strategy 1997

Victoria's Biodiversity Strategy provides guidance and fulfils commitments in the national Strategy for the Conservation of Biodiversity and requirements under the Victorian *FFG Act 1998*.

The Victorian River Health Strategy 2002

The Victorian River Health Strategy (VRHS) details the government's long-term direction for the management of Victoria's rivers (DNRE 2002a). The VRHS provides a clear vision and policy direction for the management of rivers in Victoria. The VRHS also provides a decision making framework for regional communities.

The VRHS is to be reviewed by the end of 2009 and will include rivers, estuaries, and wetlands.

Victoria's Native Vegetation Management: A Framework for Action 2002

Victoria's Native Vegetation Management: A Framework for Action (DNRE 2002) provides a strategy for the protection and enhancement of Victoria's native vegetation. The strategy endeavours to achieve a net gain in native vegetation across Victoria.

Port Phillip and Western Port Regional Catchment Strategy 2004–2009

The Port Phillip and Western Port Regional Catchment Strategy identifies catchment assets and how they are interrelated, as well as a number of objectives and goals for the catchment (PPWCMA 2004). Numerous actions are recommended for their use in a sustainable and integrated way.

Port Phillip and Westernport Regional River Health Strategy

Melbourne Water is the designated care taker of river health within the Port Phillip and Westernport region. The Port Phillip and Westernport Regional River Health Strategy outlines values, threats to waterway values, and actions required to address these threats in order to achieve the objectives for the catchment (Melbourne Water 2007).

Port Phillip and Western Port Native Vegetation Plan

The Native Vegetation Plan provides a framework for a coordinated and strategic approach to managing the region's native vegetation (PPWCMA 2006). Regional priorities, goals and targets are identified and guide the management of native vegetation within the area.

The Indigenous Partnership Framework 2007–2010

The DSE's Indigenous Partnership Framework is an over-arching Indigenous policy that provides direction for all departmental Indigenous partnering initiatives (DSE 2007). This forms the foundation upon which the department's business areas and activities align with their commitment to:

- work inclusively with Victoria's native title holders, traditional owners and Indigenous people in Victoria
- ensure Traditional Owners and Indigenous people in Victoria have a real say in the future management (DSE 2007) of Victoria's biodiversity, water and land (DSE 2007).

State Environment Protection Policy (Waters of Victoria), as varied Schedule F8 (Waters of Western Port and Catchment) No. S192, Gazette 2 November 2001

The uses and values of Western Port and its catchment were initially protected through the State Environment Protection Policy (SEPP) (Waters of Western Port Bay and Catchment) which was prepared in 1979. Subsequently, the activities and threats to Western Port and its catchment have altered and the SEPP was replaced (EPA 2001). The following factors contributed to the replacement of the 1979 SEPP (Waters of Western Port Bay and Catchment):

- seagrass loss between the early 1970s and 1983
- high turbidity and nutrient levels
- changes in sources of pollution
- improved community knowledge and understanding
- improved environment tools and approaches
- changes to institutional arrangements
- development of the SEPP (Waters of Victoria)
- improved scientific knowledge (EPA 2001).

The SEPP (Waters of Victoria) was prepared in 1988 and Schedule F8 Waters of Western Port and Catchment was inserted in 2001. The SEPP and Schedule F8 provide a framework to manage actions in order to protect beneficial uses within the Western Port region. The policy promotes integrated catchment and marine activities, and coordinated planning of land, water and waterway management (CCB 2003). The SEPP also defines beneficial uses to be protected in Western Port, management aspirations and environmental objectives (CCB 2003).

2 Critical components, processes, benefits and services

2.1 ESSENTIAL ELEMENTS

The following sections describe ecosystem components, processes, benefits and services that are considered when determining and maintaining the character of the Ramsar site. As defined by Muirhead (pers. comm. 2009), an essential element is a component or process that has an essential influence on the critical components, processes, benefits and services of the wetland. Cessation, reduction, or loss of an essential element would have a detrimental effect on one or more critical components, processes, benefits or services. Essential elements related to the character of the Western Port Ramsar site are considered in Table 2.1.

Table 2.1 Summary of essential elements of the Ramsar site in 1982

Element	Component/ process	Summary description	Summary of linkages with critical components or processes
Water quality	Process	Variable water quality throughout the site	Influenced by catchment inflows, tidal regime and water circulation Maintains suitable habitat for vegetation, particularly seagrass and mangroves Contributes to habitat availability for marine invertebrates, fish, and waterbirds
Tidal regime, hydrodynamics and catchment inflows	Process	Tides occur twice daily, with tidal range varying from 1.6 m at Flinders to about 2.2 m at Tooradin. Greater exchange at the western entrance results in a slow flushing time in the northern and eastern sections and clockwise water circulation 2.9 million ML at high tide 1100 ML of freshwater per day from catchment inflows	Influences sediment distribution and water quality Contributes to vegetation distribution by providing suitable sediments for colonisation Contributes to waterbird and fish habitat by inundating and exposing seagrass, mangrove and saltmarsh vegetation Contributes to diverse marine assemblages by providing suitable conditions, i.e. fast currents
Climate	Process	Mediterranean climate characterised by a dry and warm-to-hot summer and a wet winter-spring (LCC 1991, cited in Government of Victoria 2002). Highly variable locally.	Provides suitable habitat for vegetation growth, e.g. White Mangroves (*Avicennia marina* subsp. *australasica*) Contributes to catchment inflows and water quality Wind influences tidal regime and water circulation

2.1.1 Water quality

Process description and driving forces

Historically, water quality within Western Port has been monitored over two periods from 1973 to 1977 and from 1984 to present. As such, no water quality data is available for Western Port for the period 1977 to 1984, during which time the Ramsar site was listed (Longmore 1997). As no additional information is available, results from the analysis of the 1973 to 1977 bay-wide monitoring program are assumed to closely resemble the status of water quality within the Ramsar site at the time of listing. This assumption is based on the commencement of seagrass decline and associated water quality fluctuations in the early 1970s (Shepherd et al. 2009).

Longmore (1997) analysed the data from both Western Port monitoring programs. Data for a number of water quality parameters monitored at three sampling sites from 1973 to 1977 are provided in Table 2.2. These three sampling sites are situated within the boundaries of the Ramsar site and were monitored during both programs (1973 to 1977, and 1984 to 1997) (Figure 2.1).

Table 2.2 Water quality data for three fixed sites within the Ramsar site monitored in 1973 to 1977 (Source: adapted from Longmore 1997)

Variable	Site 709	Site 716	Site 724
	Mean	Mean	Mean
Salinity (ppt)	35.16	34.47	34.47
Ammonium (µmol)	0.65	0.62	1.00
Oxidised nitrogen (µmol)	0.12	0.10	0.19
Phosphate (µmol)	0.15	0.09	0.12
Total phosphorus (µmol)	0.39	0.35	0.51
Silicate (µmol)	2.14	3.10	11.43
Chlorophyll-a (µg L^{-1})	1.12	1.05	2.45
Dissolved oxygen (% saturation)	100.3	97.0	99.3
Variable	Median and range	Median and range	Median and range
PAR attenuation coefficient (k_d) (m^{-1})	No data	No data	No data
Total suspended solids (mg L^{-1})	No data	No data	No data
Chlorophyll-a (µg L^{-1})	1.14 (0.81–1.42)	0.96 (0.25–4.69)	2.41 (0.98–5.89)
Dissolved inorganic nitrogen (µmol)	0.88 (0.23–2.19)	0.88 (0.23–3.55)	1.43 (0.34–2.50)
Dissolved inorganic phosphorus (µmol)	0.14 (0.07–0.30)	0.09 (0.02–0.28)	0.11 (0.05–0.35)
Total kjeldahl nitrogen (µmol)	No data	No data	No data

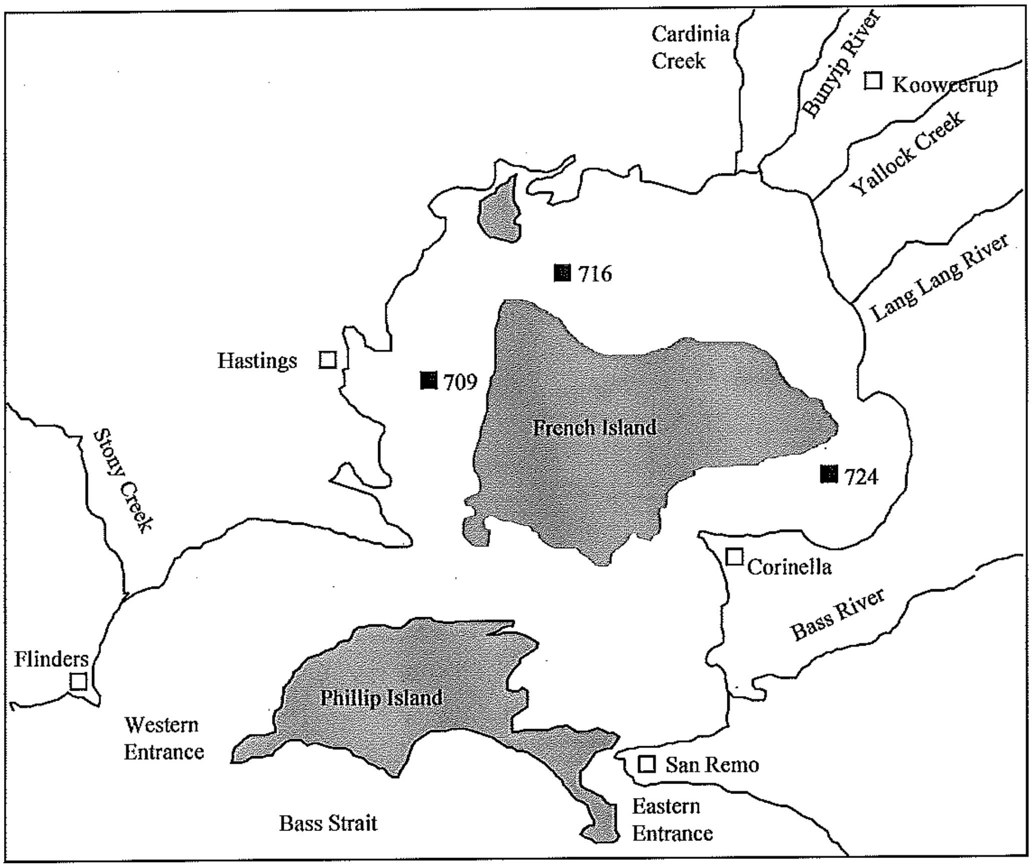

Figure 2.1
THREE WATER QUALITY SAMPLING SITES WITHIN THE RAMSAR SITE MONITORED DURING 1973 TO 1977 AND 1984 TO 1997
(Source: Longmore 1997)

Temporal and spatial variability in a number of water quality parameters within Western Port has been reported. Longmore (1997) stated that all variables monitored from 1973 to 1977 showed large tidal variation. Similarly, salinity and temperature are reported to have shown strong seasonal patterns. For example, in dry periods, the north and east of the Ramsar site exhibit the highest salinity while in spring when catchment inflows are strong, salinity is the lowest in the north-east and south-east (Longmore 1997). Higher salinity levels result from evaporation in summer while lower levels result from dilution by freshwater catchment inflows in spring.

Water quality within the Ramsar site is impacted by the surrounding catchment and is influenced by the tidal regime and a clockwise pattern of water circulation as illustrated by the conceptual model published by the Central Coastal Board (CCB) in 2003 (Figure 2.2). Western Port has a small surface area and two entrances. As such, the tides travel across the entire bay resulting in extensive flushing of the system (EPA undated). Water movement within the bay is complex with circulation of water in a clockwise direction (Longmore 1997). As such, the quality of water in the Corinella and Rhyll basins to the east is generally poor as a result of water circulation and tides.

In addition, catchment freshwater inflows influence water quality within the bay (Figure 2.2). Western Port receives an average of 1100 ML of freshwater per day from the 17 waterways that flow into the bay (Shapiro 1975). It should be noted that this represents less than 1 per cent of the total volume of water in Western Port at high tide

(CCB 2003). The Bunyip and Lang Lang Rivers, and Cardinia Creek to the north-east of the Ramsar site contribute approximately 75 per cent of total freshwater inflows into the bay (Shapiro 1975, Longmore 1997; EPA 2001). The Bass River to the south-east discharges 22 per cent, while Stony Creek to the south-west contributes only 3 per cent (Longmore 1997). Each of these watercourses, except for Stony Creek, discharge directly into the Ramsar site.

A number of the parameters identified in Table 2.2 are considered essential in sustaining the critical components which characterise the Ramsar site, particularly for their ability to support seagrass and mangrove vegetation that subsequently provides suitable habitat for marine invertebrates, fish and waterbirds. In addition, the critical parameters on which seagrass and mangrove survival depends resulted in the site satisfying Criteria 1(a) and 1(b) when it was listed in 1982.

Based on the data presented in Table 2.2, Longmore (1997) identified approximate minimum water quality conditions for seagrass survival using the following parameters. These are considered critical to the site's character for the reasons described above.

- PAR attenuation coefficient (k_d)
- Total suspended solids
- Chlorophyll-a
- Dissolved inorganic nitrogen
- Dissolved inorganic phosphorous

Additionally, salinity and dissolved oxygen are considered critical water quality parameters as a result of their influence on suitable habitat for seagrass and mangrove vegetation (Rogers 2005) as well as their importance in maintaining faunal values.

Linkages to critical components, processes, benefits and services

Seagrass within the Ramsar site is highly dependent on water quality as it requires light, nutrients and saline water to survive. Seagrass vegetation absorbs nutrients required for growth such as phosphate from the water column and sediments while giving off total organic carbon, dissolved organic carbon, phosphate and silicate (particularly in summer) (Longmore 1997). Historical seagrass loss in Western Port has been reported to be accompanied by significant water quality changes, including increases in oxidised nitrogen, phosphate and total phosphorus concentrations, and a decrease in dissolved oxygen (Longmore 1997; Shepherd 2009). In addition, poor water quality can threaten seagrass. Increased levels of turbidity and elevated levels of nutrients are of particular concern for seagrass growth and survival (Longmore 1997). These are discussed further in Section 4.

Mangrove vegetation is also highly dependent on water quality. Salinity levels and light availability are known to be factors that influence the distribution and health of mangroves (Rogers et al. 2005). This is discussed further in Sections 4 and 5.

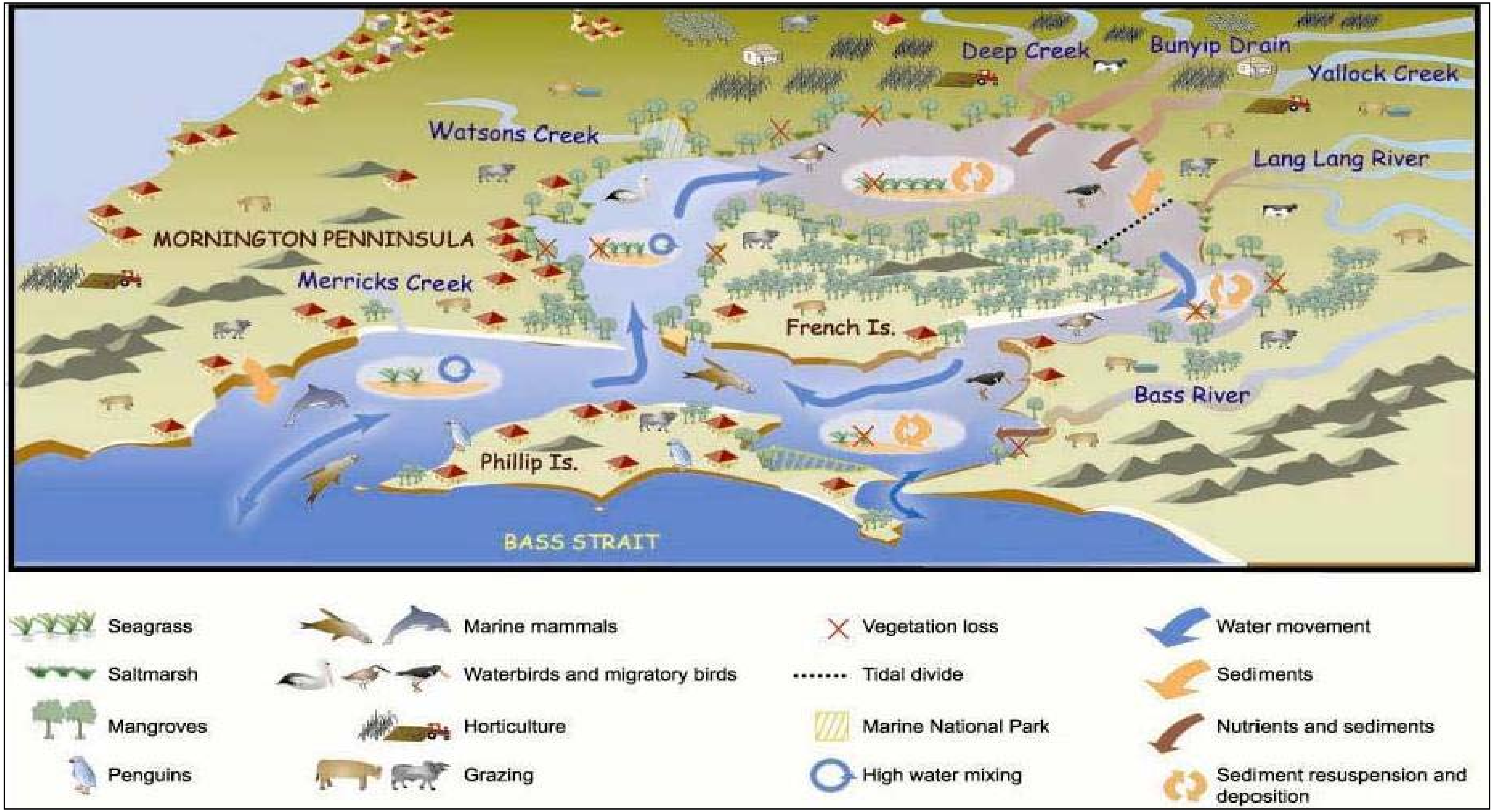

Figure 2.2 CONCEPTUAL MODEL ILLUSTRATING WATER QUALITY, CIRCULATION AND A RANGE OF THREATENING PROCESSES ACTING ON THE RAMSAR SITE (Source: CCB 2003)

2.1.2 Tidal regime, hydrodynamics and catchment inflows

Western Port is a large coastal bay (approximately 60 000 ha) with a coastline of approximately 260 km (Wallbrink and Hancock 2003a). The tidal regime of the Ramsar site is considered an essential element of critical components such as bathymetry, sediment transport and deposition, and habitat. In particular, the tidal regime experienced by the site directly results in the exposure of intertidal mudflats, a significant attraction for migratory waders for which the site satisfied criterion 3(b) at the time of listing and continues to satisfy current criterion 3 (Section 1.3.1). In addition, the tidal regime facilitates a number of benefits and services, including commercial shipping, recreational boating and passive recreation.

Hydrodynamics and catchment inflows are also considered essential elements of critical processes within the system due to the influence they have on bathymetry and sedimentation. In particular, catchment inflows and water circulation directly influence sediment input, resuspension and deposition. Significant negative consequences may result from changes to these processes.

Process description and driving forces

Tides occur twice daily within Western Port, the rise and fall resulting from gravitational interactions of the moon, sun and earth. Western Port has a tidal range that varies from about 1.6 m at Flinders, near the western entrance, to about 2.2 m at Tooradin to the north (WPRCC 1992). The average difference between high and low tide is between 2.5 m to 3 m. The IMCRA Technical Group (1998) reported maximum amplitude within Western Port of 3.1 m. The tidal regime in the Ramsar site is characterised by an unequal, semidiurnal pattern (Hinwood 1979, cited in Parks Victoria 2007). This means that the flooding and ebbing both have a higher and lower event every day.

At high tide, the total volume of water within the bay is 2.9 million ML (CCB 2003). Therefore, the tidal flux is significantly greater than the freshwater inflows received by Western Port which represents less than 1 per cent of the total volume of water at high tide (CCB 2003).

The pattern of water circulation within the bay is also a significant driving force behind the character of the Ramsar site. Water movement within the bay is complex with circulation of water in a clockwise direction (Shapiro 1975). Water movement within Western Port is known to be related to tidal currents around Philip Island and French Island (Shapiro 1975; CCB 2003). Due to the presence of a wider entrance in the west, there is greater water exchange between Western Port and Bass Strait from the western entrance (Shapiro 1975). This results in a slow flushing time in the northern and eastern parts of the site with sediment movement occurring frequently within major channels (Shapiro 1975). As a result of the clockwise direction of water circulation, much of the sediment delivered to the north-east section of the Ramsar site is transported into the Corinella and Rhyll basins where much of it is deposited (CCB 2003).

Catchment freshwater inflows are essential elements of critical processes which influence the character of the Ramsar site. Western Port receives an average of 1100 ML of freshwater per day from the 17 waterways that flow into the bay (Shapiro

1975). This equates to less than 1 per cent of the total volume of water in Western Port at high tide (CCB 2003). As previously noted, the major waterways draining the catchment are said to contribute approximately 75 per cent of the total freshwater inflows into the bay all of which drain directly into the Ramsar site (Dale and Pooley 1979, cited in EPA undated).

Linkages to critical components, processes, benefits and services

Tides are a significant process in Western Port and other marine environments for many reasons. These include:

- they are responsible for moving large amounts of sediment
- they influence the distribution and inundation of tidal flats.

The frequency of inundation of the wetland areas of the Ramsar site is primarily governed by the tides. Tidal influences are an essential process providing varied and critical habitat exhibited by the Ramsar site. Global warming and resultant sea level changes could impact on the frequency of inundation and area exposed that provides habitat for waterbirds. This is discussed further in Section 4.

Tidal influences are also the driving process behind providing feeding habitats for waterbirds in the Ramsar site by exposing intertidal mudflats and seagrass vegetation and contributing to the assemblages of marine invertebrates and fish present within each habitat. Loyn et al. (2001) describe the main feeding habitats used by waders in the site, which include: the mudflats and shallows of the tidal areas; seagrass; saltmarsh; and fresh water margins.

Similarly, the energy created by tidal movements is responsible for moving sediments which plays an important role in creating suitable habitats for vegetation growth such as seagrass which in turn contributes to habitat for waterbirds, fish species and marine invertebrates. Water movement associated with tidal flows, or waves generated by localised winds, also significantly affect sediment transport and water quality by resuspending fine sediments.

2.1.3 Climate

The climate of the Western Port Region is considered an essential element in maintaining the Ramsar site by contributing to the provision of suitable habitat for characteristic species, specifically White Mangrove. By providing suitable habitat for the species, which is close reaching its southern limit, the site directly satisfied Criteria 1(a) and 1(b) at the time of listing. Climate is also an essential element as wind modifies water movement and tidal amplitude which in turn influences sediment distribution, water quality, and habitat availability.

Process description and driving forces

Western Port experiences a Mediterranean climate characterised by a dry and warm-to-hot summer and a wet winter-spring (LCC 1991, cited in Government of Victoria 2002). Shapiro (1975) identified that the mean maximum temperatures within the region ranges from 13ºC (July) and 25ºC (February) with mean minimum temperatures ranging between 7ºC (July) and 14ºC (February). Winds occur predominately from the south during October to March and from the north-west during April to September (Shapiro 1975).

Table 2.3 illustrates the climate experienced by the Port Phillip and Western Port region from 1961 to 1990. This broadly characterises the climate of the Ramsar site prior to and at the time of listing.

Table 2.3 Seasonal and annual average temperatures and rainfall in the Port Phillip and Western Port region (1961 to 1990) (Source: DSE 2008)

	Average daily temperature (ºC)	Average daily maximum temperature (ºC)	Average daily minimum temperature (ºC)	Average rainfall (mm)
Annual	13.5	18.7	8.3	864
Spring	12.9	18.1	7.6	239
Summer	18.3	24.7	12	166
Autumn	14.2	19.3	9.2	213
Winter	8.6	12.6	4.6	245

Linkages to critical components, processes, benefits and services

Climate is linked to all critical ecosystem components and processes within the Ramsar site. Climate, in conjunction with the bathymetry and tidal regime experienced by the site, contributes to the presence of each of the biological, chemical and physical components and processes discussed (Figure 2.3). Specifically, the climate experienced by the Western Port region contributes to the existence of White Mangrove at the Ramsar site where the species is close to reaching its southern limit. Colder air temperatures and frosts result in slower growth rates in the species (Rogers et al. 2005).

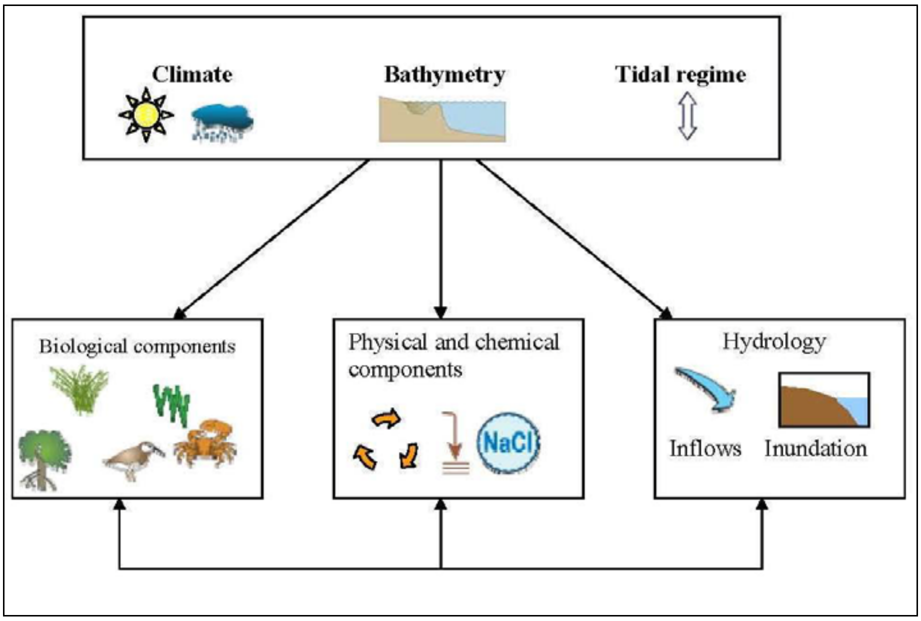

Figure 2.3
FLOW CHART SHOWING THE INTERACTION OF CLIMATE WITH CRITICAL COMPONENTS AND PROCESSES WITHIN THE RAMSAR SITE

2.2 CRITICAL ECOSYSTEM ELEMENTS

Specific elements have been identified as critical when determining and maintaining the character of the Ramsar site in accordance with the following recommendations:

- They are important determinants of the site's unique character
- They are important for supporting the Ramsar or Directory of Important Wetlands in Australia (DIWA) criteria under which the site was listed
- Change to which is reasonably likely to occur over short or medium time scales
- They will cause significant negative consequences if change occurs (DEWHA 2008).

A quantitative description of the ecosystem element and driving forces behind each is provided for the time of listing of the Ramsar site where possible. Following this, links to other ecosystem elements and how they are considered to comply with these recommendations are identified. Where quantitative information is not available for 1982, this has been explicitly stated.

2.3 ECOSYSTEM COMPONENTS AND PROCESSES

As defined by DEWHA (2008), ecosystem components are physical, chemical and biological parts of a wetland and can include large to very small-scale components. However, ecosystem processes are defined as the dynamic forces that occur within an ecosystem (DEWHA 2008). Given the high degree of interaction and dependency between ecosystem components and processes, they have been grouped into a single section for the purposes of this description.

Table 2.4 summarises the critical ecosystem components and processes identified for the Ramsar site.

Table 2.4 Summary of critical ecosystem elements of the Ramsar site in 1982

Element	Component/ process	Summary description	Summary of linkages with other components or processes
Wetland bathymetry	Component	Deepwater coastal inlet Extensive intertidal mudflats (270 km^2) intersected by deep channels	Contributes to the presence of eight distinct marine habitats (particularly intertidal mudflats) Array of marine habitats support diverse wetland vegetation, marine invertebrates, fish and waterbirds
Geomorphology and sedimentation	Process	Total sediment load in 1982 was estimated at 40 000 t/a. However, estimates of sediment input loads following European settlement have ranged from 40 000 to 100 000 t/a Coarse and medium sand was concentrated towards the western entrance, encircled French Island and along inshore areas and channel margin banks Depositional fans were reported near the mouths of river inlets while finer sediments were deposited on intertidal areas	Tidal regime and water circulation result in resuspension and redistribution of sediment Resuspension of sediments influences water quality by causing continual turbidity Seagrass, mangroves and saltmarsh are colonisers of mud, silt and sand and are dependent on sediment distribution
Flora—seagrass	Component	72 km^2 of seagrass and macroalgae in Western Port in 1983	Highly productive and important in energy transfer within the ecosystem, nutrient cycling and stabilising sediment Important habitat for invertebrates, fish and waterbirds
Flora—mangrove and saltmarsh	Component	31 000 ha of saltmarsh vegetation in 1984 13 700 ha of mangrove vegetation in 1984 Near continuous coverage along the western and northern shoreline, and along the northern shoreline of French Island. Scattered vegetation along the eastern shoreline	Important habitat for migratory waterbirds and nursery habitat for fish and invertebrates Stabilises and accumulates sediment, important in erosion protection, nutrient cycling, filters pollutants
Flora—significant species	Component	The site supports a number of species of Victorian conservation significance considered critical in maintaining its character. White mangroves are listed as rare within Victoria and are characteristic of the mangrove fringe within the site Creeping Rush (*Juncus revolutus*), Marsh Saltbush (*Atriplex paludosa* subsp. *paludosa*), and Salt Lawrencia (*Lawrencia spictata*) which are characteristic species of saltmarsh vegetation	As above for mangrove and saltmarsh vegetation

Table 2.4 Continued

Element	Component/ process	Summary description	Summary of linkages with other components or processes
Fauna—waterbirds	Component	115 waterbird species considered critical to the site's character have been recorded within the Ramsar site Total numbers of waders and other non-pelagic waterbirds have exceeded 20 000 in all years of the BOCA survey. Typically these include 10 000 to 15 000 waders, 5000 to 10 000 swans and a few thousand ducks, gulls and other species. Nine wader species breed locally in or near the Ramsar site The Ramsar site regularly supports more than 1 per cent of the estimated flyway population of five wader species and three other non-pelagic waterbird species The site also supports a number of seabirds, most of which use the site opportunistically. Small numbers of Little Penguins (*Eudyptula minor*) and Short-tailed Shearwaters (*Puffinus tenuirostris*) nest within the Ramsar site on Barralliar Island and Tortoise Head, respectively. Thousands of Short-tailed Shearwaters gather in the Ramsar site in autumn before embarking on their annual pan-Pacific migration: estimates of up to 250 000 birds have been made (Loyn 1978). Waterbirds considered critical to the site's character protected by bilateral agreements: 36 species listed under CAMBA, 38 species listed under JAMBA and 34 species listed under ROKAMBA	Extensive tidal mudflats are of significant value to waterbirds, particularly wader species. Bathymetry tidal regime provide important food resources for wader species by exposing mudflats Peripheral habitats, including mangroves provide breeding, roosting, drinking or high tide feeding areas Seagrass is a main source of primary production within the ecosystem
Fauna—marine invertebrates	Component	In 1974, surveys of Western Port benthos reported 19 853 individuals recorded from 14 phyla	Marine habitats support diverse assemblages of marine invertebrates Important food source for fish and waterbirds Important in energy transfers to higher trophic levels
Fauna—fish	Component	Diverse assemblages, including commercially significant species	Important food source for waterbirds and marine mammals Seagrass beds and mangroves provide important nurseries for a number of species Supports commercial and recreational fishing Important in transferring energy
Fauna—significant species	Component	18 *EPBC Act 1999-listed* species have been observed within the Ramsar site	Saltmarsh vegetation provides important overwintering habitat for the Orange-bellied Parrot (*Neophema chrysogaster*)

2.3.1 Wetland bathymetry

The bathymetry of Western Port is a significant driving force behind the character of the Ramsar site contributing to, and determining, a number of other components, processes, benefits and services.

Component description and driving forces

Western Port is described as a deepwater coastal inlet and is characterised by deep channels, banks and large intertidal zones (Longmore 1997; EPA 1996). The Ramsar site comprises extensive areas of intertidal mudflats (approximately 270 km^2) intersected by deep channels greater than 15 m in depth. Towards the north of the Ramsar site, channels can be deeper than 20 m or 30 m in some places such as near Crawfish Rock and offshore from Seal Rocks (EPA 1996).

Figure 2.4 provides a graphical representation of the bathymetry of Western Port.

Shapiro (1975) indentified discrete morphological units within Western Port, some of which have been classified according to the vegetation types they support (Figure 2.5). These are considered to closely represent the morphological character of the Ramsar site when it was listed in 1982. They include:

- beaches, cliffs and rock platforms and the saltmarsh zone situated above the high tide mark. The saltmarsh zone is periodically fully inundated
- mangrove zone that is situated at and below the high tide mark
- inshore marginal sandy zone that slopes gently outwards, often to tidal flats
- intertidal flats and banks, that cover an extensive proportion of the site, usually have a seaward margin that descends steeply into deep channels
- subtidal offshore banks and shoals
- permanently submerged embayment plains that are characterised by irregular relief that descend deeply into tidal channels
- tidal channel system comprising the dendritic channels to the north of the Ramsar site, the main trunk systems in the north and the east arm, and a limited system of channels in the eastern entrance (Shapiro 1975).

No additional quantitative information on the bathymetry of the Ramsar site at the time of listing has been accessible during the preparation of this description. It is considered likely that detailed bathymetry mapping or nautical charts are available for Western Port and are specifically designed to meet the requirements of marine navigation, showing depths of water, nature of the bottom, configuration and characteristics of the coast, dangers to vessels and aids to navigation. These maps have not accessed during the preparation of this description and are considered to be of limited ecological use.

Linkages to other components, processes, benefits and services

The bathymetry of the Ramsar site contributes to the presence of eight distinct marine habitats that are critical components of the site's character and its Ramsar listing. These habitats are defined primarily by tidal level, substrate type, geology and geomorphology, exposure to wave energy, and dominant flora, all of which interact with bathymetry. The habitats are:

- intertidal rocky shores
- subtidal rocky reefs
- seagrass beds
- sheltered tidal flats
- mangroves
- intertidal sandy beaches
- subtidal soft substrates
- pelagic (open water) environments.

Bay wide marine habitat mapping within the Ramsar site at the time of listing is believed not to exist.

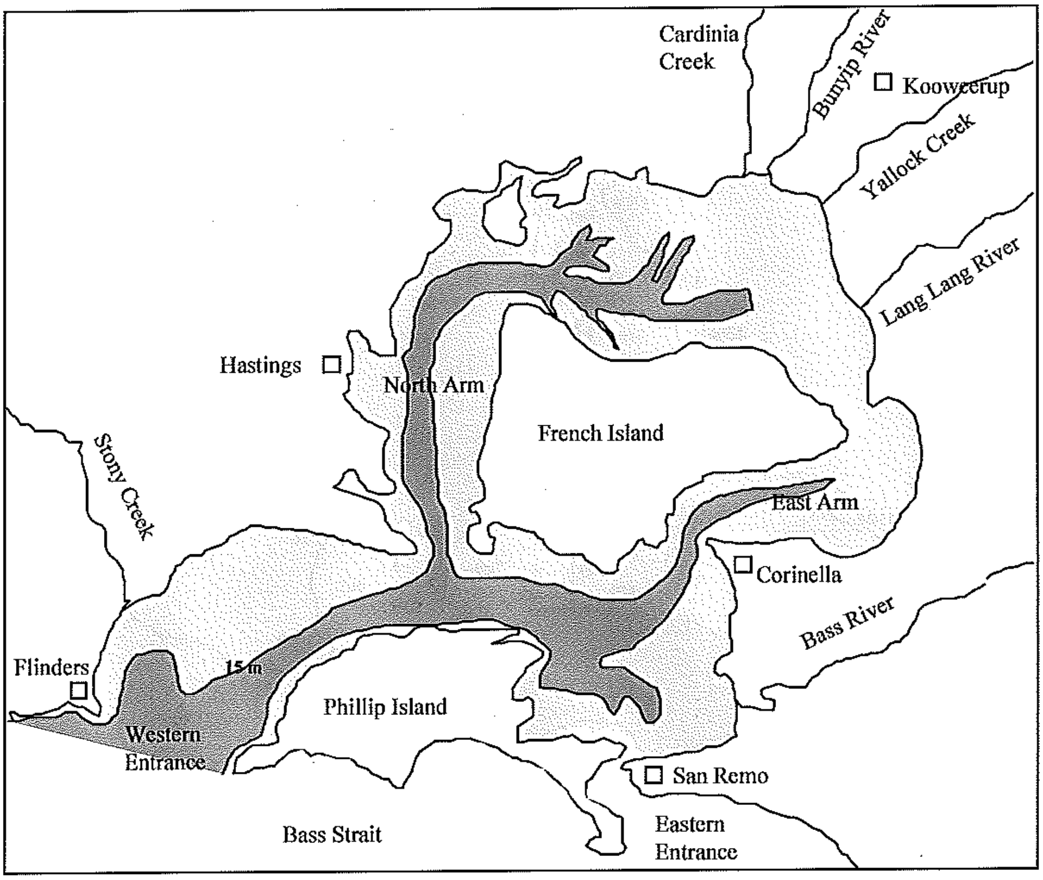

Figure 2.4
WESTERN PORT IDENTIFYING FEATURES. WATERS GREATER THAN 15 m DEEP ARE SHADED DARK; THOSE LESS THAN 15 M DEEP ARE SHADED LIGHTLY (Source: Longmore 1997)

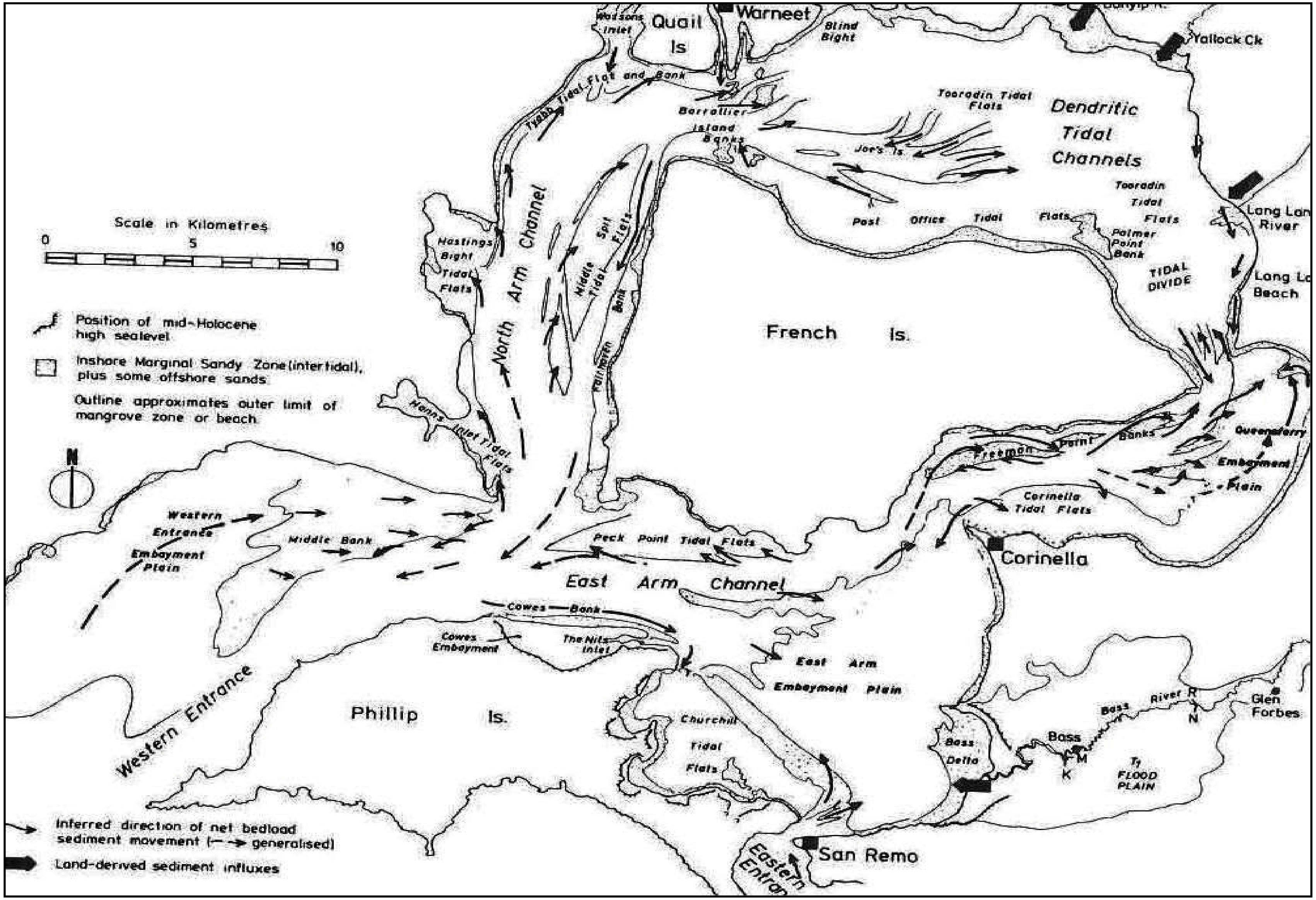

Figure 2.5
MAJOR MORPHOLOGICAL FEATURES OF WESTERN PORT
(Source: Shapiro 1975)

At low tide, approximately 40 per cert (or 270 km^2) of Western Port consists of exposed mudflats, all of which is situated within the Ramsar boundary (CCB 2003; Parks Victoria 2007b). The mudflats represent an important and defining habitat within the Ramsar site. The mudflats support seagrass and macro-algae, a number of molluscs and crustaceans, including crabs and ghost shrimp, which provide important food sources (Parks Victoria 2007). When inundated, the mudflats provide feeding areas for a number of fish species, including flounder, stingrays, flathead and mullet (Parks Victoria 2007).

The bathymetry of the bay also contributes to the deposition of subtidal soft sediments in deep channels within the Ramsar site. Subtidal soft sediments provide diverse and nutrient-rich habitats that are characteristic of the Ramsar site. These habitats arise from a coarser sand substrate settling in deep channels rather than the fine muddy substrate that characterises the intertidal mudflats (Parks Victoria 2007). Strong currents sort the sediment and give rise to these important habitat types. Deep channels, including the subtidal soft sediments, provide habitat for a variety of organisms, including invertebrates (such as crustaceans, bivalves, and gastropods) and fish (such as stingrays, Gurnard Perch (*Neosebastes scorpaenoides*), and Sand Flathead (*Platycephalus bassiensus*) (Parks Victoria 2007).

Bathymetry also contributes to a number of feeding and roosting habitats for waterbirds, the component for which three out of four Ramsar criteria were satisfied in 1982 (Table 1.3). Loyn et al. (2001) describe the main roosting habitats used by waders in and around Western Port. These include: raised spits and islets; rocks; saltmarsh; beaches; freshwater margins; rocky islets; mangrove banks; wooden structures; and vegetated rocky mounds. Similarly, Loyn et al. (2001) describe the main feeding habitats used by waders in the bay. These include: the mudflats and shallows of the tidal areas; seagrass; saltmarsh; and freshwater margins, all of which interact with bathymetry.

Wetland bathymetry is also a significant determinant of the distribution and composition of vegetation, in particular seagrass, mangroves and saltmarsh vegetation, the component for which Ramsar Criteria 1(a) and 1(b) were satisfied in 1982 (Table 1.3). Bathymetry determines the potential depth and duration of inundation of wetland areas which plays a critical role in determining the distribution of particular vegetation communities. For example, seagrass meadows are often found in water depths of 2–12 m, where sunlight intensity is sufficient to maintain growth (Lloyd 1997). However, the depth of seagrass growth can be highly variable and depends on local water quality conditions.

In addition, the Ramsar site provides habitat for a wide range of significant species that are critical in maintaining its unique character with varying habitat requirements, including; White Mangrove (*Avicennia marina* subsp. *australasica*), a number of species of Victorian conservation significance that contribute to the saltmarsh vegetation, and a number of nationally and regionally listed waterbird species. These are discussed in Sections 2.2.6 and 2.2.7. These threatened species contributed to the Ramsar site being listed in 1982 by satisfying the criteria outlined in Table 1.3. Wetland bathymetry is highly influential over available habitat by determining the potential depth and period of inundation. Wetland bathymetry ultimately influences habitat availability by determining vegetation distribution and composition, areas of open water, mudflats, etc.

2.3.2 Geomorphology and sedimentation

Turbidity and sedimentation within Western Port have been a focus for study since the 1970s. This has resulted predominately from the negative relationship between increasing turbidity and sediment loads, and seagrass loss. The detrimental impacts of sediment input on the Ramsar site are discussed below in Section 4.

Process description and driving forces

Several investigations into the supply and distribution of sediment in Western Port have been undertaken (Wallbrink and Hancock 2003a; Wallbrink et al. 2003b; Hughes et al. 2003; EPA undated). It has been reported that the main sources of sediment to Western Port are from catchment sources, including stream bank and catchment erosion as well as coastal erosion of the shoreline (Wallbrink and Hancock 2003a; refer to Figure 2.5). In particular, channel and gully erosion of the Bunyip and Lang Lang River systems are the dominant sources of fine sediment to Western Port (Wallbrink and Hancock 2003a). Dredging, which has occurred in the bay since 1921, provides an additional source of sediment (Wallbrink and Hancock 2003a). The primary reasons behind dredging were to excavate new shipping channels and swing basins and, following this, to maintain them (Wallbrink and Hancock 2003a).

The Ramsar site is highly connected and influenced by the catchment. Major streams draining into the Ramsar site, including the Bunyip, Bass and Lang Lang Rivers, deliver a significant load of sediment from the catchment to the bay (CCB 2003; EPA undated). The literature reports a number of estimates for historic annual total sediment loads to Western Port.

Hancock et al. (2001, cited in EPA undated) estimated the pre-European sediment loads entering Western Port to have been approximately 24 000 t/a (on average).

Sargeant (1977, cited in Wallbrink and Hancock 2003a) reported an annual sediment load of 99 200 m^3 from 1888 to 1976. This estimate would incorporate sediment delivery associated with substantial modification resulting from European settlement and therefore cannot be used to accurately describe the ecological character of the Ramsar site at the time of listing.

An estimated annual total sediment load from all catchment rivers to Western Port from 1973 to 1976 of 56 000 t/a was also reported by Sargeant (1977, cited in Wallbrink and Hancock 2003a). This provides an estimate of total sediment load to Western Port prior to listing in 1982.

Similarly, an assessment undertaken in 1996 analysed data collected from 1973 to 1985 and provided an estimate of a mean input load of 40 000 t/a (Wallbrink and Hancock 2003a).

Estimates of sediment input loads following European settlement have therefore varied between approximately 40 000 and 100 000 t/a. This may reflect variability resulting from human activities, natural fluctuations or methods used in calculating input loads. However, this range of sediment input loads can therefore be used in describing the ecological character of the site.

Figure 2.6 provides a detailed account of sediments within Western Port during 1970 to 1975. This figure therefore details the sediment distribution within the bay prior to listing as a Ramsar site in 1982. No additional graphical representations of sediment distribution within the Ramsar site from the 1980s have been accessible in preparing this description. No significant events are known to have occurred after 1975 or prior to 1982; therefore this is considered representative of conditions within the site at the time of listing.

In 1975, coarse and medium sand was concentrated mainly towards the western entrance of Western Port, encircling French Island and along inshore areas and channel margin banks (Wallbrink and Hancock 2003a). The distribution of these coarser materials corresponds with the bathymetry of the embayment with deposition occurring largely in deeper channels. The distribution and materials present in these areas also corresponds with high energy of water movement (Harris et al. 1979, cited in Wallbrink and Hancock 2003a).

Depositional fans, associated with freshwater catchment inflows, were reported near the mouths of river inlets (Wallbrink and Hancock 2003a).

Deposition of finer sediments (including fine sand to silt, and clay) is associated with intertidal zones and closely corresponds to those areas mapped as exposed at low tide (Parks Victoria 2007b). It has been reported throughout the literature that seagrass beds and mangroves are highly influential over the deposition of finer sediments, including clay by trapping and binding sediments. The distribution of seagrass in 1983 closely matches the distribution of finer sediments, particularly clay, in 1975 (Section 2.2.6).

Sediments deposited within Western Port are subject to suspension and dispersal by the tides, waves and wind. This results in persistently high turbidities from daily resuspension (Wallbrink et al. 2003a). Sediments within the Ramsar site are transported in a clockwise direction around the embayment as a result of the complex pattern of water circulation. Wallbrink et al. (2003a) report that:

> Sediment delivered to the northern region has the ability to affect water quality and seagrass habitat of eastern and southern regions by the creation of a zone of turbid water during transport and by increasing the extent of mud deposition in the Corinella and Rhyll segments (Figure 2.7).

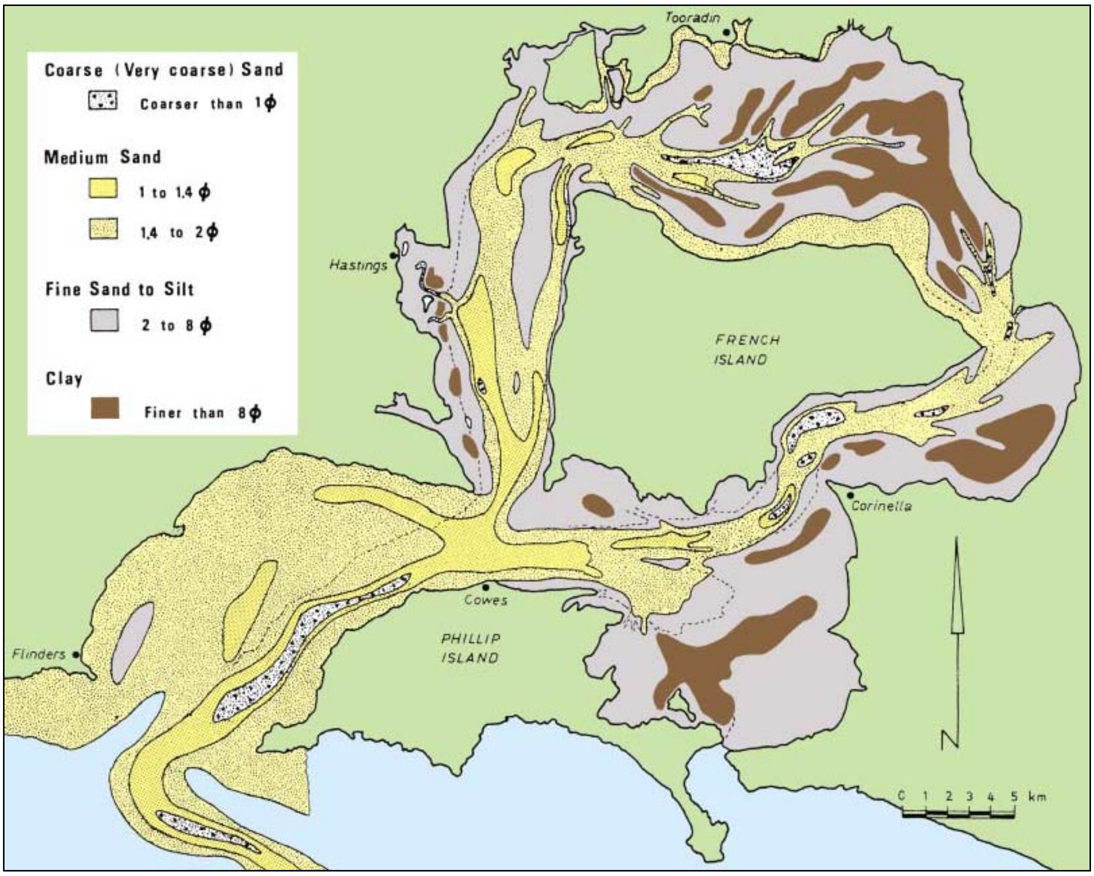

Figure 2.6
DISTRIBUTION OF SEDIMENTS IN WESTERN PORT
(Source: Marsden et al. 1979, cited in Wallbrink and Hancock 2003a)

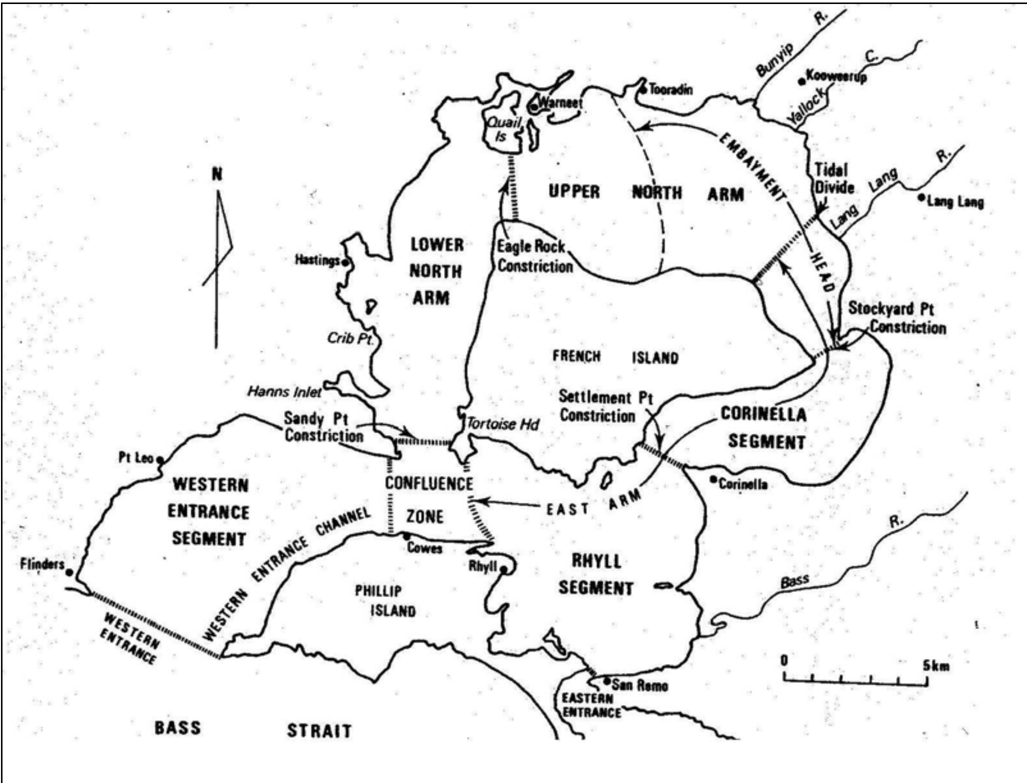

Figure 2.7
NOMENCLATURE FOR DIFFERENT SEGMENTS OF WESTERN PORT
(Source: Marsden et al. 1979, cited in Wallbrink et al. 2003a)

Linkages to other components, processes, benefits and services

Seagrasses and mangroves are colonisers of mud, silt and sand, using their extensive rhizome systems to anchor them and consequently stabilising the sediments (Blake and Ball 2001). As such, these vegetation communities are highly dependent upon available substrate. Tidal influences, wind and waves cause the movement of deposited mud and sands, therefore greatly influencing the distribution of vegetation (Wallbrink et al. 2003a).

Sediments delivered to the Ramsar site from the catchment can also have a negative impact on seagrass habitat, mangroves and other flora by generating persistent turbidity, and by the rapid accumulation and deposition of fine sediment. High turbidity can restrict the growth and production of seagrass. Similarly, excessive deposition of sediment can smother vegetation. Turbidity is also generated by re-suspension of sediments, can be exacerbated by the decline of the seagrass beds, and may hamper seagrass recolonisation (Wallbrink et al. 2003a).

The redistribution and deposition of sediments characterises habitat availability within the Ramsar site and influences bathymetry. Although the intertidal areas and deep channels are characterised by the size of sediments delivered to them, excessive deposition can result in negative changes to these habitat types such as a loss in seagrass. Sediment deposition in certain areas can also alter bathymetry such as in the Rhyll and Corinella segments where deposition is common.

In addition, there are several geological/geomorphological sites of international, national, state, regional and local significance within the Ramsar site that contribute to the site's significance. Those of international and national significance are provided in Table 2.5.

Table 2.5 Sites of international and national geological/geomorphological significance within the Ramsar site (Source: Parks Victoria 1999)

Name	Significance	Description
Pioneer Bay—quaternary stratigraphy	International	The best documented and dated site in the region to contribute to an understanding of late Quaternary sea level changes.
Western Port—tidal watershed	International	One of the most intensely investigated tidal watershed systems on the Australian coast. The dynamics of the area are critical in determining the nature of tidal flow in other parts of the bay. Sediments in this area provide important data on the development of on-shore swamplands and late Quaternary sea level changes.
Bass River Delta and floodplain	National	Provides the largest natural influx of sediment and is one of the most closely investigated quaternary sedimentological and geomorphological sites in Western Port. Displays considerable complexity and provides opportunities for research into deltaic and intertidal dynamics.
Yallock Creek—swamp sediments	National	One of few remnants of the great swamp areas that existed to the north east of the Ramsar site. Demonstrates the hydrological and topographical distinctiveness of the area between the Tobin Yallock and Koo-Wee-Rup swamps. Outcrops in coastal cliffs display the phases of wetland sediment accumulation.
Lyall Inlet to Bunyip River—coastline	National	Exhibits the impact of draining the Koo-Wee-Rup Swamp on the adjacent coast. The site can also be used as a reference point for measuring the rates and nature of coastal change. Also, the low cliff between the saltmarsh and the fluvial and swamp deposits is important in determining the Holocene sea level history of the region.

2.3.3 Flora

The Ramsar site exhibits a variety of habitat types that give rise to many different types of vegetation. Each marine habitat is colonised by characteristic flora, with seagrass, saltmarsh, and mangrove vegetation critical in maintaining the character of the site (ARI 2000, DSE 2003).

The extensive seagrass, saltmarsh and mangrove vegetation within Western Port in 1982 directly satisfied Ramsar Criterion 1, therefore contributing to the listing of the site. Similarly, the interactions between these communities and waterbirds also contributed to the site being listed in 1982. These vegetation communities provide an important source of primary production and are essential elements of the character of the Ramsar site (Parks Victoria 2007). They provide important habitats for fish species which in turn supports recreational and commercial fishing. As such, these vegetation communities are considered critical components of the ecological character of the site.

Seagrass

Component description and driving forces

A seagrass mapping study of Western Port was undertaken in 2001 in response to understanding the importance of seagrass to the ecology of the bay, and recognition that the seagrass areas have changed over time. The investigation mapped the distribution of the different seagrass species in Western Port and compared the distribution at 1998 to 2000 with that observed over the previous 30 years (DSE 2009b). This mapping project has provided ecological information towards an improved understanding of seagrass distribution and diversity as well as baseline data for future environmental monitoring. The results of this study will help to determine a change in ecological character in the future.

Seagrass occurs on the intertidal mudflats of the Ramsar site and is typically found in water depths of 2–12 m (Lloyd 1997; Parks Victoria 2007). Figure 2.8 provides a simple conceptual model of the vegetation profile within the Ramsar site. Four species of seagrass have been found in the Ramsar site, including *Zostera muelleri*, *Heterozostera tasmanica*, *Halophila australis* and *Amphibolis antarctica* (Blake and Ball 2001).

The importance of seagrass beds within Ramsar site has been recognised for many years, as has the changed extent. The distribution of seagrass within Western Port in 1983/84 closely represents its distribution at the time of listing in 1982. Blake and Ball (2001) report that:

> Previous seagrass mapping studies in Western Port identified a marked decrease in seagrass and macroalgae cover between 1973/74 and 1983/84. Over this 10 year period approximately 70 per cent of the total area of seagrass and macroalgae was lost in Western Port (Table 2.6). However, the comparison of seagrass areas between different years needs to be made with some caution as each study has employed different mapping techniques and field verification methods.
>
> A qualitative assessment of historic photography from the years 1956 to 1999 was conducted at four sites around Western Port to identify patterns of seagrass change during this period. The historical aerial photography showed a pattern of seagrass decline in Western Port commencing in the late 1970s and continuing through the 1980s, followed by a recovery of seagrass areas in the late 1990s. For each site the greatest area of seagrass cover could be observed either in 1974 or earlier and the lowest area of seagrass cover could be observed between 1985–90. This pattern was consistent with the observations of seagrass studies undertaken in Western Port during this period.

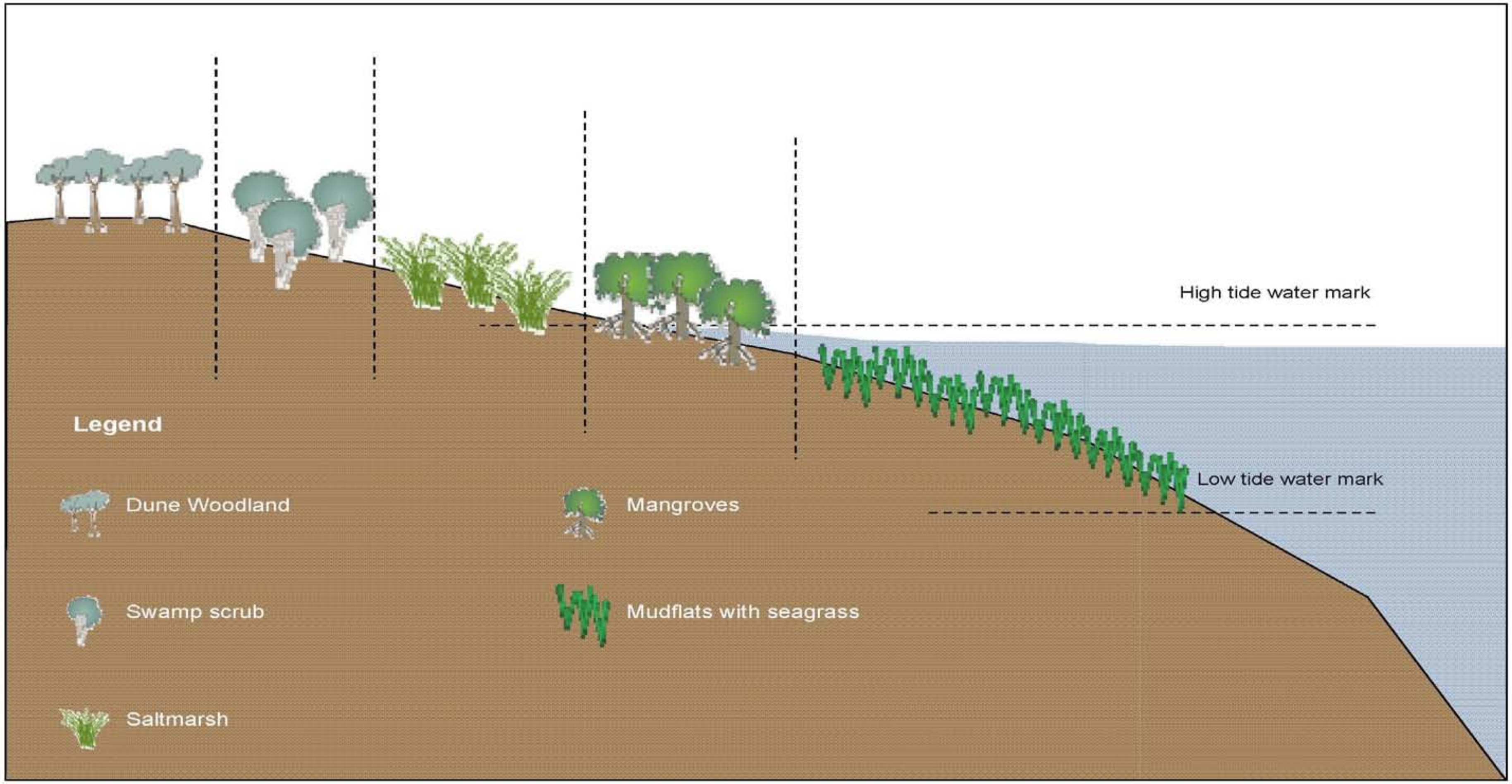

Figure 2.8
SIMPLE CONCEPTUAL MODEL OF THE VEGETATION PROFILE IN THE RAMSAR SITE (Source: adapted from EPA 1996; www.ozcoasts.org.au)

Table 2.6 Changes in the area of seagrass and macroalgae in Western Port over time (Source: adapted from Blake and Ball 2001)

	1973/74* (km^2)	1983/84† (km^2)	1994†† (km^2)	1999§ (km^2)
Total area of seagrass and macroalgae, including the western entrance	251	72	113	154.5

* *Bulthuis 1981*

† *Bulthuis 1984*

†† *Stephens 1995*

§ *Marine and Freshwater Research Institute (MAFRI) 1999 (Blake and Ball 2001).*

Detailed mapping of seagrass cover exists for Western Port prior to and following listing as a Ramsar site in 1982 (Blake and Ball 2001). This mapping and the quantitative information provided in Table 2.5 enables assessment of change in seagrass cover within the Ramsar site.

Seagrass distribution in 1983 was greatly reduced from the early 1970s coverage of approximately 250 km^2. Figure 2.9 illustrates the distribution of seagrass following the site's listing in 1982, presented as dark grey shading. This figure shows that seagrass loss between 1970 and 1983 occurred predominantly from intertidal areas with small patches remaining in the northern arm, and almost continuous cover remaining along the shorelines of the western entrance, upper north arm, and Rhyll segments. High turbidity and sedimentation levels, and blooms of epiphytic algae are considered to have been significant driving forces behind the loss of seagrass within Western Port (Parks Victoria 2007).

A discussion on the variation in seagrass distribution since the time of listing is provided in Section 5 (Figures 5.2 and 5.3).

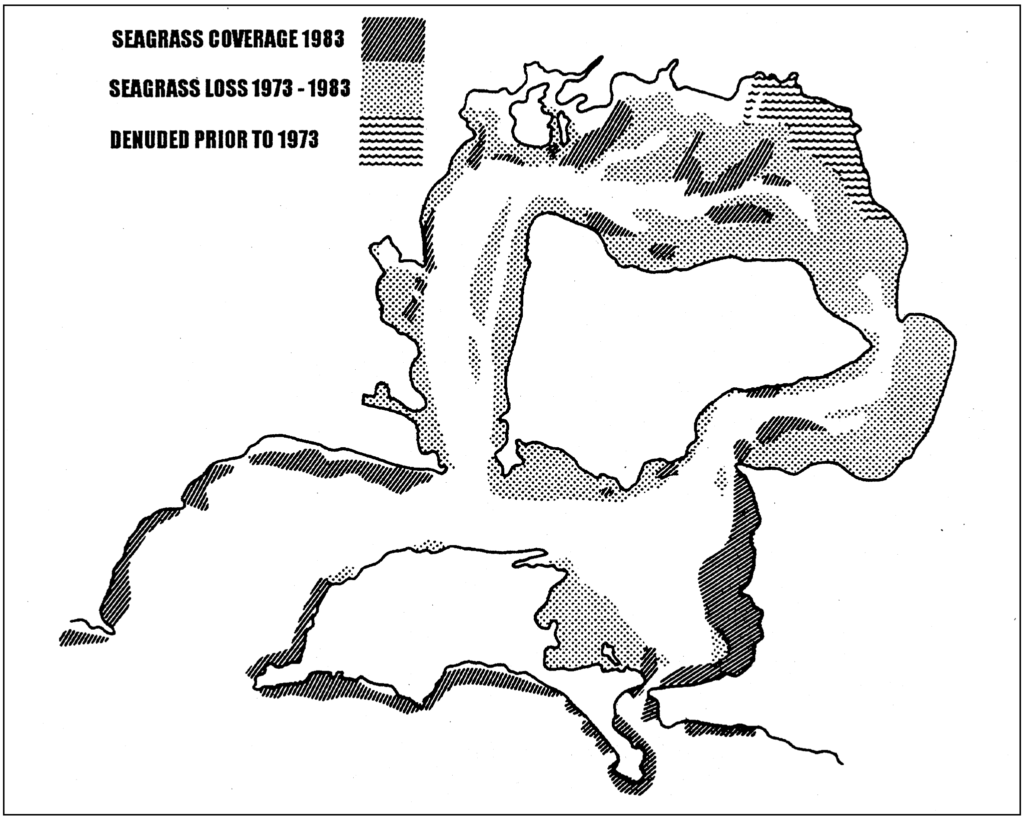

Figure 2.9
SEAGRASS DISTRIBUTION IN WESTERN PORT IN 1983 AND PRIOR TO 1983
(Source: Blake and Ball 2001)

Linkages to other components, processes, benefits and services

Seagrass is an ecologically significant habitat as it is highly productive and provides food and shelter for a wide variety of organisms. Seagrass beds are known to provide important habitat for grazing invertebrates, including molluscs, crustaceans, polychaetes and crabs. In addition, they are significant nursery habitats for many fish species, including Smooth Toadfish, pipefish, Yellow-eye Mullet, leatherjackets, King George and Blue Rock Whiting, and Rock Flathead (Parks Victoria 2007). In turn, seagrass beds foster commercial and recreational fishing.

Seagrass beds also provide a number of services. Seagrass is thought to be a driver behind many processes that give rise to maintaining waterbirds and suitable habitat. Figure 2.10 provides an intertidal food chain created for BOCA (2003). This figure demonstrates that seagrass either directly or indirectly supports waterbirds in the Ramsar site. Seagrass also stabilises sediment and removes dissolved nutrients from the water, a critically important ecosystem service (Parks Victoria 2007).

Figure 2.11 provides a simple conceptual model illustrating the habitat and services provided by seagrass vegetation within the Ramsar site.

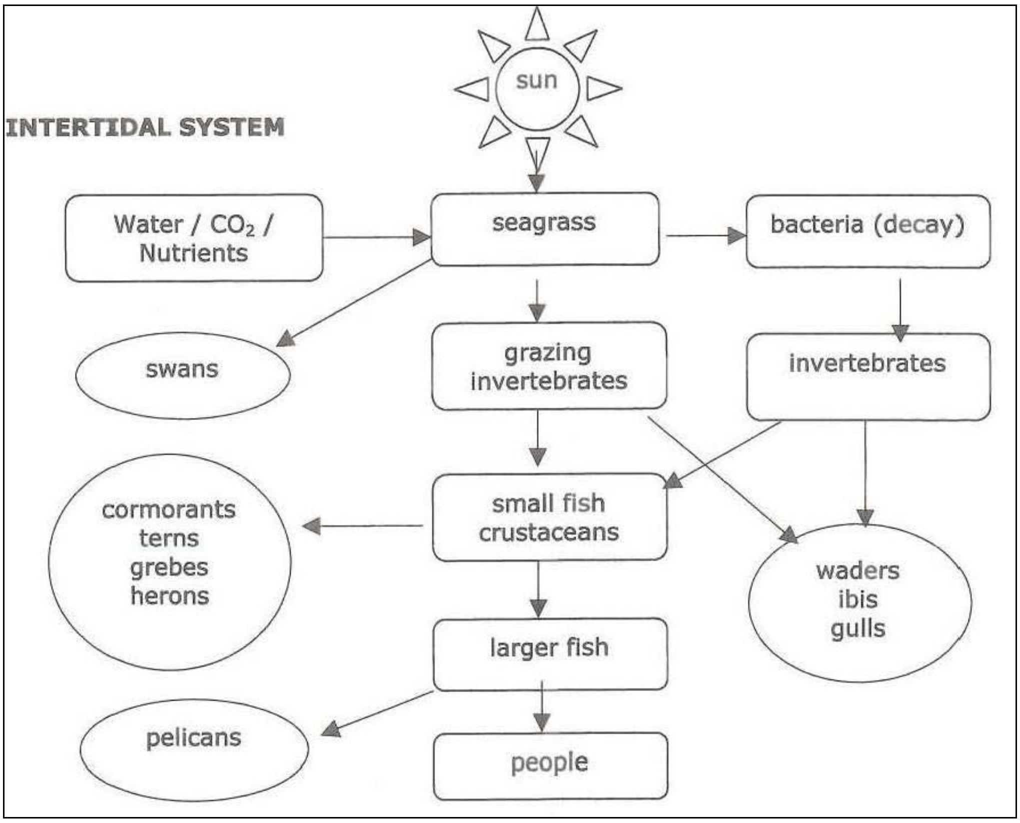

Figure 2.10
DIAGRAM FOR FOOD CHAIN FOR INTERTIDAL SYSTEMS
(Source: BOCA 2003, provided by Richard Loyn)

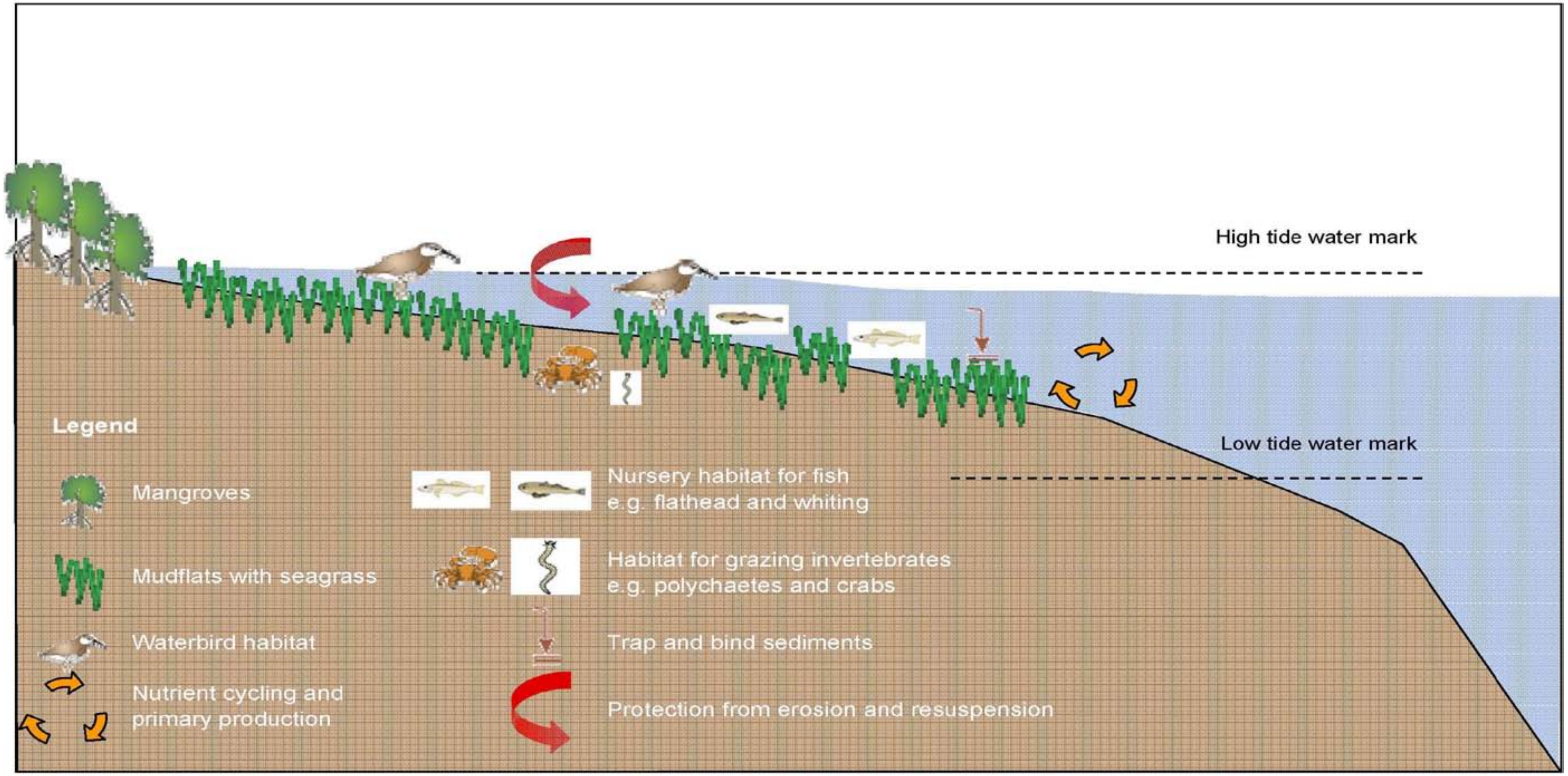

Figure 2.11
SIMPLE CONCEPTUAL MODEL SHOWING HABITAT AND SERVICES PROVIDED BY INTERTIDAL MUDFLATS AND SEAGRASS VEGETATION (Symbols: www.ozcoasts.org.au and http://ian.umces.edu)

Saltmarsh and mangrove vegetation

Component description and driving forces

The relatively shallow embayment supports extensive areas of saltmarsh and mangrove vegetation.

Quantitative data is available for the distribution of both saltmarsh and mangrove vegetation within Western Port in 1974 and 1984 (Table 2.7). The historical distribution of mangroves within Western Port experienced significant change between 1842 and 1974 as a result of activities and removal associated with European settlement (EPA 1996; Ross 2000). However, no significant change in the mapped distribution of mangroves was reported by Bird and Barson (1975, cited in EPA 1996) between 1974 and 1984, during which time the Ramsar site was listed.

As such, data available for mangrove and saltmarsh distribution within Western Port in 1984 are considered to resemble the distribution throughout the bay at the time the Ramsar site was listed in 1982.

Table 2.7 Changes in the area of saltmarsh and mangrove vegetation in the Ramsar site from 1974 to 1984 (Source: adapted from EPA 1996))

	1974* (ha)	1984† (ha)
Area of saltmarsh vegetation	26,700	31,000
Area of mangrove vegetation	12,100	13,700

* *Ministry for Conservation 1975 and King and Kay 1980, cited in EPA 1996; Shapiro 1975*

† *Victorian Institute of Marine Sciences, cited in EPA 1996*

Figure 2.12 provides a graphical representation of the distribution of the mangrove fringe within Western Port in 1984. This figure shows that near continuous coverage of mangrove vegetation was reported along the western and northern shoreline of the Ramsar site (from Sandy Point to the Inlets). In addition, the northern shoreline of French Island, from Fairhaven to Spit Point, was characterised by continuous mangrove coverage. The eastern shoreline, particularly from Stockyard Point to Corinella, around the Bass River estuary, and from Newhaven to Observation Point, was largely characterised by scattered mangrove vegetation (Bird and Barson 1975, cited in EPA 1996). This is considered to represent mangrove coverage at the time the Ramsar site was listed. Shapiro (1975) described the mangrove community within Western Port as monospecific, consisting of mature trees, with small seedlings abundant on landward and seaward margins. In 1975, the 12 100 ha of mangrove vegetation were estimated as having a collective biomass of 283 000 t (Shapiro 1975). No estimates of biomass for mangrove coverage in 1984 are available within the literature.

A discrete map detailing the distribution of saltmarsh vegetation in 1984 is not available for the site; however it has been suggested that the distribution of saltmarsh vegetation closely follows that of the mangrove fringe.

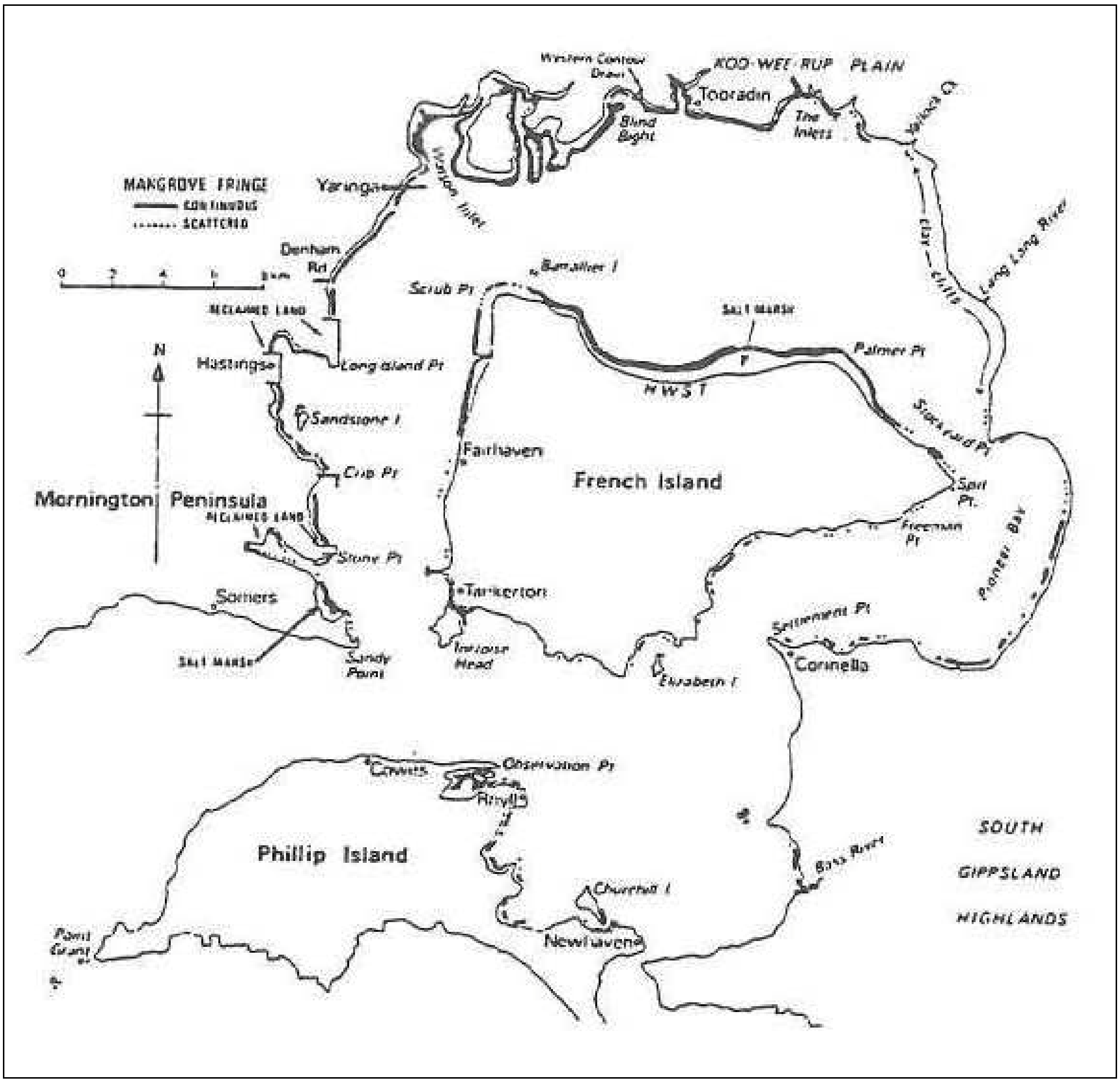

Figure 2.12
MANGROVE DISTRIBUTION IN WESTERN PORT IN 1984 (Source: Bird and Barson 1975, cited in EPA 1996)

Saltmarsh and mangrove communities are commonly situated in parallel stands with saltmarsh vegetation landward of mangroves above and around the mean high water mark (Parks Victoria 2007). Refer to Figure 2.8 for a simple conceptual model outlining the vegetation profile within the Ramsar site. Generally, the mangrove zone runs parallel to the shore, occurs inshore of seagrass, sand and mudflats, and has a width of 100 m to 300 m (DSE 2009b). White Mangroves grow from the high water mark to approximately mean sea level and have higher inundation frequencies than saltmarsh vegetation (EPA 1996; Rogers et. al. 2005). The banded zones of saltmarsh and mangrove vegetation within Western Port represent a long-term successional sequence, with mangroves advancing seawards to be replaced by saltmarsh (Ross 2000; Rogers et al. 2005).

Shapiro (1975) identifies the following natural and artificial constraints to the expansion of mangrove vegetation:

- high and fluctuating salinity
- soil aeration and drought
- frost
- destruction by grazing and fungi
- mechanical barriers to dispersal
- soil type
- wave action.

Linkages to other components, processes, benefits and services

The Ramsar site’s mangrove and saltmarsh vegetation is considered to be of regional, state, national and international significance supporting the most well developed communities in Victoria (DSE 2009b).

In particular, the site is of national botanical significance as a result of the extensive, floristically rich and relatively undistributed saltmarsh communities it supports (Parks Victoria 1999). The site also supports the White Mangrove, the only species of mangrove to occur in Victoria where it is nearing its southern limit. The mangrove communities within Western Port are the most well-developed and extensive in Victoria (Parks Victoria 2007). As such, they are considered to be of state significance.

Mangrove and saltmarsh vegetation supports a number of wetland components providing significant habitat for resident and migratory shorebirds, and a nursery for invertebrates and fish species (Parks Victoria 2007). Mangroves and larger saltmarsh plants provide important high tide roosting sites. In particular, saltmarsh vegetation is known to provide important roosting habitat for migratory birds, including a number of rare species such as the Orange-bellied Parrot (Zann 1997, cited in Rogers et al. 2005). The saltmarsh is of national zoological significance for its population of the Orange-bellied Parrot (Parks Victoria 1999). The trunks and pneumatophores of mangroves within the bay provide habitat for epiphytic filamentous algae, barnacles, and Blue Mussels (Parks Victoria 2007).

In addition, this vegetation provides a number of services, including stabilising and accumulating the sediments, filtering pollutants, nutrient cycling and protection from shoreline erosion (EPA 1996; Rogers et al. 2005; Parks Victoria 2007; DSE 2009b). The pneumatophores are known to trap sediment, encouraging deposition and formation of a terrace at the landward edge of the mangroves (EPA 1996). This terrace then supports colonising saltmarsh vegetation.

Figure 2.13 provides a simple conceptual model illustrating the habitat and services provided by saltmarsh and mangrove vegetation within the Ramsar site.

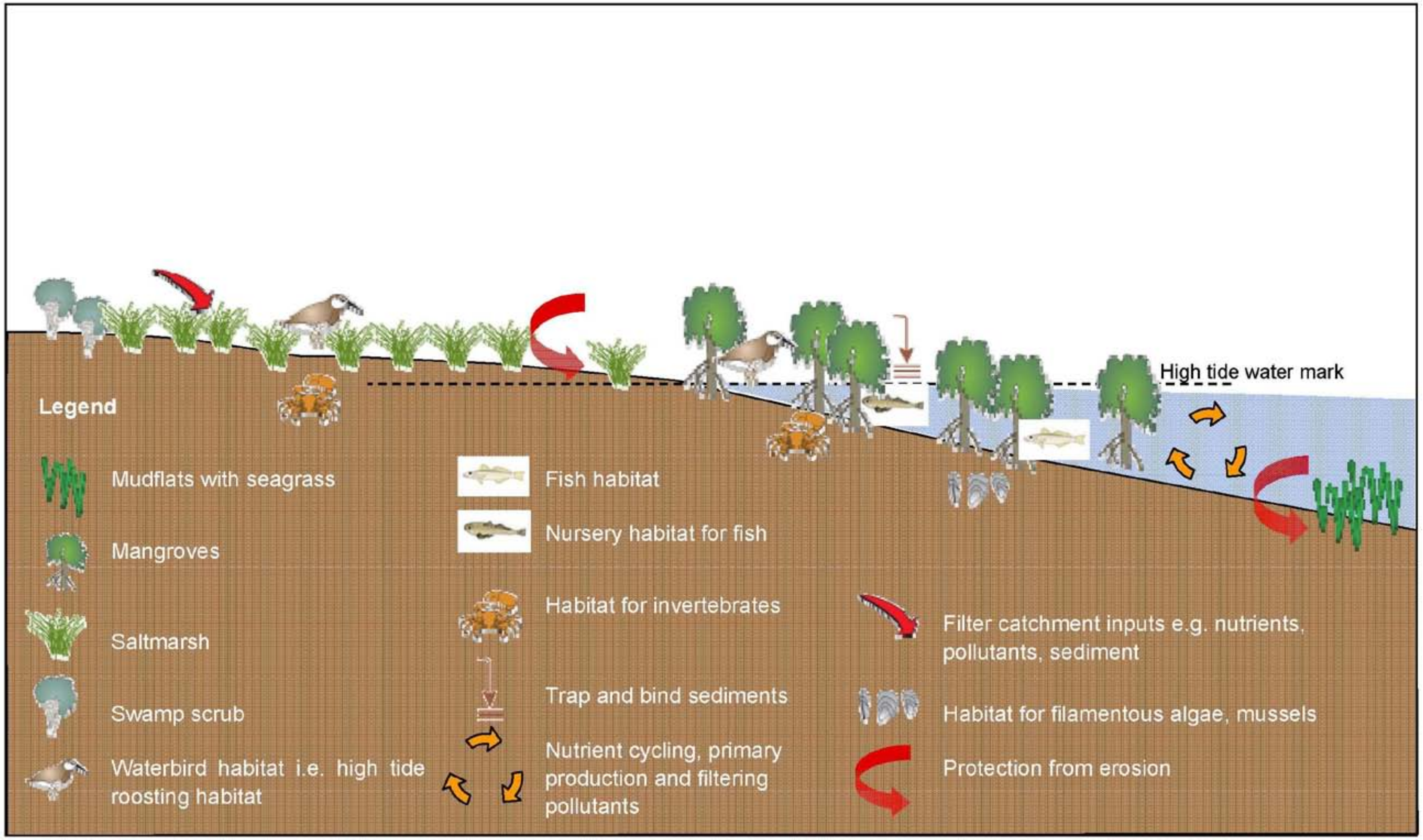

Figure 2.13
SIMPLE CONCEPTUAL MODEL ILLUSTRATING HABITAT AND SERVICES PROVIDED BY SALTMARSH AND MANGROVE VEGETATION (Symbols: www.ozcoasts.org.au and http://ian.umces.edu)

Historically, modifications to the extent and distribution of mangrove and saltmarsh vegetation within Western Port largely resulted from clearing for:

- agriculture, including grazing
- boat access (landings, jetties or harbours)
- allow the outflow of run-off from drainage canals and ditches
- produce barilla ash for soap production
- reclaiming land for industrial and port development (Shapiro 1975; Ross 2000).

Clearing to facilitate these activities also exposed nearby mangroves and saltmarsh to the damaging effects of tidal scour, erosion and increased sedimentation (Ross 2000). Loss of saltmarsh and mangrove vegetation therefore results in an increase in erosion and turbidity (Parks Victoria 2007). Areas of deposition that were once occupied by mangroves are said to have impeded their regeneration (Ross 2000). Additional activities currently threatening mangrove and saltmarsh vegetation within the Ramsar site are discussed in Section 4.

Significant species

Component description and driving forces

The Flora Information System (FIS) identifies sixteen flora species of conservation significance that have been previously recorded within the boundary of the Ramsar site (Table 2.8). This comprises of 15 species of Victorian conservation significance and a single nationally listed species.

Of these, 11 species were recorded prior to, or in, 1982. The Dense-leek Orchid, a species listed as vulnerable under the national *EPBC Act 1999*, has been recorded within the Ramsar site prior to and following listing. This species is dependent on coastal heath and sandhill habitats provided within the site (Walsh and Entwisle 1994). The remaining 10 species are considered as Rare or Threatened species within Victoria and are not protected by legislation (DSE 2005).

Of the species recorded within the Ramsar site at, or in, 1982, White Mangrove, Creeping Rush (*Juncus revolutus*), Marsh Saltbush (*Atriplex paludosa* subsp. *paludosa*), and Salt Lawrencia (*Lawrencia spictata*) are considered species of critical importance to maintaining the saltmarsh and mangrove vegetation communities within the site. These communities are critical as they enabled the site to directly satisfy Ramsar Criterion 1 in 1982 (Table 1.3). Quantitative information on the distribution of mangrove and saltmarsh vegetation throughout the Ramsar site at the time of listing has been provided above.

It should be noted that although Spotted Gum *(Corymbia maculata*) is considered threatened within Victoria and has been recorded within the site, it is classified as an environmental weed within the Western Port region. Its range extends from New South Wales to the south of Buchan in East Gippsland. However, there are many roadside plantings of this species in the region (S. Coutts [Parks Victoria] 2009, pers. comm., 23 June). Records from the FIS indicate that Spotted Gum was recorded within the Ramsar site in 1993; however this has been omitted from Table 2.8.

Table 2.8 Flora Information System Database Records: Threatened flora historically recorded within the Ramsar site and a 500m buffer outside the site (Source: DSE 2009a)

Common name	Scientific name	Year(s) recorded within Ramsar site	Year(s) recorded within 500 m buffer of Ramsar site	EPBC status	FFG status	DSE status
Coast Ballart	*Exocarpos syrticola*		1988			Rare
Coast Wirilda	*Acacia uncifolia*	1963				Rare
Cobra Greenhood	*Pterostylis grandiflora*		1998, 1991			Rare
Creeping Rush	*Juncus revolutus*	1972, 1973, 1974, 1980, 1991	1973, 1980 1982, 2006			Rare
Crested Sun-orchid	*Thelymitra X irregularis*	1982	1988			Rare
Currant-wood	*Monotoca glauca*		1999			Rare
Dense Leek-orchid	*Prasophyllum spicatum*	1969, 1991, 1992		Vulnerable		Endangered
French Island Spider-orchid	*Caladenia insularis*		1991	Vulnerable	Listed	Vulnerable
Fringed Midge-orchid	*Corunastylis ciliata*		1993			Poorly known
Green Leek-orchid	*Prasophyllum lindleyanum*	1969, 1992	1998			Vulnerable
Green-comb Spider-orchid	*Caladenia dilatata* s.s.	1957, 1971, 1980, 2006				Poorly known
White Mangrove	*Avicennia marina* subsp. *australasica*	1973, 1980, 1989 1993, 1996, 1999	1989, 1991, 1997, 1999, 2006, 2007			Rare
Grey Pouchwort	*Acrobolbus cinerascens*		2001			Vulnerable
Large Duckweed	*Spirodela polyrhiza*	2005				Poorly known
Long Pink-bells	*Tetratheca stenocarpa*		1988, 1989			Rare
Marsh Saltbush	*Atriplex paludosa* subsp. *paludosa*	1958, 1973, 1980, 1993, 1996, 1999	1904, 1935, 1970, 1988, 1991, 1997, 2006, 2007			Rare
Marsh Sun-orchid	*Thelymitra longiloba*	1957	1988			Endangered
Nodding Baeckea	*Euryomyrtus ramosissima* subsp. *prostrata*		1989			Rare
Pallid Sun-orchid	*Thelymitra pallidiflora*	1995, 2000				Endangered
Salt Blown-grass	*Lachnagrostis robusta*	1997, 1999				Rare
Salt Lawrencia	*Lawrencia spicata*	1980, 1989, 1991	2002, 2003			Rare

Table 2.8 Continued

Common name	Scientific name	Year(s) recorded within Ramsar site	Year(s) recorded within 500 m buffer of Ramsar site	EPBC status	FFG status	DSE status
Sand Brome	*Bromus arenarius*	1999				Rare
Sticky Wattle	*Acacia howittii*		1913, 2004			Rare
Summer Spider-orchid	*Caladenia flavovirens*		1905			Rare
Swamp Everlasting	*Xerochrysum palustre*		1972	Vulnerable	Listed	Vulnerable
Tiny Arrowgrass	*Triglochin minutissima*	1991				Rare
Wetland Blown-grass	*Lachnagrostis filiformis* var. 2		1993			Poorly known
Yellow Sea-lavender	*Limonium australe*	1973, 1993, 1999, 2000	1989			Rare

Twelve additional flora species of conservation significance have been historically recorded within a 500 m buffer of the Ramsar site (Table 2.8). Two species are of particular note. The French Island Spider-orchid (*Caladenia insularis*) is listed as endangered under the federal *EPBC Act 1999*, and is listed under the Victorian *FFG Act 1988*. Similarly, Swamp Everlasting (*Xerochrysum palustre*) is listed as vulnerable under the *EPBC Act 1999*, and is listed under the Victorian *FFG Act 1988*. These additional species are important in describing the ecological character of the Ramsar site as they illustrate the complementary habitats that exist beyond the boundary of the site.

Linkages to other components, processes, benefits and services

The interaction between White Mangroves and saltmarsh vegetation (critical vegetation communities) and other ecosystem components has been outlined above.

2.3.4 Fauna

Waterbirds

Western Port has been recognised as an important habitat for waterbirds for many years. This component is considered critical in maintaining the character of the Ramsar site specifically as three of the five criteria satisfied in 1982 directly relate to waterbirds within the site. In addition, for many years the occurrence of waterbirds at the site has facilitated passive recreation and aesthetic enjoyment, particularly bird watching.

Component description and driving forces

Counts of waterbirds have been conducted on a regular basis in the Ramsar site three to five times per year since 1973, by BOCA (Loyn 1975, 1980; Dann et al. 1994; Loyn et al. 1994; Loyn et al. 2001; BOCA 2003). Five counts were conducted each year until around 1995, at which time counts were reduced to three per year (two summer counts and one winter count). The counts have focused on high-tide roosts used by waders and other waterbirds. This gives an unusually complete picture of the changes in numbers of birds of intertidal habitats over this time.

One hundred and fifteen waterbird species have been recorded within the Ramsar site both prior to and following 1982 (Appendix D). These species can be classified into a number of guilds based on their taxonomy and requirements for feeding, nesting and roosting. Pelagic species, although known to occur within the site, are not largely considered significant contributors to its character (see below). Thousands of Black Swans feed from seagrass beds on exposed mudflats. They are the most numerous waterbird in the bay and the only one to feed mainly on intertidal vegetation. Other species feed mainly on invertebrates in the mud (e.g. hundreds of Australian White Ibis (*Threskiornis molucca*) or fish in the water (e.g. cormorants and Australian Pelican). To the casual observer, large and conspicuous waterbirds such as these stand out as being particularly numerous compared with many coastal locations. More familiar waterbirds, e.g. Silver Gulls (*Larus novaehollandiae*), can also be numerous at coastal towns, though that species is remarkably scarce in more remote parts of the site. Most of these waterbird species have wide distributions in coastal and inland wetlands in Australia.

More careful searching is needed to find some of the less conspicuous bird species that also contribute to the site's character, such as waders. They can be present in thousands, but they are small in size, disperse widely at low tide to feed from invertebrates in the mud, and congregate in dense flocks at high tide in secluded sites such as spits or islets. Most wader species need extensive areas of tidal mudflats with rich supplies of invertebrate food, and this restricts their distribution compared with some of the larger waterbirds. In south-eastern Australia, these habitats are best represented in three large embayments (Port Phillip, Western Port and Corner Inlet) and those three areas consistently attract the highest numbers of these birds.

Total numbers of waders and other non-pelagic waterbirds have exceeded 20 000 (Ramsar Criterion 5) in all years of the BOCA survey (Table 2.9). Typically these include 10 000 to 15 000 waders, 5000 to 10 000 swans and a few thousand ducks, gulls and other species. These totals do not include seabirds, which are occasionally represented by even greater numbers but usually remain in the deeper parts of the bay outside the Ramsar site. The mean number of waterbirds has been calculated over the 10 year periods identified.

Waders (shorebirds)

Tidal mudflats can provide rich sources of food at low tide, but are inaccessible to birds at high tide. Hence waders have a defined window of opportunity to meet their energy needs on each tidal cycle. Many of them can feed at night, though with reduced efficiency. All of them need to find alternative habitats at high tide, when they may extend their feeding period in nearby non-tidal wetlands or roost in large flocks on exposed stretches of shore. Some species choose to perch on vegetation such as mangroves at high tide, while others prefer to find exposed banks of sand, shell-grit or rock. The bathymetry of the bay means that there is plenty of food for species that can meet their energy needs by feeding for short periods at low tide (generally the larger wader species) but more limited food supplies for small species that need to feed for longer periods (Evans 1975; Dann 1999). The mangrove fringe further restricts the availability of mudflats exposed at high tidal levels: this feature is shared with many wader habitats in northern Australia. Small species are generally the most common waders in the Ramsar site (as elsewhere in southern Australia), but the site has special local importance as a habitat for some of the larger species in Victoria, notably Eastern Curlew, Bar-tailed Godwit, Common Greenshank (*Tringa nebularia*) and Grey-tailed Tattler.

Table 2.9 Mean and maximum counts of waterbird guilds in the Ramsar site from 1973 to 2009 (Source: BOCA survey)

Guild	1973–1983		1984–1993		1994–2003		2004–2009		Percentage declines from previous five years
	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	
Total non-pelagic waterbirds	15,237	43,483	14,075	34,726	14,468	38,492	12,096	25,677	16.4
Australasian waders	730	1,676	823	1,924	851	1,990	694	1,250	18.4
Palaearctic migratory waders	6,682	15,716	6,521	15,268	6,761	14,809	6,774	13,897	-0.2
Ducks	634	1,972	812	3,096	1,054	2,898	572	1,110	45.7
Fishers	688	1491	400	1,024	398	596	229	473	42.5
Grebes	36	207	31	137	28	117	2	17	92.9
Gulls	3,181	11,966	2,742	5,580	1,817	4,656	1,531	3,170	15.7
Large wading birds	1,221	4031	791	1,425	1,076	2,920	736	1,256	31.6
Swans	2,064	6424	1,956	6,272	2,482	10,506	1,558	4,504	37.2

Some waders nest locally, on beaches above the tide-line or in nearby vegetation. However, their numbers are greatly limited by the extent of such habitat and by disturbance from people and their pets (Section 4.5). Several wader species breed on beaches round the Ramsar site, but there is not enough breeding habitat to support the thousands of birds that feed there at low tide. The most numerous wader species adopt quite a different strategy, migrating thousands of kilometres to breed in rich but temporary feeding and breeding habitats elsewhere. By far the most important of these distant breeding habitats is the Arctic tundra of Siberia and Alaska. As the snow melts in the Arctic spring, vast areas of tundra become exposed, with pools of water and wet mud and ideal breeding sites for insects and the waders that feed on those insects and their larvae. Many of the waders that feed from tidal mudflats in the Ramsar site migrate to breed in the Arctic tundra: these include 27 of the species that regularly or occasionally visit the Ramsar site in summer when it is winter in the Arctic. Just one species (Double-banded Plover) migrates south-east to breed in the mountain tundras of the south island of New Zealand. Altogether nine wader species breed locally in or near the Ramsar site, and four wader species breed elsewhere in Australia (Appendix D).

At a national or international level, the Ramsar site regularly supports more than 1 per cent of the estimated flyway population (Bamford et al. 1996) of five wader species (Table 2.10). These include one species that breeds locally (Australian Pied Oystercatcher); the single species that migrates to Australia from breeding areas in New Zealand (Double-banded Plover), and three species that migrate to Australia from breeding areas in the far north of Asia or Alaska (Eastern Curlew and the two common small waders: Red-necked Stint and Curlew Sandpiper). A discussion on waterbird numbers in recent years is provided in Section 5.7.

Four species of wader nest regularly in the Ramsar site or adjacent coasts (Appendix D). These are Pied Oystercatcher, Red-capped Plover (*Charadrius ruficapillus*), Hooded Plover (*Thinornis rubicollis*) and Masked Lapwing (*Vanellus miles*). French Island supports many breeding pairs of Pied Oystercatchers, where the absence of Red Foxes (*Vulpes vulpes*) may contribute to their success. Masked Lapwings nest widely in a range of wetlands, farmland and even suburban habitats. Red-capped Plovers nest locally on beaches round the bay, and hooded plovers nest on just two sandy beaches within the Ramsar site. Larger numbers of Hooded Plover and Sooty Oystercatcher (*Haematopus fuliginosus*) nest nearby on exposed southern coasts of Phillip Island, and Banded Lapwing (*Vanellus tricolor*) nests in farmland near the Ramsar site.

Other non-pelagic waterbirds

The challenges faced by waders feeding in intertidal areas are also faced by other waterbirds, but they deal with them in different ways. Some coastal species nest in Western Port or on coastal islands in Bass Strait (Appendix D), and some species nest commonly in peripheral habitats such as saltmarsh (notably Black Swan, Appendix D). However, freshwater swamps provide the major breeding habitat for the majority of species, and they may fly large distances within Australia to access ephemeral swamps as they fill with water and become suitable for breeding. Some local breeding sites for these birds are listed in Appendix D. Many were dry at the time of Ramsar listing (1982), as a result of the 1981–83 drought, and they became dry again during the prolonged dry period of recent years. Local breeding of waterbirds is greatly reduced during dry periods such as these. In contrast, many waterbirds leave Western Port when good rains provide extensive habitat for feeding and breeding in inland Australia; this applies especially to nomadic species such as Grey Teal (*Anas gracilis*) (Chambers and Loyn 2006). Counts of inland-breeding waterbird species in Western Port tend to be lowest in spring (when swamps fill from spring rains or snow-melt) and highest in autumn or in other dry periods immediately following wet periods that promote successful breeding in inland Australia.

Based on the BOCA counts, the Ramsar site supports more than 1 per cent of the estimated relevant population (Delaney and Scott 2006) of three non-pelagic waterbird species other than waders (Table 2.10). These are, Chestnut Teal, Pacific Gull and Fairy Tern. Counts of another species (Pied Cormorant (*Phalacrocorax varius*)) come close to the threshold level, and would certainly have exceeded it if allowance were made for flocks of this species that sometimes roost on mangroves or rocks in less accessible areas not usually visited during regular counts. However, numbers have declined slightly in recent years. Cape Barren Goose (*Cereopsis novaehollandiae*) would probably meet the 1 per cent criterion for the introduced population on Phillip Island, just outside the Ramsar site. Two of these species (Black Swan and Pacific Gull) have exceeded the 1 per cent threshold in all years of the BOCA survey, and two others (Chestnut Teal and Royal Spoonbill) have exceeded or approached that level in most years. Musk Duck and Fairy Tern have been more erratic in occurrence.

The Ramsar site is an important breeding site for some of these species. Many Black Swans nest in saltmarsh and wetlands round the Ramsar site in most years, and Chestnut Teal nest regularly in similar habitats. Nesting colonies of Fairy Terns are occupied in some years at two sites on French Island, with patchy success. Royal Spoonbills sometimes nest with larger numbers of ibis on nearby freshwater wetlands when they hold water, which they have not done in recent years (Appendix D). Pied Cormorants have bred historically in Western Port (in mangroves in the 1960s) and have been suspected of doing so more recently though this has not been proved; the nearest regular breeding sites are in Port Phillip. Musk Duck occur mainly as non-breeding visitors, dispersing to breed at more distant wetlands elsewhere. Pacific Gulls disperse to breed on islands off Wilsons Promontory or in Bass Strait not within the Ramsar site.

As with waders, the exposed coasts of Phillip Island (outside of the Ramsar boundary) support some species that are not commonly found in the Ramsar site. These include Black-faced Cormorant (*Phalacrocorax fusescens*) (Seal Rocks) and Kelp Gull (*Larus dominicanus*) (about 20 pairs nesting at Seal Rocks and The Nobbies). Two species (Silver Gull and Crested Tern (*Sterna bergii*) nest in large numbers on Phillip Island but not in Western Port, although they occur widely through the Ramsar site when not breeding.

Seabirds

True seabirds make little use of the Ramsar site, although the southern shores of Phillip Island outside the Ramsar boundary provide breeding habitat for many thousands of two species (Little Penguin (*Eudyptula minor*) and Short-tailed Shearwater). Small numbers of both species nest within the Ramsar site: Short-tailed Shearwaters on Tortoise Head and Little Penguins on Barralliar Island. Thousands of

Short-tailed Shearwaters gather in the Ramsar site in autumn before embarking on their annual pan-Pacific migration; estimates of up to 250 000 birds have been made (Loyn 1978).

Many other species of seabird enter the deeper parts of the Ramsar site to feed, especially during rough weather, but it seems that they are just using the bay opportunistically as an extension of their pelagic habitat in Bass Strait and the Southern Ocean, rather than a regular destination in its own right. Several of these species are listed as nationally threatened mainly because birds such as albatrosses are vulnerable to becoming snared on fish-hooks associated with long-line fishing. Some of the most commonly observed species in these deeper waters are Southern Giant-Petrel, Black-browed Albatross, Shy Albatross, Australasian Gannet (*Morus serrator)* and Arctic Jaeger (*Stercorcarius parasiticus)*. The latter two species visit inshore waters more often than albatrosses and petrels. However, of the seabirds recorded in the bay, only the Little Penguin and Short-tailed Shearwater make a significant contribution to the ecological character of the Ramsar site by virtue of their numbers, breeding status and regular occurrence in the Ramsar site.

Land birds

Three nationally threatened land bird species have been recorded in the vicinity of Western Port, but only one of them (Orange-bellied Parrot) is associated with the wetland habitats of the Ramsar site. Small numbers of this critically endangered species visit the Ramsar site in winter from their breeding sites in south-west Tasmania. Their favoured habitats include saltmarsh, wetlands and nearby pasture, and they are often attracted to small islands. They have been seen on French Island, Barralliar Island, and occasionally elsewhere, but numbers and frequency have declined greatly over the years.

Small numbers of Swift Parrots (Endangered) are occasionally seen in winter in flowering eucalypts near Western Port, as winter visitors from Tasmanian breeding sites. The Helmeted Honeyeater (Critically endangered) was known from Bass Strait in the 19th century but otherwise there have been no records near the Ramsar site. Neither species uses wetland habitats associated with the Ramsar site.

Several more common land birds make use of saltmarsh habitats in the Ramsar site (Appendix D). Some dryland habitats in the vicinity of the Ramsar site are important habitats for some less common land bird species on a state or local level. For example, heathland on French Island supports one of the few remaining populations of King Quail (*Excalfactoria chinensis*) in Victoria (BOCA 2003). However, these species are not threatened at the national level, and do not contribute to the ecological character of the Ramsar site.

Two species of swifts are international migrants, and hence are listed in international migratory bird agreements (Appendix D). Both visit the Ramsar site irregularly in late summer or early autumn: they are White-throated Needletail (*Hirundapus caudacutus*) and Fork-tailed Swift (*Apus pacificus*). They forage for insects along the coast and rarely make landfall in the region, roosting on the wing (Fork-tailed Swift) or in tall trees further inland (White-throated Needletail). They probably migrate to breed in north-east Asia and they are not listed as threatened.

Table 2.10 Non-pelagic waterbird species with > 1 per cent of estimated flyway populations recorded in the Ramsar site prior to and following 1982

Common name	1 per cent of estimated relevant population, e.g. flyway (Delaney and Scott 2006; Bamford et al 2008)	Maximum count 1973–83	Maximum count 1984–2009	Years count exceeds 1% (35 full years 1974–2008)	Comments
Musk Duck	250	264	226	1	Flocks on sea easily missed; may meet criterion more often than counts suggest.
Black Swan	10,000	6,424	10,506	1	Over 12,000 recorded using targeted non-standard survey methods (twice standard count); criterion likely to be met in ~ 20 years if allowance made for incomplete counts.
(Cape Barren Goose)	160	Few	Few		Substantial uncounted population established on Phillip Island.
Chestnut Teal	1,000	1,582	2,887	11	Exceeds or approaches criterion most years.
(Pied Cormorant)	1,000 to 10,000	230	162	0	Many missed on regular counts, and population believed to be significant in south-eastern Australian context, but unlikely to exceed 1000.
(Royal Spoonbill)	1,000	395	296	0	Population of regional significance but not known to approach criterion
(Whimbrel)	250	33	143	0	Rarely approaches criterion, but population is of local significance as one of the most southerly in the world.
Eastern Curlew #	380	1,498	2,251	35	Exceeds criterion all years, despite recent decrease (no more than 775 since 2004).
Red-necked Stint #	3,250	7,276	9,625	35	Exceeds criterion all years.
Sharp-tailed Sandpiper	1,600	566	1,856	1	Rarely meets criterion.
Curlew Sandpiper #	1,800	6,472	7,098	30	Exceeds criterion most years, but no more than 2260 since 2004.
Pied Oystercatcher #	110	215	419	34	Exceeds criterion most years.
(Red-necked Avocet)	1,100	2	850	0	Peak numbers may be missed in spring.
Double-banded Plover #	500	1,172	1,078	22	Exceeds criterion most years, but no more than 597 since 2004.
Pacific Gull #	50	738	800	35	Exceeds criterion all years.
Fairy Tern #	25	128	108	24	Breeds erratically on French Island.

* *Species are included in brackets if they come close to meeting the criterion, or are of regional significance.*

\# *If they meet the criterion frequently (> 17 years out of 35, based on counts). Names and order follow Christidis, L. & Boles, W.E. 2008, Systematics and taxonomy of Australian birds, CSIRO, Collingwood.*

Linkages to other components, processes, benefits and services

The extensive tidal mudflats are the main attraction in the Ramsar-listed area, and the relatively unmodified nature of those mudflats contributes to their value for birds. A range of peripheral habitats provide further support, attracting some additional species and providing alternative habitats where some birds that feed from mudflats can breed, roost, drink or continue feeding at high tide. Several freshwater swamps are scattered around the bay, but generally they are small and ephemeral, drying out during prolonged dry periods. A much larger and more permanent swamp (Koo-Wee-Rup Swamp) existed on the north-west shores of the bay before European settlement, but it was drained at an early stage, and little information has been documented about its waterbird populations. It is likely that this swamp supported large numbers of waterbirds, providing breeding habitat for many of the species that continue to breed in small freshwater swamps in the region.

Compared with other tidal embayments in south-eastern Australia, the Ramsar site is remarkable for the extent of its mudflats exposed at low tide, and for the relatively intact fringe of mangroves and saltmarsh vegetation (notwithstanding substantial historical reductions to that vegetation as a result of human activity). Primary productivity comes mainly from seagrass beds on the mudflats, and mangroves in the peripheral vegetation (Shapiro 1975).

Western Port is of national zoological significance as a foraging areas and high tide roosting site for migratory waders as well as for its population of the endangered Orange-bellied Parrot (Parks Victoria 1999).

Marine invertebrates

The diversity of marine habitats, particularly deep channels, intertidal mudflats, beaches and rocky reefs, exhibited by the Ramsar site support a variety of marine invertebrates, assemblages of which characterise particular habitats (EPA 1996; DSE 2003). Prior to 1982, Western Port was identified as a unique Australian embayment due to the diversity and composition of macroinvertebrate fauna (Shapiro 1975). Invertebrates are considered critical in maintaining the character of the Ramsar site due to their importance as direct food sources for waterbirds and fish, therefore contributing the site's listing in 1982, and in energy transfers throughout the system.

Component description and driving forces

Detailed surveys of benthic invertebrates within Western Port were undertaken in 1965 to 1970 and from November 1973 until January 1974 (Shapiro 1975). As no quantitative information on marine invertebrates within Western Port in 1982 is available, the data collected from 1974 has been presented in Table 2.11. Shapiro (1975) states that although this provides quantitative data on the number of benthic invertebrates within Western Port, its use a baseline inventory data is limited as seasonal variation was not taken into account at the time.

Table 2.11 Numbers of the various phyla and classes found in the 1973–74 surveys of Western Port benthos (Source: adapted from Shapiro 1975)

Phylum	Class	No. of individuals collected within Western Port during the 1973–74 surveys
Porifera		277
Coelenterata	Anthozoa	116
Platyhelminthes	Turbellaria	3
Nemerthea		105
Nematoda		246
Annelida	Polychaeta	10,819
Mollusca		1,130
Mollusca	Crustacea	6,516
Arthropoda	Pycnogonida	31
Arthropoda	Insecta	12
Arthropoda	Crinoidea	1
Arthropoda	Asteroidea	9
Echinodermata	Ophiuroidea	328
Echinodermata	Echinoidea	52
Echinodermata	Holothuroidea	10
Sipuncula		24
Phoronida		2
Brachiopoda		56
Hemichordata	Enteropneusta	19
Chordata	Ascidiacea	97

Distinct assemblages of marine invertebrates have been described for the habitats of the Ramsar site prior to listing in 1982 (Appendix E). Marine invertebrates common in intertidal areas include infauna and epifauna; however mudflats vegetated with seagrass are known to exhibit greater diversity than unvegetated mudflats (EPA 1996). The assemblages found in this habitat are essential in maintaining the character of the site as they form an integral component of energy transport throughout the system and are a critical food source for a variety vertebrate species. These habitats within the site are considered some of the most productive in the world (Watson et al. 1984, cited in EPA 1996).

Marine invertebrates within the deep channels of the Ramsar site are characterised by species that are tolerant of coarser sandy substrates and stronger currents (EPA 1996). Species of significance, that have existed in abundance within the channels prior to 1982, include molluscs (*Neotrigonia margaritacea* and *Anadara trapezia*), and brachiopod (*Magellania australis*). These species are living fossils that are restricted in distribution elsewhere in Victoria (Smith et al. 1975, cited in EPA 1996).

The reefs and rocky substrates are characterised by epifaunal invertebrates that favour hard substrate, low light levels and high current flows. Prior to listing, Western Port was considered unique in comparison with other Australian embayments as a result of the rich diversity of sessile, filter-feeding organisms such as sponges, ascidians, hydroids, bryozoans, bivalves and brachiopods (Shapiro 1975). This fauna is characteristic of the reefs and rocky substrates to the north of the site such as Crawfish Rock.

In association with the high diversity of marine invertebrates within the Ramsar site, the San Remo Marine Community has been identified in the reef and seagrass flats off San Remo to the south of the Ramsar site (DSE 2003b). This marine community is listed under the Victorian *FFG Act 1988* and is characterised by an extremely species-rich assemblage of marine biota (DSE 2003b). EPA (1996) indicates that the marine invertebrates include a high number of species of opisthobranch molluscs (e.g. nudibranchs) and bryozoans. It is probable that the San Remo Marine Community existed within the Ramsar site when it was listed in 1982 as it was investigated by Kinhill Engineers in 1988 and the Marine Research Group of Victoria in 1989.

Linkages to other components, processes, benefits and services

The range of marine habitats within the Ramsar site provides the widest possible spectrum of habitats available for marine invertebrates resulting in great diversity (Shapiro 1975). Each habitat is known to support a unique assemblage of marine invertebrates which in turn maintain the diversity of waterbirds and fish (Shapiro 1975). The composition of invertebrate assemblages is highly influenced by water movement, tidal regime and exposure, sediment types and substrate availability (EPA 1996).

In addition, macroinvertebrate assemblages within the Ramsar site are highly dependent on the bathymetry of the embayment. For example, the San Remo Marine Community extends from the coastline to the edge of a deep channel. Its existence is also known to be driven by the tidal regime experienced in the channel and the underlying substrata (DSE 2003b).

The invertebrates of the Ramsar site provide a critical link for numerous other components, processes, benefits and services. Invertebrates are important in transferring the production of seagrasses, mangroves and other plants to higher trophic levels in the ecosystem, particularly fish and waterbirds (EPA 1996).

Fish

Fish species within Western Port, especially non-commercial species, at the time of listing are poorly documented in comparison to other critical components. However, they are considered critical in maintaining the character of the Ramsar site by providing an important food source for a number of waterbirds and marine mammals, and supporting a variety of benefits and services, namely wetland products produced by commercial fishing, recreational fishing and passive recreation (discussed further in Section 2.3). Fish are also an important component facilitating energy transfers to higher trophic levels.

Component description and driving forces

Prior to 1982, Negilski (1975, cited in EPA 1996) examined aspects of the fish communities of Western Port. This survey formed a component of the Westernport Bay Environmental Study prepared by Shapiro in 1975; however a detailed list of fish species recorded during this survey is not provided within this document and has not been accessible for the preparation of this description.

EPA (1996) states that a total of 92 fish species have been reported within Western Port since 1975. Most of these are small species such as gobies (*Gobiidae*), pipefish, and weedfish (*Clinidae*).

Although a number of species are widely distributed throughout Western Port, evident differences in fish community structure between habitats have been reported (Negilski 1975, Edgar and Shaw 1995a, cited in EPA 1996). In particular, intertidal areas vegetated with seagrass are known to support the highest diversity of fish species in comparison to unvegetated intertidal mudflats and deeper channels. Fish species are attracted to a variety of marine invertebrates and flora species as primary food sources which subsequently results in varying assemblages in different habitats. Appendix F provides a list of common species and assemblages found within Western Port detailed by EPA (1996).

Fish assemblages common within intertidal mudflats dominated by seagrass comprise predominantly of small fish, including pipefish, gobies, weedfish, leatherjackets, Globefish (*Diodon nicthemerus*), Soldierfish (*Gymnapistes marmoratus*), Blue Rock Whiting, and Rock Flathead (EPA 1996). Unvegetated mudflats are known to support a different assemblage of fish species, including gobies, flounder (*Pleuronectidae*), flathead (*Platycephalidae*), Smooth Toadfish, and Sandy Sprat (*Hyperlophus vittatus*) (EPA 1996). Juvenile King George Whiting are known to occur in intertidal mudflats supporting seagrass and unvegetated areas.

Deeper channels within the Ramsar site support Stingarees (*Urolophidae*), Gurnard Perch, Sand Flathead and some gobies (EPA 1996).

A variety of mobile, pelagic fish species are also known to occur in the Ramsar site and have not been identified to be restricted to the above habitats. Some of these species include Australian Salmon (*Arripis* spp.), Yellow-eye Mullet, Pilchards (*Sardinops sagax*), Anchovies (*Engraulis australis*), Snapper (*Pagrus auratus*), Barracouta (*Thyrsites atun*), and a number of sharks and rays (EPA 1996).

The fish assemblages occurring at beaches, rocky reefs, and mangroves when the site was listed in 1982 remains undocumented.

Linkages to other components, processes, benefits and services

The presence of these fish species and assemblages within the Ramsar site is highly influenced by the availability of habitat, particularly intertidal mudflats, seagrass vegetation and deeper channels. For example, seagrass beds within the Ramsar site are known to be important nursery habitats for many fish species, such as Smooth Toadfish, pipefish, Yellow-eye Mullet, leatherjackets, King George and Blue Rock Whiting, and Rock Flathead (Parks Victoria 2007). The existence of these habitats is driven by a range of critical components and processes discussed in this description, including bathymetry, tidal regime, climate, water quality, geomorphology and sedimentation.

The variety of fish species within the Ramsar site provides a critical food source for a number of waterbird species, for which the site was listed in 1982, and marine mammals, including dolphins and seals. In addition, they are important in transferring production of aquatic vegetation to higher trophic levels.

The diversity of fish within the Ramsar site enables the use of wetland products in commercial fishing and provides numerous opportunities for recreation and tourism. Recreational fishing and passive recreation (bird watching, penguin parade, seals and dolphins, etc.) are important cultural services offered by the Ramsar site.

Significant species

Component description and driving forces

The Ramsar site has supported a number of threatened fauna species prior to and after listing. Appendix G provides a full list of threatened fauna species (national and state significance) that have been historically recorded within the boundary of the Ramsar site and documented on the Atlas of Victorian Wildlife (AVW) Database (DSE 2009d). Each of these, excluding nine recordings, has been recorded in or prior to 1982 although not all are considered critical in maintaining the site's character (Appendix G).

Eighteen species recorded within the Ramsar site in or prior to 1982 are listed under the federal *EPBC Act 1999* (Table 2.12). Several of the nationally threatened species recorded within the Ramsar site are pelagic seabirds, such as albatrosses, that are known to enter the site opportunistically to feed in deeper areas especially during rough weather. Although the site supports these listed species they are not considered critical in maintaining the site's character. The site provides important overwintering habitat for the listed Orange-bellied Parrot, for which the site is considered to be of national zoological significance.

According to the AVW, an additional fauna species of national significance has been historically recorded within a 500 m buffer of the Ramsar site boundary. The Regent Honeyeater (*Xanthomyza phrygia*) is currently listed as endangered under the federal *EPBC Act 1999*, and is listed under the Victorian *FFG Act 1988*. This additional species is considered important in describing the ecological character of the Ramsar site as it illustrates that complementary habitats exist beyond the boundary of the Ramsar site.

The Ramsar site has also supported a number of waterbirds considered critical to the site's character listed under international bilateral agreements prior to and following 1982 (Appendix D). This includes 36 waterbird species listed under CAMBA and 38 species listed under JAMBA. An additional two species, Australian Painted Snipe and Orange-bellied Parrot would also be included under JAMBA by virtue of their threatened status in Australia. Thirty-four species recorded within the site are also listed under ROKAMBA (Appendix D). As discussed above, these species are considered to significantly contribute to the character of the Ramsar site as it provides one of three most important sites in Victoria for migratory waders.

Table 2.12 Atlas of Victorian Wildlife Database Records: Nationally significant threatened fauna recorded within the Ramsar site (Source: DSE 2009d)

Common name	Scientific name	Year recorded	EPBC status	FFG status	DSE status
Australian Painted Snipe	*Rostratula australis*	1966, 1974	Vulnerable	Listed	Critical
Black-browed Albatross	*Thalassarche melanophris*	1971, 1974, 1975, 1976, 1977, 1978, 1980, 1981, 1994	Vulnerable		Vulnerable
Blue Petrel	*Halobaena caerulea*	1973, 1980, 1985, 1998	Vulnerable		
Fairy Prion	*Pachyptila turtur*	1960, 1966, 1974, 1975, 1977, 1978, 1979, 1980, 1981, 1983, 1998	Vulnerable		Vulnerable
Grey-headed Albatross	*Thalassarche chrysostoma*	1974	Vulnerable	Listed	Vulnerable
Grey-headed Flying-fox	*Pteropus poliocephalus*	1952, 1966, 1981	Vulnerable	Listed	Vulnerable
Growling Grass Frog	*Litoria raniformis*	1788, 1979	Vulnerable	Listed	Endangered
Helmeted Honeyeater	*Lichenostomus melanops cassidix*	1948	Endangered	Listed	Critically endangered
Long-nosed Potoroo	*Potorous tridactylus*	1971, 1976	Vulnerable	Listed	Endangered
Northern Giant-Petrel	*Macronectes halli*	1974	Vulnerable	Listed	Near threatened
Orange-bellied Parrot	*Neophema chrysogaster*	1974, 1975, 1976, 1977, 1980, 1981, 1983 1984, 1985, 1987, 1992, 1994	Critically endangered	Listed	Critically endangered
Royal Albatross	*Diomedea epomophora*	1976	Vulnerable	Listed	Vulnerable
Shy Albatross	*Thalassarche cauta*	1974, 1977, 1978, 1979, 1980, 1981, 1994, 1998	Vulnerable	Listed	Vulnerable
Southern Brown Bandicoot	*Isoodon obesulus obesulus*	1968, 1970, 1971, 1975, 1979, 1980	Endangered	Listed	Near threatened[#]
Southern Giant-Petrel	*Macronectes giganteus*	1974, 1975, 1980, 1983, 1985	Endangered	Listed	Vulnerable
Swift Parrot	*Lathamus discolor*	1979, 1980, 1995	Endangered	Listed	Endangered
Wandering Albatross	*Diomedea exulans*	1977, 1978, 1983	Vulnerable	Listed	Endangered
Yellow-nosed Albatross	*Thalassarche chlororhynchos*	1977	Vulnerable	Listed	Vulnerable

Current DSE status requires confirmation

In addition to supporting listed threatened species, the Ramsar site supports a number of sites of national, state and regional zoological significance (Table 2.13).

Table 2.13 Sites of national, state and regional zoological significance within the Ramsar site (source: Parks Victoria 1999)

Site	Significance	Description
Primary foraging area of waders in Western Port	National	Western Port is one of the three most important areas for migratory waders in south east Australia with respect to total numbers and density.
Yallock Creek mouth	National	A major high tide roost for migratory waders.
Settlement Road	National	One of the few sites within Western Port where the Orange-bellied Parrot (*Neophema chrysogaster*) was recorded. The shore is also a major high tide roost for migratory waders.
Reef Island	National	Important high tide roost for migratory waders and other waterbirds.
French Island	National	Although the body of French Island is not within the boundary of the Ramsar site, the shores are considered part of the wetland area. The extensive saltmarsh areas provide valuable breeding sites for waterfowl.
		Tortoise Head provides one of the two most important roosts in the Ramsar site and is the most important roost for Mongolian Plovers (*Charadrius mongolus*) and Eastern Curlews (*Numenius madagascariensis*). The site also supports a breeding colony of Short-tailed Shearwaters (*Puffinus tenuirostris*), Caspian and Fairy Terns (*Sterna caspia* and *Sterna nereis*).
		Rams Island provides an important breeding site for the Fairy Tern and is also used for breeding by Caspian Terns and Pied Oystercatchers (*Haematopus longirostris*). The island is also one of the most important roosting sites for waders.
		Elizabeth Bluff (Red Bluff) is a site where the White-bellied Sea-eagle (*Haliataeetus leucogaster*) is known to breed.
		Barrallier Island provides a large high tide roost where some of the highest numbers of waders in Western Port have been observed.
Yaringa	State	One of the few sites in the state where the New Holland Mouse (*Pseudomys novaehollandiae*) has been recorded. The Southern Emu-Wren (*Stipiturus malachurus*) is also locally common in the saltmarshes of this site.
Secondary foraging areas of waders in Western Port	State	The intertidal mudflats provide important feeding sites for a number of migratory waders.
Tooradin	State	The Mourning Skink (*Egernia coventryi*), a species regarded as uncommon and has restricted habitat preferences has been found in high densities at this site. The saltmarsh and mangroves at the site also provide an important roost for a number of waterbirds.
Bass River mouth	State	The Orange-bellied Parrot has been observed in the saltmarsh vegetation opposite Reef Island.

Linkages to other components, processes, benefits and services

The Ramsar site is known to support a variety of threatened fauna species, directly resulting from the diversity of habitat types offered. Deeper areas of the site attract pelagic seabirds for feeding, whilst waders are drawn to the intertidal areas exposed at low tide.

Wetland bathymetry determines the potential depth and period of inundation with deep wetlands taking longer to dry than shallow ones after filling. The depth and duration of inundation in turn influences vegetation composition and health, which contributes to different habitat types that are required by different fauna species.

Terrestrial vegetation along the site boundary also provides suitable habitat for a number of nationally listed mammals and terrestrial bird species (Table 2.10), although these are not considered to significantly contribute to the character of the Ramsar site.

2.4 ECOSYSTEM BENEFITS AND SERVICES

Ecosystem benefits and services are currently defined as 'the benefits that people receive from ecosystems' (DEWHA 2008).

Four main categories of ecosystem benefits and services have been identified within the National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands:

> Provisioning services—the products obtained from the ecosystem such as food, fuel and fresh water
>
> Regulating services—the benefits obtained from the regulation of ecosystem processes such climate regulation, water regulation and natural hazard regulation
>
> Cultural services—the benefits people obtain through spiritual enrichment, recreation, education and aesthetics
>
> Supporting services—the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.

Table 2.14 provides a summary of ecosystem benefits and services identified within the Ramsar site, and the relationships with critical components and processes discussed throughout this description.

Table 2.14 Ecosystem benefits and services at Ramsar site

Benefit and service	Summary description	Contributing critical components and processes
PROVISION SERVICES		
Commercial port	Western Port has been a used as a commercial port since the 1960s and is considered to be of national economic significance. The Port of Hastings receives approximately 200 vessels each year. A 25-year staged development of the port is planned to cater for anticipated growth.	Bathymetry: the site has naturally deep channels which allow ship passage and supports a valuable commercial port.
Wetland products—commercial fishing	The Ramsar site is an important source of commercial fishing although suffering a decline since the 1960s and following a ban on commercial net fishing. The total commercial catch for 1981/82 and 1982/83 were 179 t and 142 t, respectively. The estimated values of which were $368 000 and $311 000, respectively.	Seagrass beds provide important nursery habitat for commercially significant species such as King George and Blue Rock Whiting (*Sillaginodes punctatus* and *Haletta semifasciata*, respectively). Seagrass beds provide important primary food sources, including invertebrates and flora. Bathymetry: contributes to diverse marine habitats supporting distinct fish assemblages.
CULTURAL SERVICES		
Recreational fishing	The Ramsar site has long been an important source of recreational fishing and, following the ban on commercial net fishing in 2007, was declared a 'recreational fishing haven' (EPA undated).	Seagrass and mangrove vegetation provides important nursery habitat for fish species. Invertebrate populations provide an important food source. Bathymetry contributes to diverse marine habitats supporting distinct fish assemblages.
Passive recreation	Recreational sailing and boating are popular activities within the Ramsar site. Paragliding is popular near Observation Point. Hovercrafting is also growing in popularity. The site offers excellent opportunities for passive recreation, including bird watching, bushwalking, sightseeing, picnicking, and visiting local beaches. The surrounding areas offer excellent tourist attractions, including the French Island National Park, Churchill Island and Port Phillip Nature Park.	Bathymetry and tidal regime enable recreational boating. Waterbirds occurrences draw tourists and bird watchers to the site. Fish and invertebrate populations provide an important food source for birds and marine mammals.
Spiritual and inspirational	The site supports a number of cultural heritage sites listed on the Victorian Aboriginal Heritage Register as well as sites of important European heritage (e.g. Churchill Island).	Fish provide an important food source. Bathymetry: naturally deep channels facilitate boating and passage.

Table 2.14 Continued

Benefit and service	Summary description	Contributing critical components and processes
SUPPORTING SERVICES		
Biodiversity—wetland type/habitat availability	The site supports a variety of marine habitat types which are critical elements of the wetland ecosystem attracting an array of invertebrate, fish and waterbird species.	Bathymetry, tidal regime and climate contribute to diverse habitats, e.g. intertidal mudflats, mangroves, and seagrass beds. Characteristic flora species define several habitat types.
Biodiversity—high diversity of waterbird species	Over the term of the BOCA survey, 115 waterbird species considered critical to the site's character, have been recorded.	Bathymetry, tidal regime, and climate contribute to diverse habitats, e.g. intertidal mudflats, seagrass beds. Critical flora and fauna components provide primary food sources, e.g. seagrass, invertebrates, fish. Mangroves and saltmarsh vegetation provide important high tide roosts.
Distinct or unique wetland species—seagrass, mangrove and saltmarsh communities	The Ramsar site supports the most developed and extensive mangrove population in Victoria and extensive seagrass communities. The site also supports the most floristically diverse saltmarsh in Australia. These vegetation communities provide significant habitat for a variety of native flora and fauna species, and play an important role in stabilising the coastal system and nutrient cycling in the bay.	Bathymetry, tidal regime, geomorphology and sedimentation, climate, and water quality contribute to suitable conditions for vegetation growth.
Threatened wetland species, habitats and ecosystems	Species of Victorian conservation significance characteristic of the mangrove fringe and saltmarsh vegetation. Supports a marine invertebrate community of Victorian conservation significance (San Remo Marine Community). Important overwintering habitat for the nationally listed Orange-bellied Parrot (*Neophema chrysogaster*).	As above.
Priority wetland species and ecosystems	Supports a number of migratory waders protected under bilateral agreements, including JAMBA, CAMBA and ROKAMBA Supports globally threatened species, including the Fairy Tern (*Sterna nereis*).	As above.

2.4.1 Provisioning services

Commercial port

The bathymetry of the site has facilitated the development of a valuable and busy commercial port for Victoria. The Port of Hastings (situated within the Ramsar site boundary) represents a significant state economic asset (DSE 2003). Western Port has been used as a commercial port since the 1960s and is considered to be of national economic significance as a result of its natural deep channels and potential for future development (DSE 2003).

Western Port facilitates large scale international shipping with the Port of Hastings receiving approximately 200 vessels each year (EPA undated). Commercial shipping, port and industrial facilities occur within the Western Entrance and the lower north arm of the Ramsar site (CCB 2003).

It has been forecasted that the Port of Hastings will reach capacity beyond 2030. The Port of Hastings Land Use and Transport Strategy therefore details the proposed staged development, over 25 years, of the port to cater for anticipated growth (Maunsell 2006). As part of the proposed strategy, the Port of Hastings endeavours to create a sustainable port development (Maunsell 2006). Threats to the Ramsar site associated with the port and its proposed expansion are discussed in Section 4.

Wetland products–Commercial fishing

At the time of listing the Ramsar site was an important source of commercial fishing. The commercial fish catch from Western Port is reported to have experienced a slow decline since the mid-1960s. Table 2.15 details the total commercial catch and estimated value for each of the major species caught 1981/1982 and 1982/1983. This provides quantitative information on the commercial fish catch taken from Western Port at the time the Ramsar site was listed (DPI 2008a). The total commercial catch for 1981/82 and 1982/83 were 179 t and 142 t, respectively. The estimated values of which were $368 000 and $311 000, respectively (Table 2.15).

In 2007/08, the commercial catch of 30 t had a wholesale value of $254 000 (DPI 2008a). A ban on commercial net fishing in Western Port was enacted in 2007. However, commercial long-line fishing is still permitted.

No aquaculture activities are known to exist within the boundaries of the Ramsar site (DSE 2003).

The components and processes considered critical in maintaining the site's character provide suitable habitat for a variety of commercially significant species.

Wetland bathymetry contributes to diverse marine habitats which support distinct fish assemblages (Section 2.2.7). Intertidal seagrass beds support an array of fish species attracted to the diversity of primary food sources, including marine invertebrates and flora species. Seagrass beds also provide important nursery habitat for King George Whiting, the catch of which was worth $77 000 and $56 000 in 1982 and 1983 respectively (Table 2.15).

The diverse marine habitats also support a number of mobile, pelagic fish species of commercial significance, including Australian Salmon and Yellow-eye Mullet. For example, although not exclusively, Yellow-eye Mullet are known to feed on seagrass (MAFRI 2002). In 1982, the commercial catch of Australian Salmon and Yellow-eye Mullet was worth $24 000 and $21 000 respectively.

Table 2.15 Commercial catch and value for each major species caught in Western Port during 1981/82 and 1982/83 (Source: adapted from DPI 2008a)

		Commercial catch (t)		Values ($)	
Species	Scientific	1981/1982	1982/1983	1981/1982	1982/1983
Australian Salmon	*Arripis trutta* and *A, truttacea*	25	19	24,000	22,000
Australian Sardine (Pilchard)	*Sardinops sagax*	0	1	0	1,000
Barracouta	*Thyrsites atun*	1	1	1,000	1,000
Calamari, Southern	*Sepioteuthis australis*	15	12	59,000	43,000
Elephantfish	*Callorhinchus milii*	0	0	0	0
Flathead, Rock	*Platycephalus laevigatus*	22	23	30,000	34,000
Flounder, Greenback	*Rhombosolea tapirina*	2	2	5,000	7,000
Garfish, Southern	*Hyporhamphus melanochir*	26	13	50,000	29,000
Mullet, Yellow-eye	*Aldrichetta forsteri*	29	26	21,000	20,000
Shark, Gummy	*Mustelus antarcticus*	6	4	16,000	11,000
Snapper	*Pagrus auratus*	3	3	9,000	9,000
Weed-Whiting, Blue	*Haletta semifasciata*	4	2	2,000	1,000
Whiting, King George	*Sillaginodes punctata*	15	10	77,000	56,000
Other		31	26	74,000	77,000
Total		**179 t**	**142 t**	**$368,000**	**$311,000**

2.4.2 Cultural services–recreation and tourism

Recreational fishing

The Ramsar site has long been an important source of recreational fishing. The marine habitats offered by the site support distinct assemblages of fish species attracted to suitable habitat conditions and primary food sources. In 2007, following the ban on commercial net fishing, the Department of Primary Industries (DPI) declared the area a ‘Recreational Fishing Haven’ (EPA undated).

Although quantitative estimates for the commercial fish catch are provided for a long period in Western Port, quantitative information is not available for the recreational catch within the bay (DSE 2003).

Over time, technological improvements have resulted in an increase in the recreational fishing effort within Western Port (DSE 2003a). This has in turn led to an increase in pressure on fish stocks within the bay.

Passive recreation

Recreational sailing and boating is also popular within the Ramsar site (DSE 2003; EPA undated). Hovercrafting and paragliding are also growing in popularity. However, quantitative information on boating within the Ramsar site is not available for 1982.

The Ramsar site has long been recognised for the diversity of waterbirds that visit Western Port. As such, the Ramsar site offers excellent opportunities for passive recreation, including bird watching. Other recreational activities that are popular with the Ramsar site include bushwalking, sightseeing, picnicking, and visiting local beaches (DSE 2003). Quantitative information is not available for these activities within the Ramsar site.

No major tourist attractions exist within the boundary of the Ramsar site; however the French Island National Park, Churchill Island and Port Phillip Nature Park receive 6000, 17 000 and 1.5 million visitors per year, respectively (DSE 2003). The Penguin Parade on Phillip Island is known to be one of the most important sources of recreation within the vicinity of the site receiving 528 000 visitors a year, including 300 000 international tourists. The Koala Conservation Centre, which also forms a component of the Phillip Island Nature Park, regularly records 100 000 visitors (PINPBoM 2001, cited in DSE 2003).

2.4.3 Spiritual and inspirational

The Ramsar site is known to support a number of cultural heritage sites. DSE (2003) state that twelve Aboriginal archaeological sites within the Ramsar boundary are listed on the Victorian Aboriginal Heritage Register. This register is administered by Aboriginal Affairs Victoria (AAV). In addition, more recent cultural heritage sites have been discovered and are in the process of being recorded with AAV (M. Rodrigue [Parks Victoria] 2009, pers. comm., 20 August).

Churchill Island is the site of Victoria's first settlement consisting of the first planting of European crops and the earliest known substantial building.

Western Port has also been listed on the Register of the National Estate for its outstanding marine and coastal environment.

2.4.4 Supporting services

The ecosystem services of the Ramsar site are largely related to the criteria for which the site was listed. These services have been defined in accordance with the National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands (DEWHA 2008) and are discussed below.

Biodiversity—wetland type/habitat availability

DEWHA (2008) provides the following definition of biodiversity as a wetland ecosystem service or benefit:

> Supports a variety of wetland species, communities, habitats, and geomorphic features.

In 1982, the Ramsar site satisfied original Criteria 1(a) and 1(b) due largely to the diverse habitat types, particularly seagrass, saltmarsh and mangrove vegetation, exhibited in comparison to other sites within the South East Coastal Plain. Although comprehensive analyses of wetland types within the newly adopted Drainage Division 2: South East Coast is yet to be undertaken, the provision of diverse marine habitats is considered a critical supporting service. The existence of an array of diverse marine habitats forms the critical elements of the wetland ecosystem.

As discussed in Section 2, the site provides examples of eight marine habitats defined primarily by tidal level, substrate type, exposure to wave energy, and dominant flora. These habitats in turn attract a variety of invertebrate, fish and waterbird species, many of which exhibit distinct assemblages.

It is this habitat diversity that makes the Ramsar site very significant for the numbers and variety of plants and animals it supports.

Biodiversity–high diversity of waterbird species

Although the existence of waterbirds within the Ramsar site is considered a critical component, the ability of the site to support a high variety of waterbird species is a supporting service.

Section 2.2.7 describes the diverse range of waterbird species recorded within the Ramsar site. Over the term of the BOCA surveys, 115 waterbird species considered critical to the site's character (largely non-pelagic) have been recorded within the Ramsar site.

Interactions between critical processes and components provide suitable habitat for an array of waterbirds. For example, vegetated seagrass beds feature as the primary source of food for Black Swans, whilst invertebrates within the mud attract Australian White Ibis. Assemblages of fish species, which characterise various marine habitats, attract species such as cormorants and Australian Pelican.

In addition, the Ramsar site represents one of the three most important areas for migratory waders in south east Australia, for which it is considered to be of national zoological significance. Invertebrates of the intertidal mudflats provide an important food source for migratory waders. Saltmarsh and mangrove vegetation, spits and islets also provide important high tide roosts for a number of species.

Deeper sections of the Ramsar site provide suitable habitat for a number of pelagic waterbirds which opportunistically feed within the site. These species do not contribute significantly to the site's character; however they illustrate the diversity of habitat provided.

Distinct or unique wetland species–seagrass, mangrove and saltmarsh communities

Although the presence of seagrass, mangrove and saltmarsh communities within the Ramsar site constitute critical ecosystem components, the ability to provide suitable habitat for these communities is also considered an important supporting service.

The Ramsar site supports the most developed and extensive mangrove population in Victoria (Ross 2000) and extensive seagrass communities Blake and Ball (2001). In addition, the site supports the most floristically diverse saltmarsh in Australia (such as at Yaringa Marine National Park, Quail and Chinamans Islands) (Rogers et al. 2005; M. Rodrigue [Parks Victoria] 2009, pers. comm., 23 June). These vegetation communities are important to the marine and surrounding environment.

As previously discussed, seagrass is an ecologically significant marine habitat that is both highly productive and provides food and shelter for many organisms (Blake and Ball 2001). Seagrass meadows provide food and shelter for benthic fauna and scavenger communities living in the mudflats, these in turn provide food for fish, crustaceans, birds and waterbirds (Blake and Ball, 2001). Many organisms receive nutrients from seagrass detritus, either directly or indirectly. Some animals feed directly on the seagrass, such as Black Swans, while others graze on epiphytes or seagrass detritus. Seagrass meadows also provide ideal habitats for fish and especially as a nursery for juvenile fish.

The mangrove and saltmarsh vegetation of the Ramsar site has been reported to be of regional, national and international significance because it plays an important role in stabilising the coastal system, nutrient cycling in the bay and providing wildlife habitat (Ross 2000).

Threatened wetland species, habitats and ecosystems

Sections 2.2.6 and 2.2.7 identify the significant species supported by the Ramsar site that are considered critical in maintaining the character of the wetland. Although the presence of these species is a critical ecosystem component, the ability of the site to support these species is also considered an important supporting service.

White Mangrove, a species listed as rare within Victoria, characterises the mangrove fringe within the site. This is the only species of mangrove to occur within Victoria. The interaction of bathymetry, geomorphology and sedimentation, tidal regime, climate and water quality provides suitable conditions for this species where it is nearing its southern limit. The interaction between these processes and components also enables the site to support listed flora species characteristic of saltmarsh vegetation.

Distinct assemblages of marine invertebrates characterise habitats within the site. Of particular note, the site is known to support San Remo Marine Community, a community listed under the Victorian *FFG Act 1988*. The site’s bathymetry, tidal regime and geology provide important habitat for this listed community which extends from the coastline to the edge of a deep channel.

Saltmarsh habitat within the site provides important overwintering habitat for the nationally listed Orange-bellied Parrot. Small numbers of this species use the saltmarsh habitat during winter flying from their breeding sites in Tasmania.

Priority wetland species and ecosystems

The Ramsar site provides important habitat for a number of migratory waders protected under bilateral agreements, namely CAMBA, JAMBA and ROKAMBA (Section 2.2.7). The site is also known to be a suitable breeding habitat of Fairy Tern, a globally threatened species listed as vulnerable on the IUCN Red List of Threatened Species.

Important food sources are provided through the interaction of the tidal regime and bathymetry which provides extensive intertidal mudflats rich in marine invertebrates. Of equal importance, saltmarsh and mangrove vegetation, and geomorphic features such as islets provide important high tide roosts for many of these species.

3 Limits of acceptable change

This section provides quantitative baseline information for each of the critical components and processes outlined within this description, and identifies limits of acceptable change where possible. Limits of acceptable change are defined as:

> The variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameter, etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character that could lead to a reduction or loss of the values for which the site was Ramsar listed. In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed
>
> (Phillips 2006, cited in Hale and Butcher 2007).

Limits of acceptable change therefore acknowledge the natural variability exhibited by elements within the wetland ecosystem and establish guidelines that facilitate the assessment of change (either positive or negative) to the ecological character resulting from human activities.

Where available, quantitative baseline information for critical ecosystem components and processes from 1982 has been summarised in Table 3.1. Following this, where possible, limits of acceptable change from these baseline values have been established. Where current knowledge gaps inhibit the ability to set limits of acceptable change these have been explicitly stated below and discussed further in Section 6.

In acknowledging the difficulties associated with establishing limits of acceptable change, the following confidence levels have been applied where possible:

- High: based on long-term data considered to be adequate for establishing limits of acceptable change
- Moderate: based on empirical data; however considered unlikely to describe natural variability in time. This can include
  - repeated measurements over a limited time frame, or no/limited data available pre-listing
  - single measurement (no temporal context) of the extent of a particular habitat type, abundance of a species or diversity of an assemblage

- Low: not based on empirical data describing patterns in natural variability. These may be
  - based on a range of acceptable sources, including published documents, personal communication with relevant scientists and agency staff
  - established based on the best professional judgement of the authors where there is a distinct lack of quantitative data or published information.

Table 3.1 Limits of acceptable change for critical components and processes within the Western Port Ramsar site

Critical ecological components and processes	Baseline condition and natural variation where known	Limits of acceptable change	Level of confidence
Wetland bathymetry	Extensive areas (approximately 270 km^2) of intertidal mudflats less than 15 m in depth intersected by deep channels greater than 20 or 30 m in some areas	Limits of acceptable change: no loss of intertidal mudflat area (270 km^2)	Low
Geomorphology and sedimentation	Estimated mean sediment input load to Western Port following European settlement varies between approximately 40 000 and 100 000 t/a In 1975, coarse and medium sand was concentrated mainly towards the western entrance, encircled French Island and along inshore areas and channel margin banks Depositional fans existed near the mouths of river inlets Finer sediments (fine sand, silt and clay) occurred on intertidal zones	Limits of acceptable change unable to be established. Further advice required Better Bays and Waterways (EPA undated) has identified a committed target of reducing sediment loads by 1000 t/a by 2014	
Flora—seagrass	Area of seagrass and macroalgae cover in Western Port in 1983/84: 72 km^2 Larger patches of seagrass coverage at the time of listing were located in the western entrance, upper north arm, and Rhyll segments (Figure 2.6)	Limits of acceptable change not able to be set based on 1982 data as seagrass distribution in 1983/84 appears to have been the lowest since the early 1970s, resulting most likely from human activities influencing water quality. Further advice is required	
Flora—saltmarsh	Area of saltmarsh vegetation in Western Port in 1984: 31 000 ha Distribution is considered to closely correspond with that of mangrove vegetation below	Limits of acceptable change: 15 per cent change from 31,000 ha, based on data from 1974	Low
Flora—mangrove	Area of mangrove vegetation in Western Port in 1984: 13 700 ha In 1984, near continuous coverage of mangrove vegetation was reported along the western and northern shoreline of the Ramsar site, and along the northern shoreline of French Island. The eastern shoreline was largely characterised by scattered mangrove vegetation In 1975 the community was described as monospecific, consisting of mature trees, with small seedlings abundant on landward and seaward margins	Limits of acceptable change: 10 per cent change from 13 700 ha, based on data from 1974 and EPA (1996) which states that prior to 1974, distribution changed substantially	Low
Flora—significant species	As above for White Mangrove (*Avicennia marina* subsp. *australasica*) and saltmarsh vegetation	As above for White Mangrove (*Avicennia marina* subsp. *australasica*) and saltmarsh vegetation	Low
Fauna—waterbirds	115 waterbird species (largely non-pelagic) recorded within the site Total numbers of waders and other non-pelagic waterbirds have exceeded 20,000 in all years of the BOCA survey. The Ramsar site regularly supports more than 1 per cent of the estimated flyway population of five wader species, and three other non-pelagic waterbird species	Limits of acceptable change unless it can be demonstrated that change is due to extrinsic factors Based on BOCA survey data: a drop in mean or maximum values of ≥ 20 per cent over a five year period for the guilds identified (Table 2.9)	High
Fauna—marine invertebrates	In 1974, surveys of Western Port benthos reported 19 853 individuals recorded from 14 phyla. The largest number of individuals recorded (10 819) were Polycaetes from the Annelida phylum	Limits of acceptable change not able to be set. Further advice required. Additional quantitative information may be available at the University of Melbourne; however this was not accessed during the preparation of this description.	
Fauna—fish	No quantitative information is available around the listing of the site for 1982	Limits of acceptable change not able to be set as baseline data for 1982 was not readily available at the time of preparing this description. Quantitative information may be available in surveys undertaken by Edgar et. al. (1994, cited in EPA 1996) or Edgar and Shaw (1995a, 1995b and 1995c, cited in EPA 1996); however these reports were unable to be accessed during the preparation of this description	

3.1 WETLAND BATHYMETRY

Intertidal mudflats, which cover 270 km^2, are an important feature of the site, providing a number of resources to marine invertebrates, fish and waterbirds. As such, the area of intertidal mudflats is considered an appropriate limit of acceptable change in order to assess change to wetland bathymetry in lieu of additional quantitative information. As a result of limited quantitative information available for the bathymetry of the site in 1982, this limit of acceptable change has a low level of confidence.

Human activities within the site, such as dredging particularly as a result of Port development, have the ability to result in physical alteration to this habitat. In addition, climate change and consequent sea level rise significantly threatens the availability of intertidal mudflats within the site.

Further investigations are required to establish definitive associations between ecological response to changes in habitat availability in order to determine appropriate limits of acceptable change, i.e. marine invertebrate, fish and waterbird numbers in relation to intertidal mudflat availability or sediment deposition in deep channels.

Confirmation on the availability and detail of bay wide marine habitat mapping is also required to provide a benchmark for future comparisons and determine an acceptable percentage change in marine habitats resulting from human induced activities.

3.2 GEOMORPHOLOGY AND SEDIMENTATION

In the absence of information on the required or 'ideal' sediment loads to protect values exhibited by the Ramsar site, limits of acceptable change have not been able to be established.

The Better Bays and Waterways Program (EPA undated) identified a committed target of reducing sediment loads by 1000 t/a by 2014 which would equate to 6000 t or 15 per cent of the total sediment input load from 1973 to 1985 (Section 2.2.3). This is considered an appropriate management trigger; however cannot be directly translated into limits of acceptable change until further investigations are carried out.

Further investigations are required to establish definitive associations between ecological response to changes in habitat availability and water quality such as faunal diversity in response to fluctuating turbidity levels. Additional investigations into the required reduction of sediment loads, or 'ideal inputs', in order to protect environmental values have been identified as a requirement within the Better Bays and Waterways Program (EPA undated).

Confirmation on the availability of bay wide marine habitat mapping is also required to provide a benchmark for future comparisons and determine an acceptable percentage change in marine habitats.

3.3 FLORA—SEAGRASS

Establishing limits of acceptable change for seagrass coverage based on 1982 data is complex as seagrass distribution at this time was the lowest since the early 1970s, the causes of which remain uncertain but is likely to have been a result of human activities influencing water quality.

Site-specific monitoring records for seagrass within the Ramsar site are short in comparison to monitoring in other areas, such as Port Phillip, which further restricts the ability to establish limits of acceptable change (D. Ball [DPI] 2009, pers. comm., 16 July). Year to year and decadal criteria based on long-term variation have been established for seagrass cover at Blairgowrie in Port Phillip as part of Seagrass Monitoring Program of the Channel Deepening Baywide Monitoring Programs (DPI 2008b; DPI 2009). However, these criteria cannot be directly transferred to the Ramsar site as they are site-specific and need to be further investigated as an option for establishing limits of acceptable change.

Seagrass coverage and health within the Ramsar site experiences natural levels of variation. CEE (1995, cited in EPA 1996) identified that seagrass cover between 1939 and 1970 fluctuated around 250 km^2; however the magnitude of fluctuation was not quantified. In addition, a recovery rate of approximately 30 ha over 10 years has been reported by EPA (1995) based on recovery that occurred between 1983 and 1994 following the loss of 170 km^2 between 1973 and 1983.

Additional advice is required to determine an acceptable level of change in, or ‘healthy’ levels of, seagrass distribution and health within the site. This will also require investigations to establish clear relationships in ecological responses to changes in seagrass availability, i.e. waterbird and fish diversity and abundance in relation to seagrass distribution and health.

A comprehensive survey of the current distribution and health of seagrass across the site is required. Confirmation on the availability of bay wide marine habitat mapping is also required to provide a benchmark for future comparisons and determine an acceptable percentage change in seagrass distribution resulting from human activities.

3.4 FLORA—SALTMARSH AND MANGROVE

Mangrove and saltmarsh distribution has been reported to have changed substantially between 1842 and 1939 with additional changes between 1939 and 1974, as a result of historical clearance (Bird and Barson 1975, cited in EPA 1996; Ross 2000). As no commentary has been provided on changes between 1974 and 1984, and as data suggests an increase in distribution of both communities over this time, this level of change is considered to represent a ‘natural’ level of recovery within the site and may be used as limits of acceptable change. Fifteen per cent change to the baseline saltmarsh distribution and 10 per cent change to baseline mangrove distribution have been calculated based on data from 1974 and 1984 (Table 2.5).

These limits of acceptable change are considered to have a low level of confidence as a result of insufficient information available on natural variation and definitive associations between changes in habitat availability and health and ecological response. In particular, changes to waterbird diversity and abundance in response to fluctuations in vegetation distribution and health require investigation.

A comprehensive assessment on current saltmarsh and mangrove distribution and health within the site is required. In addition, confirmation on the availability and detail of bay wide marine habitat mapping is also required to provide a benchmark for future comparisons and determine an acceptable percentage change in marine habitat availability.

3.5 FAUNA—WATERBIRDS

Based on BOCA survey data since 1973 and considering natural variability, a decline in the mean or maximum counts of 20 per cent over a five year period for the non-pelagic guilds identified in Table 2.9 is considered an appropriate limit of acceptable change (R. Loyn [ARI] 2009, pers. comm., 20 July). As waterbird numbers within the site can ultimately be influenced by extrinsic factors it is recommended that this limit of acceptable change only be applied unless it can be demonstrated that fluctuating numbers have resulted from external factors.

Additional investigations are required to clarify relationships between waterbirds and habitat availability. For example, fluctuations in Orange-bellied Parrot numbers within the site are not believed to result solely from variations in saltmarsh distribution (R. Loyn [ARI] 2009, pers. comm., 20 July).

3.6 FAUNA—MARINE INVERTEBRATES

Limits of acceptable change for marine invertebrates were not able to be established due to a limited understanding of natural variation in diversity and abundance within the site.

To use marine invertebrates as a limit of acceptable change, if desired, a comprehensive assessment of invertebrate assemblages within each of the marine habitats is required. In addition, further investigations are required to establish clear relationships between ecological response to changes in invertebrate diversity and abundance and habitat conditions. This may include changes in waterbird or fish abundance or changes in marine invertebrates in response to changes in seagrass health or tidal fluctuations.

3.7 FAUNA—FISH

Limits of acceptable change were not able to be set due to a lack of baseline information on fish available for the site in 1982 and limited understanding of natural variability within the site. Quantitative information may be available in surveys undertaken by Edgar et. al. (1994, cited in EPA 1996) or Edgar and Shaw (1995a, 1995b and 1995c, cited in EPA 1996); however these reports have not been accessed during the preparation of this description.

In addition, further investigations are required to assess the response of waterbirds to fish abundance and diversity, and the response of fish to changes in seagrass and mangrove distribution and health.

4 Threats to the ecological character of the Ramsar site

This section provides a summary (Table 4.1) and brief description of the potential impacts to wetland elements from threatening processes to the ecological character of the Ramsar site. A likelihood of each threat occurring has been provided and is based on the results of a risk assessment undertaken for PPWCMA. Kismet Forward (2009) defined likelihood as:

- Highly likely: expected to occur in most circumstances, i.e. more than 85 per cent chance of occurring within specified time frame
- Likely: will probably occur in most circumstances, i.e. 50–85 per cent chance of occurring within specified time frame
- Moderately likely: might occur at some time, i.e. 21–49 per cent chance of occurring
- Unlikely: could occur at some stage, i.e. 1–20 per cent chance of occurring
- Very unlikely: not expected to happen.

In addition, the anticipated timing has been provided for each threat. The timing of the threat may be:

- immediate
- immediate—medium term (1 to 5 years)
- medium (5 years)
- medium–long-term (5 years to decades).

Table 4.1 Summary of threats to the Ramsar site and their likelihood and timing of occurrence

Actual or likely threat or threatening activities	Potential impact(s) to wetland components, processes and/or services	Likelihood	Timing of threat
Historical site and catchment alterations	Vegetation removal Erosion Channelisation—enhanced sediment delivery Levees—disconnected waterways from the floodplain	N/a	N/a
Catchment and coastal erosion	Sediment input Elevated turbidity levels and poor water quality Loss of seagrass beds Loss of habitat Reduced ecosystem productivity	Likely	Immediate

Table 4.1 Continued

Actual or likely threat or threatening activities	Potential impact(s) to wetland components, processes and/or services	Likelihood	Timing of threat
Deteriorating water quality	Litter	Likely	Immediate
	Algal growth		
	Loss of seagrass beds from smothering		
	Eutrophication		
Shipping	Pollution from a variety of sources	Moderately likely	Medium–long-term
	Dredging leading to increased sediment input		
	Loss or fragmentation of wetland vegetation		
	Impacts associated with port development		
Recreational activities	Fragmentation to wetland vegetation particularly seagrass	Moderately likely	Immediate
	Recreational hovercrafting damaging seagrass and intertidal mudflats		
	Mechanical disturbance, groundings and propeller scour disturbing sediments		
	Disturbance to waterbirds		
	Uncontrolled vehicle access causing damage to intertidal mudflats		
Pest plants and animals	Encroachment of exotic flora and loss of habitat	Likely	Immediate
	Increased competition with native flora and fauna		
	Predation of native fauna species		
	Degradation to intertidal areas and native vegetation		
Climate change	Sea level rise and storm surges leading to increased inundation, habitat loss and erosion	Moderately likely	Medium–long-term
	Elevated sea water temperatures altering marine habitat		
	Reductions in rainfall causing fluctuations in water quality of catchment inflows		
Urban development	Increased litter, sediment and nutrient loads	Likely	Medium–long-term
	Habitat loss		
	Increased run-off and stormwater		
Grazing	Increased sediment loads from the catchment	Likely	Immediate
	Increased nutrient loads from the catchment		
Recreational and commercial fishing	Over-exploitation	Moderately likely	Medium
	Loss of food resource		
	Loss of ecosystem productivity		

4.1 HISTORICAL SITE AND CATCHMENT ALTERATIONS

A number of historical activities undertaken in association with European settlement and agricultural development have had long-term impacts on the Ramsar site. Large scale clearance of native vegetation and the construction of drains and channels have permanently changed the condition of the Ramsar site by reducing sediment deposition within the catchment and improving the efficiency of sediment delivery to the bay. Similarly, vegetation clearance has enhanced erosion within the catchment and sediment loads delivered to waterways. Channelisation has resulted in faster velocities reducing the potential for sediment deposition that would normally occur in a natural meandering waterway. The construction of levees has disconnected the waterways from the floodplain, further minimising opportunities for sediment deposition in the catchment.

4.2 CATCHMENT AND COASTAL EROSION

Previous reports have identified sediment inputs from the catchment as a serious threat to the health of the Ramsar site (DSE 2003; Wallbrink and Hancock 2003a). In a risk assessment completed for the PPWCMA, Kismet Forward (2009) determined that sediment input and redistribution was a threat of extreme priority to the health of seagrass vegetation within the French Island Marine National Park and high priority to migratory waders.

Impacts associated with European settlement, including large-scale land clearance and modifications to the natural drainage system, led to increases in catchment erosion and increased sediment delivery into the bay (Wallbrink and Hancock 2003a). In-stream bank erosion, catchment erosion and coastal erosion have been identified as major sources of sediment input to Western Port. Kismet Forward (2009), for example, identified headland and coastal erosion as a threat of extreme priority to the health of the Ramsar site with the potential to threaten saltmarsh and mangrove vegetation communities and migratory waders. Modifications to the catchment now provide limited opportunities for sediment storage on floodplains or in reservoirs (Hughes et al. 2003). As such, the major waterways contribute a high amount of sediment into Western Port, particularly after high rainfall events, most of which is discharged directly into the Ramsar site.

Sediment can have a range of detrimental impacts on the health of the Ramsar site (Figure 4.1). Increased sediment loads can lead to higher turbidities and decreased water quality which may impact hydrodynamic processes as well as marine flora and fauna (Parks Victoria 2007). Loss of seagrass beds can result from smothering by sediment and increased light attenuation (Longmore 1997; DSE 2003; Parks Victoria 2007). The loss of seagrass beds can further impact various components and processes, i.e. loss of feeding habitat for waders. The significant reduction in seagrasses in Western Port over time, for example, has been implicated in the reduced commercial fish catch by depleting fish stocks, particularly of species for which seagrass provides an important nursery habitat (EPA 1999a).

In addition, increased turbidity resulting from sediment input will result in a reduction in light penetration and photosynthesis. This in turn will influence energy fluxes throughout the food web and potentially result in reduced ecosystem productivity (DSE 2003). Changes in sediment deposition are also likely to have an impact on the subtidal soft sediments within the deep channels and the habitat they provide.

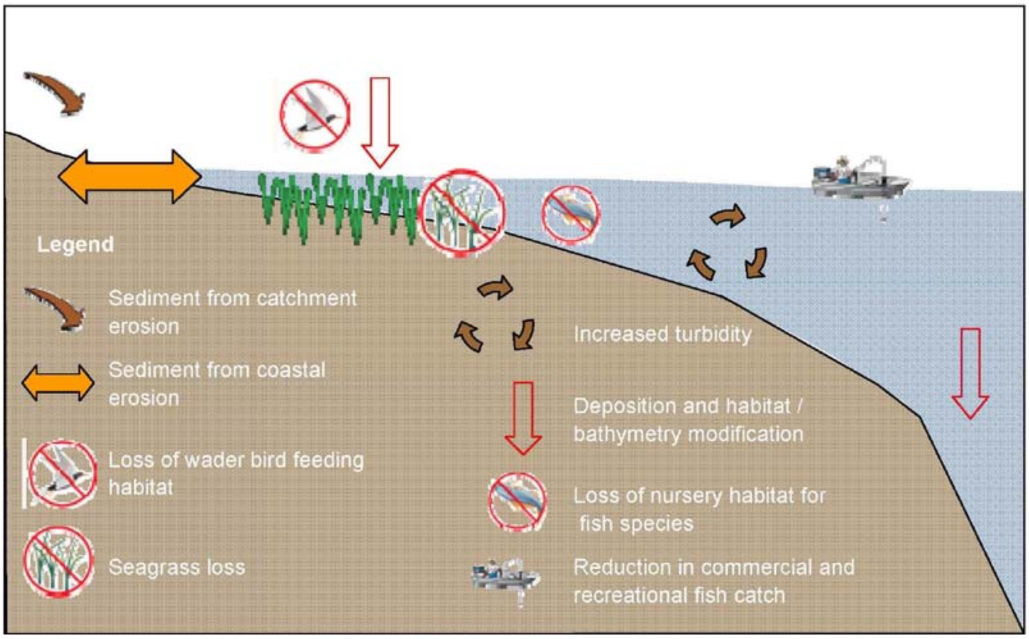

Figure 4.1
SIMPLE CONCEPTUAL MODEL ILLUSTRATING THE IMPACTS OF SEDIMENT INPUT TO THE RAMSAR SITE

4.3 DETERIORATING WATER QUALITY

Poor water quality, with specific focus on nutrients and toxicants, was identified as a threat of extreme priority to the health of the Ramsar site by Kismet Forward (2009) in a risk assessment undertaken for the PPWCMA. In particular, they identified it as a significant threat to seagrass, saltmarsh and mangrove vegetation, and migratory waders.

Increased nutrients are discharged into the bay via waterways, seepage from unsewered townships, stormwater and agricultural run-off from horticultural and dryland agricultural properties (Parks Victoria 2007). Elevated levels of nitrogen and phosphorus may have a number of detrimental impacts on the health of the Ramsar site (Figure 4.2). These include:

- algal blooms and increased epiphyte growth
- algal growth on seagrass, increased light attenuation, and a subsequent reduction in photosynthesis
- increased macroalgae production smothering seagrass beds and intertidal zones
- localised eutrophication leading to a number of associated impacts (DSE 2003; Parks Victoria 2007).

The vegetation communities that characterise the Ramsar site, including seagrass, mangroves and saltmarsh vegetation, are vulnerable to changes in herbicides and pollution as well as changes in nutrient levels (Longmore 1997; Parks Victoria 2007).

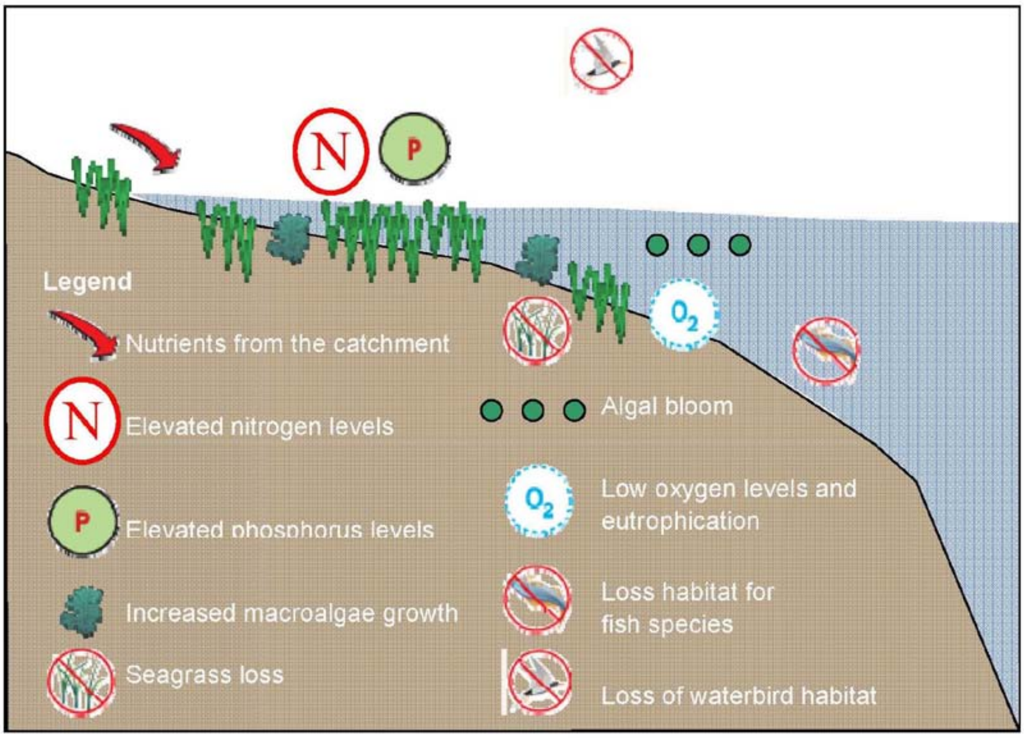

Figure 4.2
SIMPLE CONCEPTUAL MODEL ILLUSTRATING THE IMPACTS OF NUTRIENT INPUT TO THE RAMSAR SITE

Stormwater has also been identified as a potential threat to water quality and the health of the Ramsar site (EPA undated; Parks Victoria 2007). Stormwater can alter water quality by discharging sediments, nutrients, micro-organisms, toxic organics, heavy metals, oils, litter and debris into the Ramsar site. In addition, stormwater provides freshwater inputs into the bay that influence water quality. Stormwater threatens the Marine National Parks within the Ramsar site. Watsons Creek and its tributaries, for example, discharge stormwater directly into Yaringa Marine National Park. Watsons Creek is reported to have poor water quality with high nutrient levels (Parks Victoria 2007).

Litter also poses a threat to the water quality and health of the Ramsar site. Litter is transported to the site via waterways and stormwater. Parks Victoria (2007) state that sources of litter to the bay include: shopping centres, urbanised and industrial areas, vessels and recreational fishermen, and tourists and visitors. Litter can cause harm to fauna species, damage habitat and ruin the aesthetics of the site.

The impacts associated with stormwater and litter are likely to increase as a result of urban development and population growth, particularly in association with the Melbourne growth boundary and the Casey–Cardinia growth area. Water circulation within the bay has also magnifies the impacts of pollutants. The clockwise flow of water and slow flushing times in northern and eastern sections exacerbates water quality deterioration in these areas (Parks Victoria 2007).

In addition, a number of actual or likely threats have been identified as significant risks to water quality within the Ramsar site (EPA 1999, cited in DSE 2003):

- elevated levels of wastes and litter from shipping and boating activities, including the potential for oil spills (Section 4.4)
- poor quality of run-off from existing and proposed urban areas
- poor quality run-off from adjacent agricultural and horticultural land, including high levels of fertiliser and biocide, stock effluent
- potential impacts from non-sewered townships and sewage treatment plants in the catchment
- erosion resulting from dryland grazing and other land management practices
- elevated sediment yields resulting from logging within the catchment
- elevated sediment loads resulting from the existing and expanded sand extraction near the eastern arm of Western Port, particularly on sediment loads in surface waters
- disturbance of polluted marine sediments.

4.4 SHIPPING

Shipping and associated activities pose a number of threats to the health of the Ramsar site. DSE (2003) state that pollution is a significant risk and could result from: oil and chemical spills, discharge of ballast water, shipping accidents, marinas and launching ramps, sewage and bilge water, litter and other debris. Oil spills were identified as a threat of extreme priority to the migratory waders of the Ramsar site by Kismet Forward (2009). In addition, the risk of oil spills on saltmarsh and mangrove vegetation is of high priority. As noted above, the pattern of clockwise water circulation within the bay may also magnify the impacts of pollution and poor water quality.

The threat of pollution and degradation resulting from shipping activities will increase with the anticipated growth of the Port of Hastings. Potential threats resulting from the proposed development of the port include increases to the risk of oil spills, run-off, and potential vegetation removal. There may be an increase in the area of the Ramsar site subject to dredging and spoil disposal. In addition, potential reclamation could result in changes to hydrodynamics and sediment distribution, and a loss of intertidal and sub-tidal habitats (DSE 2003; Maunsell 2006).

Dredging to maintain deep shipping channels also mobilises sediments and redistributes them within the site.

Dredging has been practiced in Western Port since the 1920s for three main purposes, including:

- commercial shipping channels by the Victorian Ports Manager
- Parks Victoria management for recreational vessels
- private piers, jetties and boat ramps (DSE 2003).

Dredging threatens the Ramsar site by causing turbidity and by releasing toxicants and nutrients present in the sediments. Dredging may also threaten components of the Ramsar site such as bathymetry and habitat availability, particularly if the expansion of dredging activities is required for the development of the port (Wallbrink and Hancock 2003a).

4.5 RECREATIONAL ACTIVITIES

Recreational boating threatens vegetation communities present within the Ramsar site, particularly seagrass, mangroves and saltmarsh vegetation. Damage to these communities can result from anchoring, grounding, and propeller scour, as well as by trampling by visitors who venture ashore (Parks Victoria 2007). Seagrass beds, in particular, can be fragmented resulting in habitat loss, decreased productivity, and potential increases in erosion and degradation. In a risk assessment completed for PPWCMA, Kismet Forward (2009) identified vegetation fragmentation as a threat of extreme priority for saltmarsh and mangroves at Lang Lang, and of high priority at Warrangine, Rutherford Inlet, and French Island Marine National Park. The threat of vegetation fragmentation on migratory waders was also assessed as being of high priority (Kismet Forward 2009).

Recreational hovercrafting within the Ramsar site threatens the habitats critical to its character, particularly the intertidal mudflats. Hovercrafting at low tide can have deleterious impacts on exposed seagrass (Parks Victoria 2007). In addition, hovercrafting and personal watercrafts allow easy access to shallow areas within the bay that may otherwise be inaccessible and have the potential to disturb waterbirds.

Boating activities also threaten the subtidal soft sediments within the deep channels of the Ramsar site. Mechanical disturbance, groundings and propeller scour have been identified by Parks Victoria (2007) as activities that may disturb these sediments and the habitat they provide.

Waterbirds can be disturbed by low flying aircraft and paragliding, recreational boating and when visitors go ashore. DSE (2003) identify this as a particular problem at Barralliar Island, Tortoise Head, French Island and Observation Point at Rhyll which provide important habitat. Visitors walking their dogs in close proximity and off the leash can also disturb waterbirds.

Uncontrolled vehicle access has also been identified as a process threatening intertidal mudflats (Parks Victoria 1999). Vehicles disturb sediments and vegetation, and can lead to soil compaction restricting habitat availability.

4.6 PEST PLANTS AND ANIMALS

A number of sources have identified pest plants and animals as a significant threat to the health of the Ramsar site (DSE 2003; Parks Victoria 2007; Kismet Forward 2009). This threat includes both marine and terrestrial pest species.

In 2007, Parks Victoria reported that 18 exotic marine species had been identified within Western Port with 12 of these establishing self-sustaining populations (Parry and Cohen 2001) (Table 4.2).

Appendix H provides a detailed list of pest species known to occur within the Ramsar site, including marine species which do not have self-sustaining populations.

Table 4.2 Exotic marine species with self-sustaining populations in Western Port (Source: adapted from Parry and Cohen 2001)

Common name	Species
Ascidian	*Ascidiella aspersa*
Ascidian	*Ciona intestinalis*
Ascidian	*Styela clava*
Ascidian	*Styela plicata*
Dinoflagellate	*Alexandrium tamarense*
Bryozoan	*Bugula neritina*
Bryozoan	*Watersipora subtorquata*
European Shore Crab	*Carcinus maenus*
Algae	*Codium fragile tomentosoides*
Algae	*Ulva lactuca*
Asian Mussel	*Musculista senhousia*
Asian Bivalve	*Theora lubrica*

Further introduction of marine pest species by shipping and recreational boating activities, and extensive infestations threaten a number of values currently exhibited by the site. Marine pest species feed on, or compete with, native species for food or shelter and they can destroy habitat. The proliferation of marine pests in some parts of the world has been a driving factor behind several extinctions and the loss of biodiversity.

Marine pest species, such as the Northern Pacific Seastar (*Asterias amurensi*), currently not recorded in the Ramsar site, can be introduced via the discharge of ballast water or fouled hulls and other surfaces (DSE 2003). Western Port is known to receive a significant amount of discharged ballast water from international or domestic ports in comparison to other Victorian commercial ports (DSE 2003). It should be noted that the introduction of marine pest species is currently listed as a potentially threatening process under the Victorian *FFG Act 1988*. Similarly, given the connectivity of Western Port with other marine waters, migration of marine pest species into the Ramsar site is also a significant threat.

Terrestrial pest species pose a threat to many values of the Ramsar site. Terrestrial plant species currently threaten the intertidal and estuarine areas of the Ramsar site and in turn the habitat these areas provide. Exotic flora species are known to outcompete and displace native species, while also providing refuge for exotic fauna species. In 2003, DSE reported that a total of 93 non-indigenous plant species had been recorded within the Ramsar site; however a detailed species list was not provided.

Of particular note, Common Cord Grass (*Spartina anglica*) has been identified as a significant threat to estuaries within the Ramsar site, particularly from the entrance to Bass River in the south-east to Deep Creek in the north (Kismet Forward 2009; Parks Victoria 2007; S. Coutts [Parks Victoria] 2009, pers. comm., 1 May). Common Cord Grass has often been planted to stabilise and reclaim tidal mudflats where it now poses a major risk (Richardson et al. 2007; Parks Victoria 2007). Common Cord Grass is currently listed as a noxious aquatic species under the *Fisheries Act 1995*. The species is known to rapidly encroach within watercourses and estuaries and may cause sediment deposition, channelization and altered hydrology (Parks Victoria 2007). Waterbird habitat loss has also been correlated with infestations of Common Cord Grass (DSE 2003).

DSE (2003) also state that the spread of Spiny Rush (*Juncus acutus*) represents a significant risk to saltmarsh vegetation across the Ramsar site.

DSE (2003), Parks Victoria (2007) and Kismet Forward (2007) have also indentified terrestrial exotic fauna species as a threat of extreme priority for the Ramsar site. Species such as Red Foxes and domestic and feral cats (*Felis catus*) can kill birds and nestlings and other native fauna (DSE 2003). Other species known to impact the area include European Rabbit (*Oryctolagus cuniculus*), Feral Goat (*Capra hircus*), Pigs (*Sus scorfa*) and deer (unknown species) (DSE 2003, M. Rodrigue [Parks Victoria] 2009, pers. comm., 23 June). These exotic species cause a significant amount of damage to native flora and the intertidal areas by trampling and eating vegetation (Parks Victoria 2007).

It is anticipated that increases in fox and cat populations within and surrounding the Ramsar site will result from future urban growth within the area.

4.7 CLIMATE CHANGE

Impacts associated with climate change, particularly sea level rise, an increased frequency and intensity of storm surges, and temperature fluctuations, have been identified as significant threats to the Ramsar site and surrounding areas (DSE 2008; CSIRO 2008).

Global sea levels are predicted to rise between 0.18 m and 0.59 m by 2095 (DSE 2008). Consequently, the Victorian coastline, including Western Port, will experience greater inundation and erosion (DSE 2008). This is particularly concerning for the low-lying areas along the northern and eastern edges of the Ramsar site (CSIRO 2008). It is likely that a considerable proportion of the intertidal mudflats that are currently exposed at low tide will be permanently inundated or exposed less frequently (CSIRO 2008). This in turn will threaten dependant fauna species supported by these habitats with particular concern for the waterbirds that use these habitats for foraging.

In addition, more frequent and intense storm events and surges are expected to result from climate change. CSIRO (2008) state that storm surges will be greatest on the eastern side of the Ramsar site as a result of prevailing winds. Storm surges may exacerbate coastal erosion and sediment delivery to the Ramsar site which could have a number of deleterious impacts. Similarly, storm surges and pulse flows are likely to mobilise nutrients and pollutants from the catchment and result in a deterioration of water quality, particularly at beaches (EPA undated).

By 2030, the average annual temperature within the Port Phillip and Western Port region is predicted to be 0.8°C warmer and the total average annual rainfall is expected to drop by around 4 per cent (DSE 2008). Rainfall reductions will result in changes to catchment inflows, in both magnitude and quality, into the Ramsar site.

Future Coasts is a current project established by the Victorian government to assess the impacts on climate change to the Victorian coast and to consider climate change adaptation. This project will result in the production of high resolution mapping for both sea depth and elevation that will be used to assess the vulnerability of coastal areas to seal level rise. At present, only topographic DEM datasets are available for the catchment. Storm surge modelling and coastal processes modelling are expected to be available towards the end of 2009, while physical vulnerability assessments and bathymetric digital elevation modelling are expected to be available early in 2010 (DSE 2009e).

4.8 URBAN DEVELOPMENT

In 2008, the Victorian government released updated population growth projections that indicated that Melbourne was likely to reach a population of 5 million by 2026 (DPCD 2008, cited in EPA undated). The Western Port catchment currently supports a population of 580,000 people (ABS 2008, cited in EPA undated). The catchment is situated within an area forecast to experience significant urban growth in the future which will have a variety of impacts on the Ramsar site.

The Casey to Cardinia growth area in particular is situated to the north of the Ramsar site. The growth area includes the suburbs of Cranbourne, Pakenham and Officer, and is said to be the fastest developing growth area (GGA 2009). By 2031, this area is anticipated to support between 65,000 and 85,000 more households and support between 100,000 and 140,000 jobs (GGA 2009).

Limits to potential growth in the Casey to Cardinia growth area have been recognised in order to minimise the potential impacts on the Ramsar site and other natural features in the area (DPDC 2009). However, the forecast urban growth is likely to impact water quality discharging directly to the Ramsar site and may cause alterations to the hydrological regime. In particular, urban growth is likely to result in increased litter, sediment and nutrient loads being delivered to the site. These in turn will have consequential impacts on dependent fauna and their habitats (particularly seagrass beds and waterbirds) (DPDC 2009). Run-off and stormwater from urban areas has the potential to impact marine invertebrates and seagrass which provide an important food sources for a number of waterbird species. Poor quality stormwater is also likely to transfer high loads of total phosphorus, total nitrogen and total suspended solids directly into the Ramsar site.

The Better Bays and Waterways Program modelled predicted increases in pollution entering Western Port based on typical average years and Melbourne 2030 future land zoning data (EPA undated). The results of this modelling predicts an increase 60 t/a of total nitrogen, 10 t/a of total phosphorous and 2500 t/a suspended sediment being delivered to Western Port, most of which will be discharged directly into the Ramsar site.

Increased levels of recreational boating and other recreational activities, resulting from urban development, may result in further degradation to the site.

4.9 GRAZING

Grazing in the catchment also poses a threat to the Ramsar site. EPA (undated) identifies grazing in the Cardinia Creek, Lang Lang River, Bass River and Bunyip River catchments as significant sources of both nutrients and sediment to Western Port as a result of direct stock access to the waterways and other dryland grazing practices. These two waterways discharge directly into the Ramsar site and have the potential to significantly alter water quality, habitat availability, and dependant fauna species.

4.10 RECREATIONAL AND COMMERCIAL FISHING

Over-exploitation of fish stocks is a threat to the health of the Ramsar site (DSE 2003; Kismet Forward 2009). Although long-term quantitative data is available for the commercial fish catch, and suggests commercial fishing has experienced a decline since the 1960s, long-term information on the recreational fishing effort within the Ramsar site is unavailable. DSE (2003) identifies that a survey undertaken by MAFRI in 1998 and 2000 indicated that the recreational fish catch was greater than the commercial catch which was 52 t in 2001/02 and had a value of $279,000 (DPI 2008a). The report prepared by MAFRI has not been accessible during the preparation of this description.

Similarly, the level of pressure on fish populations in the Ramsar site is poorly understood. A lack of understanding of the fish stocks threatens the viability of the services provided by commercial and recreational fishing and the fish stocks themselves.

5 Changes to ecological character since the time of listing

This section briefly characterises the current status of each critical component and process and describes any evident changes in the ecological character since the time of listing in 1982. An assessment of change to the ecological character has been undertaken in relation to established limits of acceptable change. This section also describes changes and current status of essential elements as identified in Section 2.1.

5.1 WETLAND BATHYMETRY

There is limited quantitative information available for the bathymetry of the Ramsar site in 1982 and as such the limit of acceptable change has a low level of confidence. However, based on estimates of intertidal mudflat availability published in recent literature (CCB 2003; Parks Victoria 2007; Parks Victoria 2007b), wetland bathymetry is not considered to have changed the character of the site since the time of listing.

Deep channels have been maintained by dredging to facilitate commercial shipping; however as to whether the extent of dredging has varied from 1982 until now is not known.

Sediment distribution within the Ramsar site has varied from 1982 as a result of the water circulation within the bay and the tidal regime causing constant re-suspension and re-distribution (Section 2.2.3). However, the change to bathymetry as a result is unable to be quantified.

As more detailed limits of acceptable change were not able to be established with high levels of confidence, it is not possible to determine whether these additional changes are within boundaries of acceptability. The following additional investigations have been identified to assist in determining limits and assessing future change:

- Confirm the availability and detail of bay wide marine habitat and bathymetry mapping. Otherwise, undertake a detailed survey of the Ramsar site
- Comprehensive investigations into marine invertebrate, fish and waterbird abundance and diversity in relation to changes in habitat availability and depth.

5.2 WATER QUALITY

EPA currently monitors water quality within the Ramsar site under their fixed site program. This includes three historical sites and up to five extra sites which are monitored monthly with additional sampling to typify wet conditions. The Better Bays and Waterways Program (EPA undated) identified that the main parameters measured in Western Port include chlorophyll-a, nitrogen, phosphorus, suspended solids, and turbidity. However, a number of other parameters are monitored, including salinity, temperature, dissolved oxygen and pH.

Better Bays and Waterways reports that results from monitoring sites located off Hastings, Corinella, and Barrallier Island indicate that water quality is similar at Hastings and Barralliar Island to the west of the site but the water quality off Corinella to the east is significantly lower, with higher levels of total phosphorous, total nitrogen and suspended solids (EPA 1999, cited in DSE 2003; EPA undated; Shepherd et al. 2009). The western portion of the site is well-flushed and as such sites at Hastings and Barrallier Island have had good compliance with SEPP objectives (EPA undated). This generally results from the net clockwise direction of water flow and sedimentation within the bay (EPA undated). Consequently, water quality at the Corinella site is poor in comparison. Between 2001 and 2005, for example, the water quality at the Corinella site frequently did not meet the objectives for chlorophyll-a, total nitrogen, total phosphorus and suspended solids (EPA undated). Table 5.1 reports compliance with SEPP objectives at each of the monitoring sites between 2001 and 2005 as reported within the Better Bays and Waterways Program (EPA undated).

Quantitative data on current water quality within the site has not been available during the preparation of this description. It is presumed that this information has not been published.

Table 5.1 Attainment of objectives in Western Port shown as percentiles and ratings with respect to environmental objective/trigger values for water quality using data from 2001 to 2005 (PPWCMA 2008, cited in EPA undated)*

Indicator	Objective source	Hastings (%)	Barrallier Island (%)	Corinella (%)
Chlorophyll-*a*	SEPP Annual median	78	63	42
	SEPP Annual 75th percentile	96	87	84
	ANZECC Single value	100	100	63
Total nitrogen (TN)	ANZECC Single value	100	100	57
Total phosphorus (TP)	ANZECC Single value	100	100	47
Nitrogen oxide (NOx)	SEPP Annual median	45	50	68
	SEPP Annual median	68	96	90
Filtered reactive phosphorus (FRP)	SEPP Annual 75th percentile	82	96	76
	SEPP Annual 75th percentile	100	100	97
Transparency (Secchi depth)	SEPP Annual median	74	54	45
	SEPP Annual 75th percentile	97	89	53
Suspended solids	SEPP Annual median	89	82	51
	SEPP Annual 75th percentile	100	96	84

* *ANZECC objective is taken from Table 3.3.2 ANZECC (2000). ANZECC 99 is the objective for the protection of 99 per cent of species. Note that for nutrients the ANZECC guideline values are provided for comparison purposes only as SEPP Schedule F8 specifically excludes nutrient objectives in favour of ecologically relevant Chlorophyll-a objectives.*

Green = frequent compliance (4–5 out of 5 years, 80–100%)

Yellow = occasional compliance (2–3 out of 5 years, 40–60%)

Red = rare compliance (0–1 in 5 years, 0–20%).

An additional monitoring program was established in association with the Better Bays and Waterways Program (EPA undated). The EPA Water Quality Improvement Program includes fortnightly beach water quality sampling, with five historical and up to five extra sites in Western Port. The sites are monitored fortnightly with initial high resolution sites to typify wet and dry conditions. The parameters measured include pathogens (Enterococci, limited *E. coli*), litter (visual) and turbidity (in situ analyser). Results from these monitoring programs report that beach water quality in the site is generally good with pathogen levels consistently meeting SEPP objectives at each of the sites monitored in 1987, 1992, and 2005 to 2007 (EPA undated).

PPWCMA (2007) identified that the waters of Western Port were 'excellent' with 94 per cent of beaches meeting SEPP objectives consistently between 2005 and 2007. As such, the condition of water quality was considered to be 'stable' (PPWCMA 2007). This information provides a qualitative understanding of water quality within the Ramsar site where quantitative information has been inaccessible.

As previously noted, the Ramsar site is highly influenced by water quality within the catchment. For example, poor water quality within Watsons Creek is a significant threat to the health of the Ramsar site and marine national parks (Section 4.3). Table 5.2 details the observed trends in water quality change within the Western Port catchment from 1990 to 2005. Although, limits for acceptable change have not been established for the waters of the catchment, this provides additional qualitative information on water that is discharged directly into the Ramsar site.

Table 5.2 Western Port catchment water quality trends 1990–2005 (Source: King and Webb 2005, cited in EPA undated)

Variable	Trend
Dissolved oxygen	The overwhelming trend was declines in dissolved oxygen levels, including some quite large declines.
pH	pH levels remained relatively constant at most locations with one site showing significant improvement.
Electrical conductivity	One site showed an improvement in EC levels with many others showing insignificant changes. However, nine sites did show unfavourable increases in levels.
Nutrients	The general trend in total nitrogen levels was an increase with some large changes observed. Two sites showed minor reductions while others had no significant change.
Turbidity	The majority of sites showed no significant change in turbidity levels but the majority of the remainder showed substantial increases in levels. Only two sites showed improvements in levels. Changes in total phosphorus levels were variable: four sites showed significant reductions, four showed significant increase and the remainder showed no significant changes.
Suspended solids	All but four sites showed no significant change, with three of the remaining four showing increases in levels.
E. coli	The majority of sites showed no significant change in *E. coli* levels, but five sites showed improvements and only one site showed an increase in levels.
Metals	The results for metal were mixed with most sites for most metals showing no significant changes but at the sites where changes were observed, these changes were all increases in concentrations. Large, consistent increases were observed for copper, nickel and zinc.

In addition, the PPWCMA (2007) described the quality of water within the rivers of the catchment, the Mornington, and Casey, Cardinia and Baw Baw reporting areas in particular, as ‘moderate’ receiving condition rating of C with only approximately 40 per cent of monitoring results meeting SEPP objectives in 2006–07. The waterways in the Mornington Peninsula reporting unit exhibit declining oxygen levels and increasing turbidity and suspended solids (PPWCMA 2007). Similarly, the waterways within the Casey, Cardinia and Baw Baw area show trends of increasing salinity, nitrogen, phosphorus, turbidity and zinc levels (PPWCMA 2007). The trend was assessed as declining (PPWCMA 2007). This information provides a qualitative understanding of water quality within the catchment where quantitative information has been inaccessible.

Section 3.2 outlines that limits of acceptable change have not been established for those parameters considered critical in maintaining the site’s character and that additional assessment by a technical/scientific panel is required.

However, comparison of Table 5.1 with those critical parameters for which data is available suggests that changes to water quality within the site have occurred since the time of listing. Data shows:

- increased levels of suspended solids at the Corinella site in the east
- increased chlorophyll-a levels at Hastings, Barrallier Island and Corinella sites
- reduced transparency at Hastings, Barrallier Island and Corinella sites.

However, these changes are not considered to represent a change to the character of the site as they are not reflected in associated fluctuations in seagrass level or waterbird numbers.

5.3 GEOMORPHOLOGY AND SEDIMENTATION

Delivery of sediment to the Ramsar site has increased since the time of listing in 1982. Hughes et al. (2003) provides a prediction of the suspended sediment loads contributed to Western Port by the five major watersheds. The predicted total suspended sediment export to Western Port from the Bass, Bunyip, and Lang Lang Rivers, and the Cardinia and Yallock Creeks, equates to 62 000 t/a (Hughes et al. 2003). Each of these main waterways discharges directly into the Ramsar site. Channel and gully erosion of the Bunyip and Lang Lang catchments are reported to be the dominant sources of fine sediment to the site (Wallbrink et al. 2003b). Erosion of topsoil was most significant in the Bass catchment, accounting for 21 per cent of deposited sediments in the Bass River; however the Bass River contributes less than 10 per cent of fine sediments to the southern segment of Western Port (Wallbrink et al. 2003b).

On comparison with estimates provided for the mean input load from 1973 to 1985, an additional 22 000 t/a is now being delivered directly into the Ramsar site. However, estimates of total sediment input loads following European settlement have varied between approximately 40,000 and 100,000 t/a (Section 2.2.3). Such variation may reflect human activities, natural fluctuations or different methods used in calculating input loads. As such, the 2003 estimate of sediment input loads lies within the range of estimated input loads following European settlement.

As limits of acceptable change were not able to be established, it is not possible to state whether this has resulted in a change to the character of the site.

In addition to increased sediment supply, significant sediment redistribution has also been reported within the Ramsar site since 1982. Wallbrink et al. (2003b) compared the distribution of sediments less than 4 μm in size in 1975 (Figure 2.5) to those in 2001 (Figure 5.1). Results indicate that there has been substantial fine-sediment removal from the northern arm, above French Island and offshore from Bunyip and Cardinia Creek (Wallbrink et al. 2003b). Similarly, significant deposition and accumulation of material has occurred in the eastern and south-eastern segments of the bay (Wallbrink et al. 2003b). This long-term pattern of redistribution is consistent with the hydrodynamics that characterise the site, particularly clockwise water circulation within the Ramsar site and the tidal regime that results in resuspension of fine materials. Wallbrink et al. (2003b) report that persistent high turbidities within the site, as reflected in water quality data discussed in Section 5.4, are a reflection of the resuspension and redistribution of fine-sediment and are not solely caused by continual sediment input from the catchment.

As a result of the long-term redistribution of fine-sediment, core material within the northern arm is becoming sandier in texture than the southern and eastern segments of the site (Wallbrink et al. 2003b).

As limits of acceptable change were not able to be established it is not possible to state whether these changes in sediment distribution have resulted in a change to the character of the site.

Recommended investigations in order to determine limits of acceptable change and monitor future change include:

- the causal link between turbidity and seagrass growth/decline needs to be further clarified (Wallbrink et al. 2003b)
- waterbird, fish and marine invertebrate response to changing turbidity levels and sediment composition
- habitat loss as a result of sediment redistribution and deposition.

Further clarification on the availability and detail of bay wide marine habitat mapping will be required to quantitatively assess the loss of habitat types.

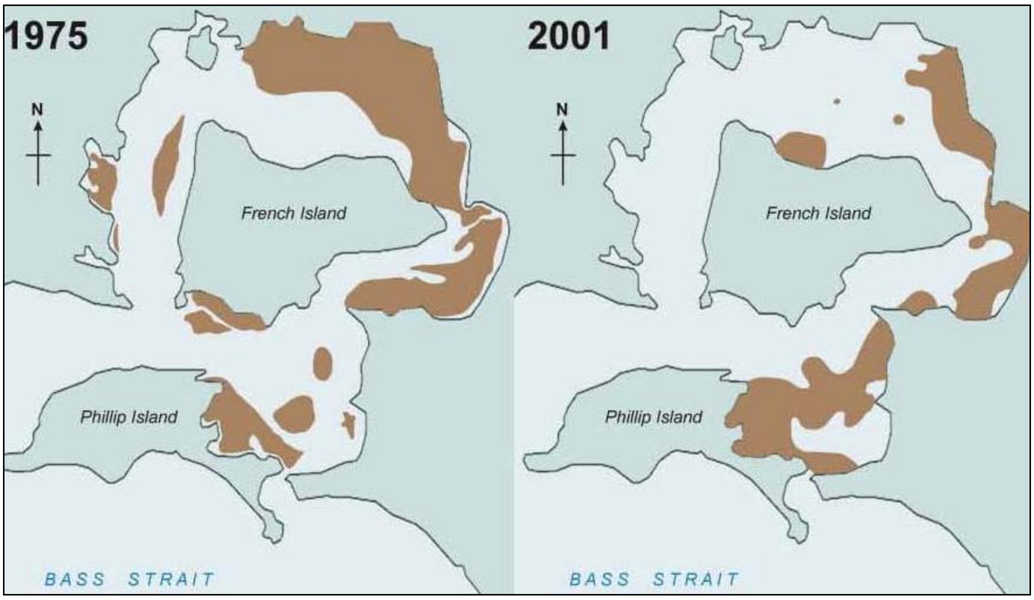

Figure 5.1
REDISTRIBUTION OF < 4 µm MUD BETWEEN 1975 AND 2001
(Source: Wallbrink et al. 2003B)

5.4 TIDAL REGIME, HYDRODYNAMICS AND CATCHMENT INFLOWS

The tidal regime, hydrodynamics and catchment inflows of the Ramsar site are not known to have changed since 1982 and information documenting any changes since then has not been available in preparing this description.

Limits of acceptable change have not been established specifically to address tidal regime, hydrodynamics and catchment inflows. Alternatively, intertidal mudflat availability (as discussed in Section 5.1) is considered to adequately reflect changes to the tidal regime. Similarly, following establishment of limits of acceptable change for sedimentation and geomorphology (Section 5.3), it is anticipated that these limits will allow assessment of changes to hydrodynamics and catchment inflows.

Given the threats to the Ramsar site posed by climate change and fluctuations to sea levels and catchment inflows, further investigations are considered important to manage activities that may be able to reduce impacts to the site. It is envisaged that the Future Coasts program will be able to provide further information on potential changes to the tidal regime and loss of intertidal mudflats associated with climate change when it is completed in 2010. Additional investigations that are recommended include:

- investigations/modelling of the potential loss of habitat, including intertidal mudflats, seagrass, and mangroves as a result of sea level rise
- investigations/modelling of coastal erosion and sedimentation resulting from climate change, including sea level rise and storm surges
- investigations into the potential response of waterbirds, marine invertebrates and fish to predicted changes in sea level.

5.5 CLIMATE

Since 1997, annual rainfall totals and stream flows have been significantly lower than the long-term average across Victoria (EPA undated). Between 1998 and 2007 average rainfall within the Port Phillip and Western Port region was 14 per cent below the 1961 to 1990 average (Table 2.11). Between 1998 and 2007 the Port Phillip and Western Port region as experienced average annual temperatures 0.4°C warmer than the 30 year average (Table 2.11) (DSE 2008).

As the current distribution of mangrove vegetation within the site, the limit used to reflect a change in climate (Section 3), remains unquantified it is not possible to determine whether any of the above changes have resulted in a change to the character of the site.

However, given the threats to the Ramsar site posed by climate change, further investigations are considered important to manage activities that may be able to reduce impacts to the site. The following additional investigations are recommended:

- investigations/modelling of the potential loss of habitat, including intertidal mudflats, seagrass, and mangroves as a result of sea level rise, changes to the tidal regime and increasing temperatures
- investigations/modelling of coastal erosion and sedimentation resulting from climate change, including sea level rise and storm surges
- comprehensive investigations into the current distribution of mangrove vegetation within the site
- investigations into the potential response of waterbirds, marine invertebrates and fish to predicted changes in sea level and increasing temperatures
- modelling potential water quality changes in association with reduced catchment inflows resulting from climate change.

5.6 FLORA

5.6.1 Seagrass

The once extensive seagrass beds in Western Port declined by approximately 70 per cent between 1971 and 1985, within which time the Ramsar site was listed (EPA 1996; Shepherd et al. 2009). In 1995, an EPA survey indicated that between 20 to 30 per cent of the degraded areas had revegetated to varying degrees of density; however most of this regrowth has occurred in the north arm and entrances with little regrowth reported to have occurred in the eastern arm (EPA 2001).

Although the exact cause of the losses remain unknown, it is generally accepted that sediment inputs from the catchment, and to a lesser extent from dredging, have been the main factors by reducing water quality and photosynthesis rates (EPA 1996).

Table 2.6 illustrates that total seagrass and macroalgae distribution within Western Port has increased from 72 km^2 in 1983/84, to 113 km^2 in 1994 and 154.5 km^2 in 1999 (Blake and Ball 2001). The distribution maps from 1994 and 1999 (Figures 5.2 and 5.3, respectively) show a similar distribution of seagrass; however Figure 5.3 shows larger areas of seagrass in comparison to Figure 5.2. Both figures illustrate that the recovery of seagrass has occurred predominately around the northern sections and entrances with very little recovery occurring in the north-east and eastern areas of the site.

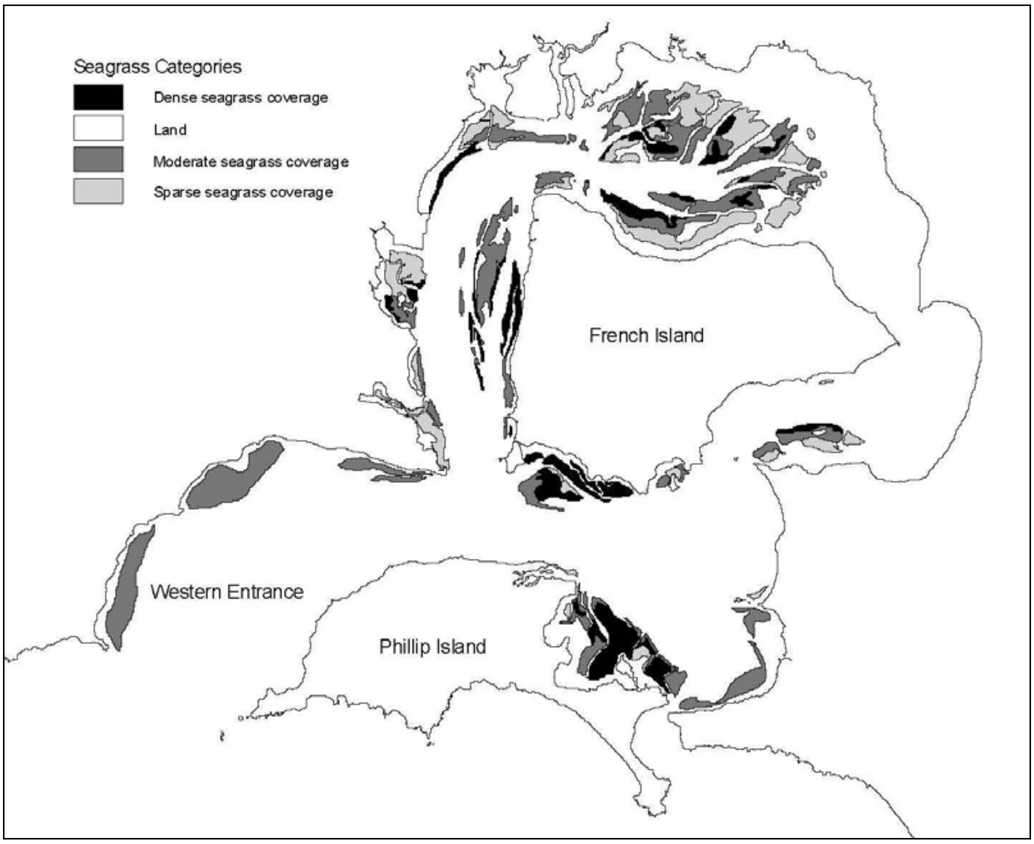

Figure 5.2
GENERALISED SEAGRASS DISTRIBUTION AND DENSITY FOR WESTERN PORT IN 1994 (Source: Stephens 1995, cited in Blake and Ball 2001)

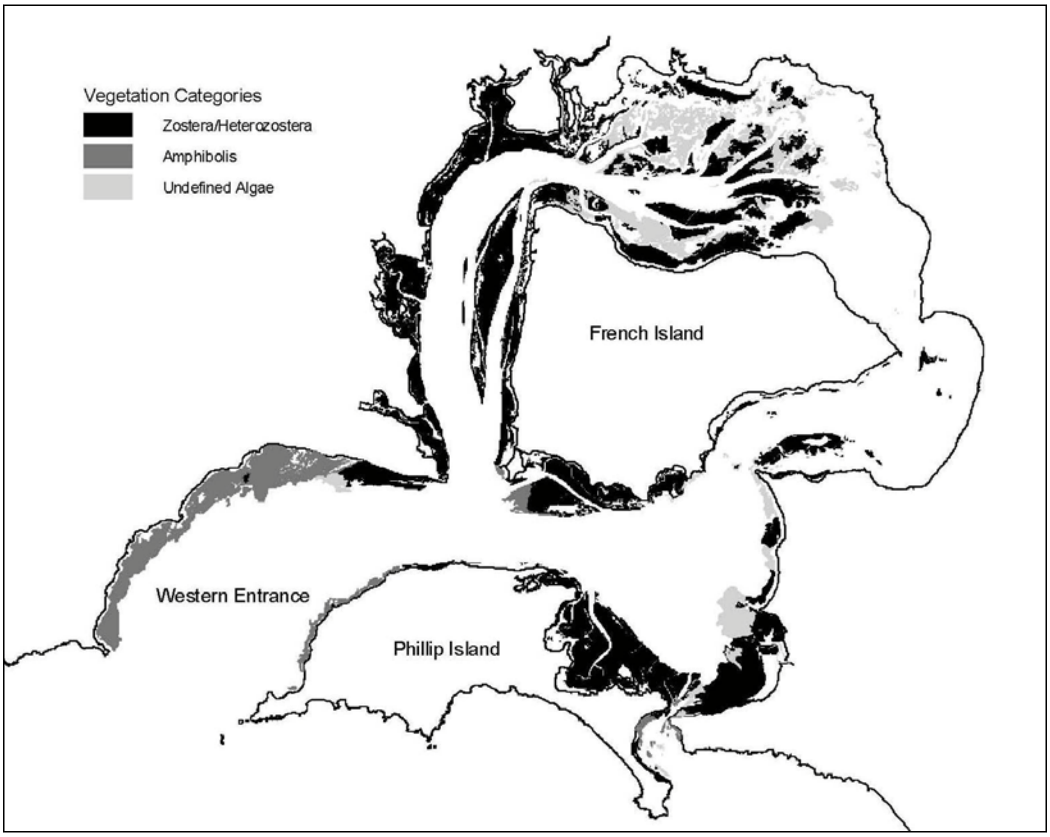

Figure 5.3
GENERALISED SEAGRASS AND MACROPHYTE DISTRIBUTION IN WESTERN PORT IN 1999 (Source: Blake and Ball 2001)

A Progress Report for a state-wide seagrass monitoring program being undertaken by DPI targeting three sites within the Ramsar site reported that seagrass distribution in 2005 was similar to that mapped in 2001 (Table 5.3). A report for this monitoring program is yet to be finalised and was not available during the preparation of this description.

Table 5.3 Seagrass area changes at Western Port monitoring sites (Source: DPI 2006)

Site	Seagrass area 1999 (m^2)	Seagrass area 2005 (m^2)	Percentage change
Woolleys Beach	–	351,497	–
Rhyll	160,524	161,726	0.7
Scrub point	1,081,109	1,085,000	0.4

Contrary to the above information, PPWCMA (2007) has reported that seagrass beds within Western Port showed significant decline between 2000 and 2004 and indicates that there is no evidence to suggest that this decline has not continued. The results presented by PPWCMA (2007) are based on the above monitoring program, observations and anecdotal evidence provided by the Western Port Seagrass Partnership (WPSP); however quantitative information to support this is not available within the document. Seagrass within the bay was determined to be in poor extent and received a rating of ‘D’. The trend was assessed as ‘declining’ (PPWCMA 2007).

Evidently, the distribution of seagrass within the Ramsar site has varied significantly since it was listed in 1982, at which time its coverage was the lowest since the early 1970s. Seagrass coverage has increased from 72 km^2 in 1983/84 to 154.5 km^2 in 1999, reflecting regrowth from the earlier decline of up to 70 per cent experienced between 1971 and 1985.

Limits of acceptable change were not able to be established for this component, and as such it is not possible to determine whether this represents a change in the character of the site. It is recommended that a technical/scientific panel is assembled to provide recommendations on limits of acceptable change for seagrass within the site.

Recommended investigations include:

- comprehensive assessment of current distribution and health of seagrass within the site
- the causal link between turbidity and seagrass growth/decline needs to be further clarified (Wallbrink et al. 2003b)
- waterbird, macroinvertebrate and fish response to varying seagrass availability and health
- further clarification on the availability and detail of bay wide marine habitat mapping will be required to quantitatively asses the loss of habitat types.

5.6.2 Saltmarsh and mangroves

The distribution of mangrove and saltmarsh vegetation within the Ramsar site has changed significantly since the 1840s when clearance commenced (Ross 2000). As noted in Section 2.2.6, vegetation was removed for a number of purposes. Historical removal of mangrove and saltmarsh vegetation led to exposure and further loss of previously protected vegetation. Similarly, this facilitated erosion and suspension of sediment. The majority of mangrove and saltmarsh vegetation removal occurred prior to listing as a Ramsar site in 1982.

Rogers et al. (2005) investigated the dynamics of mangrove and saltmarsh vegetation at four sites (French Island, Koo-Wee-Rup, Quail Island and Rhyll) from 1939 until 1999, all of which are situated within the boundaries of the Ramsar site,. Although, bay wide monitoring was not undertaken, the results of this survey provide quantitative information in the change of mangrove and saltmarsh distribution since listing in 1982.

Table 5.4 illustrates that between 1973 and 1999, at each study site, saltmarsh vegetation has retreated in distribution while mangrove vegetation has increased (Rogers et al. 2005). Progressively, since 1982, mangroves have been replacing saltmarsh vegetation, particularly by expanding along tidal creeks (Rogers et al. 2005). Refer to Figures 5.4 and 5.5. Suitable conditions for mangroves, such as salinity, light and sediment, exist within tidal creeks therefore encouraging encroachment. Rogers et al. (2005) also noted that mangrove expansion and decline in saltmarsh distribution was greatest at the most developed sites, i.e. Koo-Wee-Rup experienced a 28 per cent decline in saltmarsh vegetation distribution between 1973 and 1999.

The low elevation of saltmarsh vegetation allows increased inundation providing suitable conditions for mangrove growth (Rogers et al. 2005).

Table 5.4 Total area and percentage change of mangrove and saltmarsh vegetation at study sites between 1973 and 1999 (Source: adapted from Rogers et al. 2005)

		Vegetation extent (ha)		
Site	Vegetation type	1973	1999	Percentage change
Koo-Wee-Rup	Mangrove	14.40	18.13	26
	Saltmarsh	31.96	23.02	–28
Rhyll	Mangrove	57.86	62.28	7.6
	Saltmarsh	153.72	139.83	–9.0
Quail Island	Mangrove	73.84	97.47	32
	Saltmarsh	157.52	138.71	–12
French Island	Mangrove	178.32	183.23	2.8
	Saltmarsh	510.92	460.63	9.8

Figure 5.4. Overview map of saltmarsh and mangrove vegetation at Quail Island, Kooweerup, French Island and Rhyll (Source: Rogers 2004)

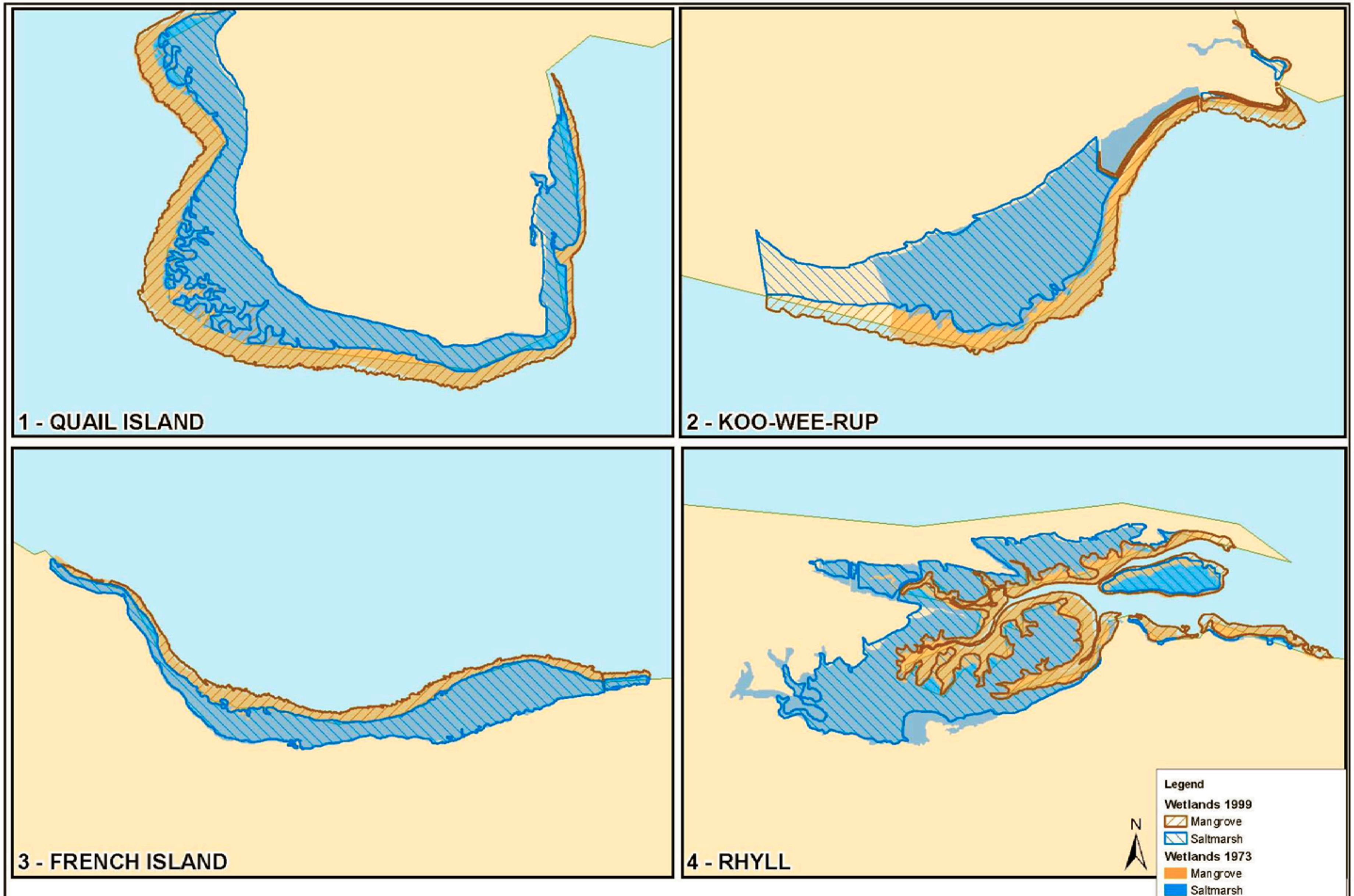

Figure 5.5. Site specific maps illustrating mangrove and saltmarsh distribution in 1973 and 1999 (Source: Rogers 2004)

A project currently being undertaken by the Arthur Rylah Institute (ARI) and Paul Boon of Victoria University endeavours to map saltmarsh vegetation units within Western Port and provide commentary on threats to vegetation communities within the bay (S. Sinclair [ARI] 2009, pers. comm., 5 May). Documentation from this project was not available at the time of preparing this description.

Variation in coverage of saltmarsh and mangrove distribution has been reported at the study sites investigated by Rogers et al. (2005). However, as the current distribution of both mangrove and saltmarsh vegetation within the site remains unquantified, it is not possible to determine whether the character of the site has changed in relation to the limits of acceptable change discussed in Section 3.

The following are recommended to assist in assessing change to the character of the site:

- comprehensive investigations into the current distribution and health of mangrove and saltmarsh vegetation within the site
- investigations into waterbird, macroinvertebrate and fish responses to changes in mangrove and saltmarsh availability and health.
- further clarification on the availability and detail of bay wide marine habitat mapping will be required to quantitatively assess the loss of habitat types.

5.7 FAUNA

5.7.1 Waterbirds

Waterbird numbers have shown several changes over time since the BOCA survey began in 1973 and since Ramsar listing in 1982. Some of the changes relate to seagrass dieback and partial recovery in the late 1970s and 1980s, with Black Swans and fish-eating birds particularly affected by those changes. Black Swans have returned in large numbers to many but not all parts of the bay, whereas numbers of fish-eating birds remain lower than in early years (Appendix I).

Three of the five species (Eastern Curlew, Curlew Sandpiper and Double-banded Plover) showed evidence of declining numbers in recent years (Appendix I), in parallel with global declines for these species. More marked changes over time were evident for some other wader species that did not meet the Ramsar criteria. In particular, Grey-tailed Tattler declined greatly in the late 1970s and had ceased to be regular visitors to the bay by the early 2000s. A recent record of a flock of 39 Grey-tailed Tattler gives hope that they may return, but essentially this species retains a very precarious foothold on the Victorian coast. On the other hand, some species have increased over time, notably Red-necked Avocet (*Recurvirostra novaehollandiae*) which became regular spring visitors to the sheltered mudflats between Jam Jerrup and Grantville in the east of the Ramsar site. Increases have also been observed in numbers of Pied Oystercatcher, Bar-tailed Godwit and Whimbrel (Appendix I). Despite these changes at the species level, total counts of waders have remained remarkably consistent in the Ramsar site over the years (Table 2.9).

Analysis of the mean counts of waterbird guilds from 2004–09 compared with the previous five years (or long term means) shows a decline greater than 20 per cent (Table 2.9) for the following guilds:

- ducks
- fishers
- grebes
- large wading birds
- swans.

It is considered likely that these changes are due to drought conditions (R. Loyn [ARI] 2009, pers. comm., 1 October) and can not therefore constitute a change to the ecological character of the site.

5.7.2 Marine invertebrates

Changes in the invertebrate assemblages of habitats exhibited by the Ramsar site have been reported within the literature.

The diversity of marine invertebrates is reported to have been similar in 1973/74 and 1992/93 surveys. However, Edgar et al. (1994, cited in EPA) identified that a number of molluscs that were not collected in 1973/74 were abundant in 1992/93. They include *Diala suturalis*, *Styliferina translucida* and *Pseudoliotia micanus*. Similarly, bivalves, *Notocallista diemensis* and *Katelysia rhytiphora,* which were abundant in 1973/74 were relatively rare in the 1992/93 (EPA 1996).

Although data deficiencies exist for the reefs and rocky substrates, anecdotal evidence reported by EPA (1996) suggests that the general composition of marine invertebrates within these habitats have generally remained unchanged since 1975.

The San Remo Marine Community has not been investigated in detail since assessments undertaken in 1988/89. As such, the current composition and abundance of marine invertebrates within this community remains unknown.

Long-term environmental impact monitoring of effluent from the steelworks of the BHP International Steel Coated Products Plant has been conducted within the Ramsar site since the early 1970s by Marine Ecology and Science. The results of this monitoring program have reported an increase in the total density of infauna and an apparent change in community structure over 20 years within the swing basin associated with the plant in the north arm of the site. Increased turbidities resulting from shipping activities are said to have resulted in these changes (Marine Science and Ecology 1990, cited in EPA 1996). Two species, *Virgularia mirabilis* and *Magellania flavescens*, have also been reported to have disappeared from the swing basin since 1980s when the site was listed as a result of increasing turbidities.

It is not possible to identify whether these changes in marine invertebrate species and abundances have resulted in a change to the character of the site as limits of acceptable change were not able to be established.

The following investigations are recommended to assist in the determination of limits of acceptable change should marine invertebrates be used as an indicator of change:

- comprehensive assessment of marine invertebrates within each marine habitat
- monitoring of marine invertebrate assemblages within the reefs and rocky substrate habitats
- further investigation and monitoring of changes to the listed San Remo Marine Community
- investigations to establish definitive links between marine invertebrate abundance and diversity with fish and waterbird abundance and diversity
- marine invertebrate responses to changes in seagrass and mangrove distribution and health
- further clarification on the availability and detail of marine habitat mapping will be required to quantitatively asses the loss of habitat types.

5.7.3 Fish

The diversity, abundance and distribution of fish within the Ramsar site are poorly documented for 1982. As such, it is difficult to make any quantitative comparisons.

However, since 1982 there have been changes to the assemblages that are characteristic of various habitat types. Between 1980 and 1995, significant changes in the pipefish fauna within the site was identified by Edgar and Shaw (1995a, cited in EPA 1996). The abundance of both Wide Bodied Pipefish (*Stigmatopora nigra*) and the Spotted Pipefish (*S. argus*) increased from low and unrecorded, respectively, to relative common (Howard and Koehn 1985, Edgar and Shaw 1995, cited in EPA 1996). Pipefish are generally known to occur in intertidal mudflats vegetated with seagrass beds.

Changes in the commercial fish catch have also been reported since the site was listed. In 1982, the Ramsar site was an important source of commercial fishing with catches of 172 t and 142 t valuing $368 000 and $311 000 in 1981/82 and 1982/83, respectively. However, since then the commercial catch has experienced a slow decline, particularly in response to the ban on commercial net fishing enacted in 2007. A catch approximately 20 per cent of the size of the commercial catch of 1982/83 was recorded in 2007/08 (DPI 2008a).

It is not possible to determine whether these changes reflect a change to the character of the site as limits of acceptable change were not able to be set. Further investigations are required to assess the impacts of changes to the fish assemblages within the Ramsar site:

- comprehensive assessment of fish species, particularly non-commercial species, within each marine habitat
- waterbird responses to changes in fish abundances and diversity
- fish abundance and diversity with changes to health and distribution of mangroves and seagrass.

6 Knowledge gaps

The purpose of this section is to summarise the knowledge gaps identified in determining the ecological character of the Ramsar site. Throughout the ecological character description, data deficiencies and knowledge gaps have been identified. It is recognised that deficiencies in data from 1982 may not be able to be resolved; however a number of additional investigations to assist in managing the wetland and assessing future change have been recommended.

Table 6.1 summarises key knowledge gaps identified throughout the preparation of this description and will assist the allocation of resources for future management of the Ramsar site.

In addition, it is recognised that although the Westernport Bay Environmental Study has been paramount in the early understanding of a complex system, a new comprehensive and integrated study of Western Port, its values, threats, and challenges, would be beneficial as population growth, port development and land use changes present Western Port with an uncertain future.

Table 6.1 Summary of knowledge gaps identified during the preparation of this description

Component/process	Identified knowledge gaps	Recommended action to address the gap
Wetland bathymetry	Quantitative information on the depths and location of each habitat type or morphological unit (from 1982 and current)	Confirm the availability and detail of bay wide marine habitat and bathymetry mapping to be used as a benchmark to assess future change
		Comprehensive survey of the Ramsar site
	Definitive associations in ecological response to changes in habitat availability	Investigations into marine invertebrate, fish and waterbird abundance and diversity in relation to changes in habitat availability
	Extensive marine habitat mapping	
	Quantitative information on representativeness of wetland types within Drainage Division 2: South East Coast	Undertake comprehensive analysis of wetland types within Drainage Division 2: South East Coast
Water quality	Quantitative information on water quality within the site in 1982	Data deficiency. Unable to be resolved
	Quantitative information on current water quality within the site	Analyse EPA water quality monitoring results. Ensure monitoring results are readily available.
Geomorphology and sedimentation	Graphical representation of sediment distribution within the site in 1982	Data deficiency. Unable to be resolved
	Definitive associations in ecological response/causal links to changes in turbidity and sediment distribution	Investigations into marine invertebrate, fish and waterbird abundance and diversity in relation to changes in turbidity, sediment distribution and habitat availability
	Extensive marine habitat mapping	Confirm the availability of bay wide marine habitat mapping to be used as a benchmark to assess future change in habitat availability in relation to sediment deposition
	Required reduction of sediment loads to protect environmental values	Comprehensive investigation into the required reduction of total sediment loads in order to protect environmental values as recommended by the Better Bays and Waterways Program (EPA undated)
Tidal regime and hydrodynamics	Predictions of habitat loss as a result of sea level rise and storm surges	Modelling of climate change predictions to investigate the predicted loss in habitat availability as a result
	Extensive marine habitat mapping	Confirm the availability of marine habitat mapping to be used as a benchmark to assess future change in habitat availability in relation to climate change predictions (i.e. sea level rise and storm surges)
	Ecological response to climate change	Investigation into the potential response of waterbirds, marine invertebrates and fish to sea level rise and storm surges
Climate	Predictions of habitat loss as a result of sea level rise, storm surges, and temperature fluctuations	Modelling of climate change predictions to investigate the predicted loss in habitat availability as a result, i.e. potential changes in mangrove distribution in response to fluctuating temperatures

Table 6.1 Continued

Component/process	Identified knowledge gaps	Recommended action to address the gap
	Extensive marine habitat mapping	Confirm the availability of marine habitat mapping to be used as a benchmark to assess future change in habitat availability in relation to climate change predictions (i.e. sea level rise and storm surges)
	Ecological response to climate change	Investigation into the potential response of waterbirds, marine invertebrates and fish to sea level rise, storm surges and temperature fluctuations
	Water quality changes as a result of climate change causing reduced catchment inflows	Modelling potential water quality changes in association with reduced catchment inflows resulting from climate change
Flora—seagrass	Current distribution and health	Comprehensive investigation into the current distribution and health of seagrass within the Ramsar site
	Definitive associations in ecological response to changes in seagrass distribution and health	Investigations into marine invertebrate, fish and waterbird abundance and diversity in relation to changes in seagrass distribution and health
	Extensive marine habitat mapping	Confirm the availability of bay wide marine habitat mapping to be used as a benchmark to assess future change in habitat availability in relation to seagrass distribution
Flora—mangroves	Current distribution and health	Comprehensive assessment of current mangrove distribution and health within the site
	Definitive associations in ecological response to changes in mangrove distribution and health	Investigations into marine invertebrate, fish and waterbird abundance and diversity to changes in mangrove distribution and health
	Extensive marine habitat mapping	Confirm the availability of bay wide marine habitat mapping to be used as a benchmark to assess future change in habitat availability in relation to mangrove distribution
Flora—saltmarsh	Mapped distribution of saltmarsh vegetation in 1982 or 1984	Data deficiency. Unable to be resolved
	Current distribution and health	Comprehensive assessment of current saltmarsh distribution and health within the site
	Definitive associations in ecological response to changes in mangrove distribution and health	Investigations into marine invertebrate, fish and waterbird abundance and diversity in relation to changes in saltmarsh distribution and health across the Ramsar site
	Extensive marine habitat mapping	Confirm the availability of bay wide marine habitat mapping to be used as a benchmark to assess future change in habitat availability in relation to saltmarsh distribution
Fauna—waterbirds	Clear relationships between waterbird numbers in relation to habitat availability, e.g. Orange-bellied Parrot (*Neophema chrysogaster*) and saltmarsh distribution	Investigations required to clarify relationships between waterbird numbers and habitat availability and health
	Quantitative information on representativeness within Drainage Division 2: South East Coast	Comprehensive analysis of waterbird data within Drainage Division 2: South East Coast

Table 6.1 Continued

Component/process	Identified knowledge gaps	Recommended action to address the gap
Fauna—marine invertebrates	Quantitative information on marine invertebrates within the site in 1982	Potential information available at the University of Melbourne. This was not able to be accessed during the preparation of this description
	Quantitative information on marine invertebrates currently within the site	Comprehensive assessment of marine invertebrates within each marine habitat, including the listed San Remo Marine Community
	Definitive associations in ecological response to changes in marine invertebrate diversity and abundance	Investigations into fish and waterbird abundance and diversity to changes in marine invertebrate diversity and abundance
Fauna—fish	Quantitative information on fish (other than commercial species) within the site in 1982. Species lists used within the Westernport Bay Environmental Study were not available in preparing this description	Investigations undertaken as part of the Westernport Bay Environmental Study need to be sourced and investigated for complete species lists
	Quantitative information on non-commercial fish species currently within the site, particularly those known to occur at beaches, rocky reefs, and mangroves	Comprehensive investigation into the current fish assemblages at each marine habitat particularly beaches, rocky reefs, and mangroves
	Quantitative information on the recreational fish catch from 1982 and currently	Conduct regular monitoring of the recreational fish catch from the Ramsar site
	Definitive associations in ecological response to changes in fish diversity and abundance	Further investigations required to assess the response of waterbirds to fish abundance and diversity, and the response of fish to changes in seagrass and mangrove distribution and health

7 Monitoring requirements

The purpose of this section is to identify the elements of the Ramsar site or threats that require monitoring in order to determine or maintain the site's ecological character.

Table 7.1 provides a summary of the elements recommended for monitoring, objectives for monitoring, a suggested frequency and priority. It is not the intention of this section to provide a detailed monitoring program as this will form an integral component of the management plan for the Ramsar site. Those considered as a high priority are essential for maintaining the character of the site and are considered the most vulnerable to threatening processes outlined in Section 4. Medium priority monitoring recommendations are considered less vulnerable to specific human activities or are driven by forces operating at a larger scale.

Some monitoring programs, such as EPA water quality monitoring and BOCA bird monitoring, are well established within the site and recommendations have been made to continue these programs.

Table 7.1 Summary of monitoring recommendations

Ecosystem element	Objective of monitoring	Indicator/measure	Suggested frequency of reporting	Priority
Bathymetry	Establish benchmarks and limits of change	Depth	Every 5 years	Medium
			Conduct habitat mapping every 5 years rather than review nautical maps every 5 years	
		Dredging		
		Habitat availability (i.e. habitat mapping)		
Water quality	Ongoing condition and detection of change	EPA currently monitors water quality under their fixed site program and Water Quality Improvement Program	Monthly Report on trends every 5–10 years	High
		Main parameters: chlorophyll-a, nitrogen, phosphorus, suspended solids, and turbidity, pathogens (Enterococci, *E. coli*), and litter		
Geomorphology and sedimentation	Establish limits, detection of change and ongoing condition	Sediment load	Every 5 years	High
		Sediment distribution	Sediment grain size mapping could reviewed every 5–10 years	
		Habitat availability (i.e. habitat mapping)		
Tidal influences	Detection of change and ongoing condition	Tides are measured and reported constantly Habitat availability (i.e. habitat mapping)	Current frequency. Report on trends every 5 years	Medium
Climate	Detection of change and ongoing condition	The Bureau of Meteorology comprehensively monitors climate within the region	Current frequency. Report on trends every 5 years	Medium
		Habitat availability (i.e. habitat mapping)		
Flora—Seagrass	Establish limits, detection of change and ongoing condition	Distribution	At least every 2 years (EPA 1995)	High
		Health		
		Habitat availability (i.e. habitat mapping)		
Flora—mangroves	Establish limits, detection of change and ongoing condition	Distribution	At least every 5 years	High
		Health		
		Habitat availability (i.e. habitat mapping)		

Table 7.1 Continued

Ecosystem element	Objective of monitoring	Indicator/measure	Suggested frequency of reporting	Priority
Flora—saltmarsh	Establish limits, detection of change and ongoing condition	Distribution Health Habitat availability (i.e. habitat mapping)	At least every 5 years	High
Flora—significant species	Establish limits, detection of change and ongoing condition	Presence/absence Distribution Health Habitat availability (i.e. habitat mapping)	At least every 5 years	High
Fauna—waterbirds	Establish limits, detection of change and ongoing condition	BOCA monitoring program	The current BOCA surveys are adequate in frequency and coverage. Five counts were conducted each year until around 1995, at which time counts were reduced to 3 per year (2 summer and 1 winter count)	High
Fauna—marine invertebrates	Establish limits, detection of change and ongoing condition	Abundance (individuals of phyla recorded in various marine habitats) Diversity (number of phyla recorded in various marine habitats)	Seasonally	High
Fauna—fish	Establish benchmarks, limits of change and ongoing condition	Total species richness Total abundance Assemblages within various marine habitats Commercial and recreational fish catch	At least every 5 years	High
Fauna—significant species	Detection of change and ongoing condition	Presence/absence Abundance	Report every 5 years	High
		BOCA monitoring program	The current BOCA surveys are adequate in frequency and coverage. Five counts were conducted each year until around 1995, at which time counts were reduced to 3 per year (2 summer and 1 winter count)	High

8 Communication, education and public awareness

A Program of Communication, Education and Public Awareness (CEPA) 2003–2008 was established under the Ramsar Convention to help raise awareness of wetland values and functions (DEWHA 2009c). In response to the program encouraging coordinated international and national wetland education, public awareness and communication, Australia was the first contracting party to develop a Wetland CEPA National Action Plan 2001–2005. DEWHA (2009c) state that Australia's National Action Plan provides an umbrella for coordinated activities across Australia. It is endeavoured that this document provides a blueprint for wetland education and raising awareness in Australia.

Recent CEPA activities to raise appreciation and awareness of the Ramsar site include the following:

- The Two Bays project is a partnership program initiated by Pelican Expeditions working with Parks Victoria, EPA Victoria, PPWCMA, the Australian government, and the Association of Bayside Municipalities. In 2009, the program aimed to undertake water quality and scientific studies, and promote awareness for Victoria's largest two embayments, Port Phillip and Western Port, as environmental and cultural assets. The program not only involved agency, local government, and industry representatives but was also open to community members. The program involved a range of community engagement activities to raise awareness of both Port Phillip and Western Port, including opportunities to meet scientists and rangers, providing information for bay users on safety and environmental management, indigenous programs linking indigenous perspectives with the bay story, and media activities. www.svpelican.com.au

- Western Port Welcomes Waterbirds—Current: this new project aims to develop an effective, well targeted management program that works with land managers and local communities to address the threats on waterbirds within Western Port (CCB 2009)

- Dolphin Research Institute (DRI) 'I see, I care': DRI are committed to help raising the value that Victorian's place on their local marine environments, particularly Port Phillip and Western Port. The 'I see, I care' project involves engaging schools from the Port Phillip and Western Port region and providing educational materials to raise awareness and appreciation of Victoria's marine environments. www.dolphinresearch.org.au/index.php

- Boating on Western Port: A Guide to recreational boating on Western Port produced by Parks Victoria provides important information to the public about caring for the environment, navigation and seamanship, aquatic pests and marine national parks. The brochure also provides detailed maps on the Ramsar site showing areas exposed at low tide, channels and open water. http://www.parkweb.vic.gov.au/resources/17_1877.pdf
- Western Port Marine National Parks: Park Notes developed by Parks Victoria provide concise information for the general public regarding several values exhibited by the sites. The park notes are available on the Parks Victoria website which also provides links to other useful documents, including brochures, maps and reports, including the Western Port Ramsar Site Strategic Management Plan. http://www.parkweb.vic.gov.au/1park_display.cfm?park=211
- Western Port Seagrass Partnership (WPSP) has undertaken several projects within the Ramsar site that have an aim to increase community awareness about issues within Western Port. These projects include
  - Northern Western Port Coastal Erosion Project—Current: as part of this project, WPSP will expand its school engagement program and seek additional sponsorship. In addition, help has been sought from community volunteers and by contracting 10 000 plants through the Mornington Youth Enterprises Nursery
  - School Engagement Program—Current: WPSP engage schools in growing and planting mangrove seedlings in an effort to raise awareness of the importance of coastal vegetation and provide practical experience in growing and planting vegetation
  - Western Port DVD Project—Current: WPSP have produced and are distributing a DVD with the aim of building public awareness and knowledge of special features and threatening processes to Western Port. WPSP see this as the first step in achieving an appreciation of Western Port and a consequential desire to protect and restore the bay throughout the community
  - Seagrass Restoration Project 2002: the first full scale seagrass transplanting experiment to be undertaken in Western Port. One of the four elements comprising this project was community education on the importance of coastal vegetation
  - Improving Water Quality in Ramsar Wetland Area: the project aimed to improve water quality by planting mangroves to reduce coastal erosion. The project provided hands on educational experiences to primary school children and has reported improved community awareness and appreciation about the role and importance of coastal vegetation, particularly mangroves
- Walk the talk a coastal journey of Victoria undertaken by Lynn Murrell in 2005 in order to create greater awareness and to test the feasibility of linking existing walking trails to create a ‘Great Victorian Coastal Walk’. At the time Lynn Murrell was a member of the Victorian Coastal Council, Chair of the Western Coastal Board and President of Friends of Cape Nelson Landcare/Coastcare: www.walkthetalk.ws

- The Western Port and Mornington Peninsula Biosphere Foundation was established in 2003 in order to implement the UNESCO Man and the Biosphere Program. The foundation forms a partnership between the Victorian government, the five local government authorities within the Biosphere, and six community roundtables. The Foundation aims to lead the community to engage in sustainable practice through conserving and improving biological diversity, building and sharing knowledge by facilitating, monitoring and utilising research, fostering, encouraging and facilitating project partnerships, and engaging with, and providing education for, all elements of the biosphere community. www.biosphere.org.au

- Project BIRDS (Bayer International Regeneration & Development Scheme) 2001: was a partnership between Bayer Australia and Parks Victoria to promote the conservation of migratory shorebird habitat in Western Port. The project involved a number of activities, including erecting exclusion fencing, constructing boardwalks, weed removal, revegetation, and designing and installing interpretive signage. The project facilitated extensive community involvement and engagement. Education programs at the local school (Tooradin Primary) and with the community were undertaken as part of the project

- Coastcare facilitate numerous activities to enhance the appreciation of Victoria's coasts, including Western Port. For example, Summer by the Sea is an annual coastal activity program that aims to introduce Victorians to the marine and coastal environment by hosting a range of entertaining and educational coastal activities. www.dse.vic.gov.au

- Marine Education Resource Kit developed by Parks Victoria assists teachers and students build their knowledge and understanding of the values of Victoria's marine and coastal environments: www.parkweb.vic.gov.au/education/marinekit

- Marine Habitat Mapping Kit developed by Parks Victoria provides information and opportunities for Victorian students to learn about marine mapping as applied to Victoria's Marine National Parks and Marine Sanctuaries: www.parkweb.vic.gov.au/education/marine-mapping

- Ranger Roo website and activities provides a series of games, activities, puzzles and information to build understanding of the importance of parks for young people: www.rangerroo.com.au

- The Coolart Reserve, managed by Parks Victoria at Somers borders the Ramsar site and has education facilities covering wetland themes, including migratory shorebirds. http://www.parkweb.vic.gov.au/1park_display.cfm?park=50 In addition, the Marine Conservation Centre at Hastings runs regular education programs for schools as well as their own research.

The following additional communication and education messages should be considered in conjunction with the above CEPA activities. These have been identified following review of the identified threats to the ecological character of the Ramsar site (Section 4):

- Catchment and coastal erosion: the importance of coastal vegetation in preventing erosion and stabilising sediments, and undertaking activities within the catchment to prevent further sediment delivery to the Ramsar site such as preventing direct access of stock to waterways and providing off-stream watering points

- Diminishing water quality: how to minimise pollution within the catchment entering the Ramsar site, particularly stormwater, run-off and litter
- Recreational activities: steps the community can take to minimise shorebird disturbance by walking, boating, recreational vehicles and domestic pets
- Pest plants and animals: the importance of controlling pest species, including terrestrial species (such as domestic cats, Red Foxes, deer) in addition to exotic marine species
- Climate change: steps the community can take to minimise the impacts associated with climate change such as helping revegetate actively eroding sites
- Ecosystem interactions: the importance of interactions between climate, water quality, tidal regime and hydrodynamics, bathymetry, sediment, flora and fauna (including marine invertebrates and fish) in maintaining the Western Port environment.

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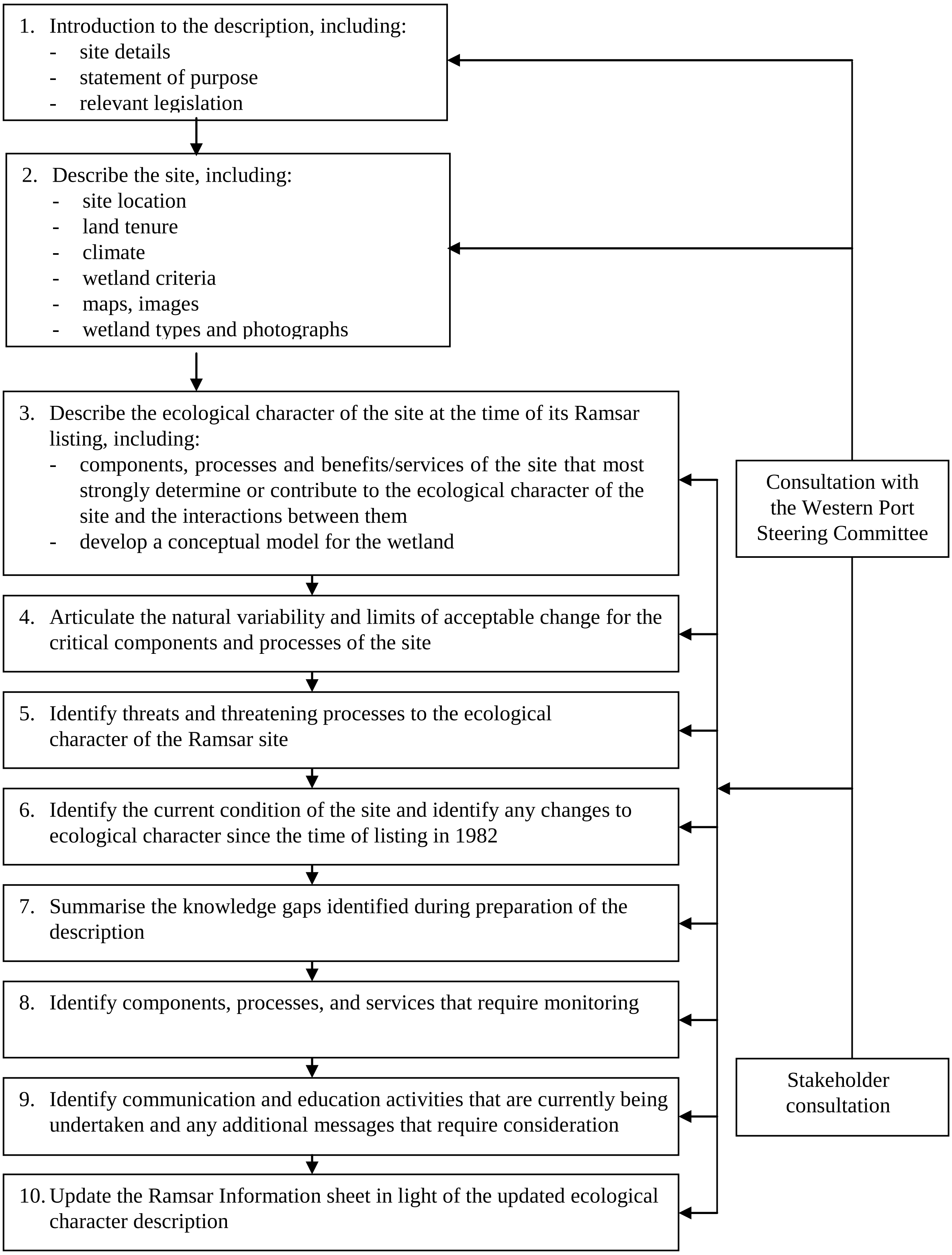
Appendix A

METHODS USED TO COMPILE THE DESCRIPTION

Appendix A

Methods used to compile the description



Appendix B

CURRICULA VITAE FOR AUTHORS OF THE DESCRIPTION

Shelley Heron

Environmental Scientist and Project Manager

Key Skills and Experience

Shelley Heron is Manager of the Water Ecosystems team in KBR's Melbourne office. This team provides specialist services to clients in the management of aquatic ecosystems, water resources and catchments.

Ms Heron has 20 years' experience in the fields of water, wetlands and natural resources management. Prior to joining KBR she established Heron Environmental Consulting after gaining substantial experience with the Department of Sustainability and Environment and the Melbourne Water Corporation.

In her consulting practice, Ms Heron undertook project management and leadership, facilitation and communication, flow rehabilitation plans, catchment plans, river health strategies and wetland investigations. She is highly experienced in the development and application of decision support tools, risk assessment systems and databases for managing water resources, including RiVERS and the FLOWS method. The projects she has worked on cover water resources and catchments throughout Victoria.

Since joining KBR, Ms Heron has managed many multidisciplinary teams in the development of prioritisation frameworks, risk management projects and environmental management plans. Recent projects include preliminary environmental work for a major water infrastructure project in south Gippsland, the Olympic Dam Expansion, Northern Sustainable Water Strategy Wetland Review, and Assessment Framework of Water Management Regimes.

Ms Heron is an invited participant in various expert panels including the review of the prioritisation process for waterways, wetlands and estuaries with the Department of Sustainability and Environment.

Qualifications

- Bachelor of Applied Science (Environmental Assessment and Landuse Policy), Victoria College Rusden and University of Waterloo, Canada, 1988
- Master of Environmental Studies (Research), University of Melbourne, 1999

Current Position

- Manager, Water Ecosystems
- Joined the company 2006
- State Sector Representative Planning and Environment

Professional Affiliations and Appointments

- River Basin Management Society
- Australian Water Association
- Chair of the Inland Fisheries Committee, Ministerial Advisory Committee

Other Training or Specialist Knowledge

- Decision support systems
- River value and environmental risk system (RiVERS)
- Trained facilitator

Publications

Numerous conference papers, technical reports and unpublished reports

2006 TO PRESENT
KELLOGG BROWN & ROOT PTY LTD (formerly Kinhill), MELBOURNE

Shelley Heron is Manager of the Water Ecosystems team, which provides specialist services to clients in the management of aquatic ecosystems, water resources and catchments. Ms Heron's experience since joining KBR includes the following projects.

Northern Region Sustainable Water Strategy Wetland Assessment: the Department of Sustainability and Environment (DSE) is seeking an understanding of the impact of future water availability scenarios on high value wetlands in northern Victoria, as part of the Northern Region Sustainable Water Strategy. The main objective of this work is to allow for the prioritisation of management actions based on the triple-bottom-line values of these wetlands and a comprehensive assessment of the risks and threats to these values. This project builds on the framework developed by KBR for the Kerang Lakes project. Ms Heron's expertise in prioritisation and decision support tools was applied to this project and she led the teams that undertook the assessment. (Client: Department of Sustainability and Environment; 2008)

Expert adviser on the relocation options of Murray Hardyhead: the Murray Hardyhead is a small freshwater fish endemic to the lower Murray–Darling river system. Although once widespread it is now restricted to a few sites and is further threatened by drought and accelerated climate change. It is currently one of the most threatened vertebrate fauna species in Australia and DSE is examining options to relocate populations of this species to ensure its long-term survival. KBR has been engaged to identify additional wetland sites in which additional populations of this fish can be established to help ensure its continued survival. The client requested that Ms Heron undertake the study so her exceptional knowledge of wetlands within the Murray–Darling basin could be applied to identify the best sites for the relocation of this species (Client: Department of Sustainability and Environment; 2008)

Groundwater impact assessment, Olympic Dam, South Australia: a significant expansion is proposed for the Olympic Dam copper, gold and uranium mine near Lake Torrens in South Australia. KBR is undertaking the groundwater component of the environmental impact assessment for the expansion. Ms Heron is leading the team examining potential links between the expansion of the mine, groundwater and changes in associated environmental assets. (Client: Resource and Environmental Management Pty Ltd; 2008)

Expert adviser for review of the prioritisation of waterway, wetlands and estuaries: the DSE and Victoria's catchment management authorities are undertaking an assessment of efficiency and effectiveness of their prioritisation methods for their investment in waterways, wetlands and estuaries. KBR is providing a technical review on these methods and advising on how to improve processes. Ms Heron is leading this project and is applying for her extensive knowledge and experience in decision support tools and prioritisation methods. (Clients: Department of Sustainability and Environment; 2008)

State of the Environment Freshwater Systems: State of the Environment reporting is a management tool for governments and organisations interested in environmental reporting. It analyses the latest information to assess environmental trends. KBR was engaged to review the Freshwater Ecosystem Condition and Status of the Victorian State components of the Environment Report. This project involved extensive data and literature reviews to produce a comprehensive overview of the condition of Victorian riparian areas and the current issues and pressures faced by these environmental assets. Ms Heron led the team that undertook this work. (Client: Victorian Commissioner for Environmental Sustainability; 2008)

Verification team leader (environment and planning): the Victorian government is considering methods of returning environmental flows to the Yarra and Latrobe Rivers. KBR is undertaking a verification review of technical reports for these rivers which will assist in developing a business case for the use of recycled water to establish a sustainable flow regime for these rivers. Ms Heron has been requested by the client to apply her extensive knowledge regarding environmental flow regimes for the verification process. (Client: Department of Sustainability and Environment; 2008)

Mulcra Island Impact Assessment: the Mallee Catchment Management Authority required an environmental impact assessment of a range of different flow scenarios at Mulcra Island. The primary purpose of this report is to identify and highlight any likely impacts associated with differing flow regimes. KBR is reviewing previous studies, reports and modelling to investigate the potential future effects on environmental, social and economic values associated with the wetlands. Ms Heron led the team that undertook this work. (Client: Mallee Catchment Management Authority; 2007)

Dryland wetland management, Victoria: this project aimed to improve knowledge of dryland wetlands and their medium- to long-term management. KBR is undertaking the development of an accurate wetland spatial database, categorising and prioritising wetlands identified through the mapping process, and providing a guide for future management of high priority wetlands. KBR is also producing a detailed action plan for wetlands which will provide guidance for management of the selected high value wetlands. Ms Heron led the team that undertook this project. (Client: North Central Catchment Management Authority; 2008)

Regional Wetland Strategy prioritisation review, Victoria: the North Central Catchment Management Authority is developing a strategy for guiding its regional wetland management. Ms Heron reviewed the strategy, developed a discussion paper and made recommendations for advancing the strategy towards its goals. (Client: North Central Catchment Management Authority; 2008)

Goulburn River management, establishing objectives (phase one), Victoria: the Goulburn Broken Catchment Management Authority is seeking a clear understanding of the current management objectives and targets for the Goulburn River. Ms Heron applied her knowledge of waterway management to review existing plans, strategies and reports to assist in developing resource condition and management action targets for the river. (Client: Goulburn Broken Catchment Management Authority; 2006–07)

South West Waterway Health Sub-Strategy and associated decision support system, Western Australia: the South West Catchments Council is developing a Waterway Health Strategy, a prioritisation framework and a decision support tool to assist in determining investment priorities. Ms Heron was commissioned to lead a team of independent environmental subconsultants to develop the prioritisation framework and waterway health substrategy and assist in developing a practical investment decision support tool. (Client: Spatial Vision; 2006–08)

Sustainable water use plans for local government, Victoria: each local government council in Victoria was required to produce a sustainable water use plan which examines its water consumption and sets targets and actions to reduce consumption. KBR produced plans for councils in south-western and central Victoria and in East Gippsland. The plans bring together data on council water consumption, examine local and state government regulations, explore avenues for funding, and assist councils to set their water reduction targets and establish actions on how to achieve these targets. Ms Heron assisted the project team developing the plans for East Gippsland and Macedon Ranges by providing technical advice and review, and facilitated stakeholder workshops. (Clients: Wannon Water; Warrnambool City Council; and Shire Councils of Southern Grampians, Glenelg, Moyne, Corangamite, East Gippsland and Macedon Ranges; 2006–07)

Wastewater treatment and disposal, Toora and Foster, Victoria: KBR is investigating the feasibility and cost of using effluent from wastewater treatment lagoons at Toora and Foster to create sustainable wetlands and produce discharges that are socially acceptable and comply with environmental limits. Ms Heron is the Principal Wetland Ecologist, responsible for ecological condition assessment, commenting on possible effects on Ramsar wetlands and providing ecological input to placement options for constructing future treatment wetlands. (Client: South Gippsland Water; 2007–)

Assessment framework of water management regimes, Kerang Lakes, Victoria: KBR has developed a framework for assessing the effects on the health of the Kerang Lakes of changes in water management regimes. Ms Heron was Principal Wetland Ecologist and Project Manager. She managed all aspects of the project and provided technical advice and review to the KBR project team. (Client: Department of Sustainability and Environment; 2007)

HERON ENVIRONMENTAL CONSULTING
1999 TO 2006

Ms Heron established Heron Environmental Consulting in 1999 after gaining substantial experience with the Department of Sustainability and Environment and the Melbourne Water Corporation. She has undertaken numerous projects in the management of water resources and catchments for many clients, including the following.

Decision support systems and priority setting frameworks: Ms Heron has developed several asset-based risk management decision support frameworks and database applications. These include the River Value and Environmental Risk System (RiVERS) decision support tool; the Estuary Entrance Management Support System (EEMS); the Targeted Waters Catchment Prioritisation Framework; the Loddon Wetlands Priority Setting Model; the Risk Assessment System for groundwater impacts on remnant vegetation; the Lerderderg River Risk System (LeRRS); and the Maribyrnong River Risk System (MaRRS). Ms Heron has worked closely with clients while developing these systems. Clients have included the Department of Natural Resources and Environment, the Department of Primary Industries, catchment management authorities and Deakin University.

Regional river health strategies and catchment action plans: catchment management authorities throughout Victoria have developed regional river health strategies and catchment action plans to assist in determining priorities for natural resource management. Ms Heron has worked with several catchment management authorities to assist in developing the following plans: the Coliban Catchment Action Plan; the Goulburn Broken River Health Strategy; the East Gippsland Regional River Health Strategy; and the Risk Assessment for the Mallee Regional River Health Strategy.

Flow studies, Lerderderg and Maribyrnong rivers, and Steels, Pauls and Dixons creeks, Victoria: many waterways throughout Victoria have undergone major changes in flow regimes due to water resource development, and studies have been undertaken to determine the environmental flow requirements using the FLOWS method. Ms Heron has led teams of scientists to develop environmental flow studies for several river systems. She has acted as project leader and has provided technical input on waterway and wetland management.

Facilitation: Ms Heron has facilitated workshops to assist in the development of regional river health strategies, catchment action plans and flow rehabilitation plans.

Wetland prioritisation studies: Ms Heron has established various wetland priority-setting frameworks, including the Wimmera Wetland Information System for the Wimmera Catchment Management Authority; the Mallee Wetland Prioritisation Scoping Study for the Mallee Catchment Management Authority; and the Loddon Wetlands Priority Setting Framework and Model for the North Central Catchment Management Authority.

Ecological Character Descriptions for Ramsar Wetlands: the Department of Sustainability and Environment is responsible for preparing Ecological Character Descriptions for wetlands listed on the Ramsar Convention. Ms Heron developed Ecological Character Descriptions for the Westernport and Edithvale Seaford Ramsar Sites.

1997 TO 2000
MELBOURNE WATER, WATERWAYS AND ENVIRONMENT GROUP

Waterway Management Strategy: Melbourne Water is responsible for the health and condition of Melbourne's waterways. While working for Melbourne Water, Ms Heron developed a management strategy for Melbourne's waterways, promoting the principles of asset-based risk management (at the time a new concept). An important component of this work was establishing the Environmental Risk Assessment Priority Setting Model (ERAPSM), a database application which stored waterway data and assisted in setting management priorities.

Fishway construction: Melbourne Water constructed fishways in priority locations to improve fish migration. Ms Heron developed the priorities for fishway construction and played an active role in the inspection and design of the fishways. She also represented Melbourne Water on the State Fishway Implementation Committee.

Bunyip and Yarra Bulk Entitlements: the Bulk Entitlement program established the flow-sharing between consumptive use and environmental water allocations. Ms Heron participated in technical groups for the Bunyip River and Yarra Bulk Entitlement Process.

1988 TO 1997
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Senior Policy Analyst, Waterways and Floodplains

Ms Heron was a Senior Policy Analyst and participated in the development and implementation of environmental water policy at state and national levels. She provided specialist advice on environmental and conservation aspects of water resource management for non-consumptive uses and assisted in determining environmental flow-sharing arrangements (1994–97).

1991 TO 1994
DEPARTMENT OF CONSERVATION AND ENVIRONMENT

Wetland Policy Specialist, Office of the Environment

Ms Heron contributed technical expertise and policy advice and development to aspects of wetland management. She assisted in preparing the State Planning Scheme Amendment (S24) to protect wetlands on private land. She convened public meetings and presented the proposed amendment to rural communities (1991–94).

Leader of the Environmental Assessment Team, Bendigo

As part of the development of management plans for dryland and irrigation salinity in north central Victoria, Ms Heron supervised and coordinated a team of scientists in assessing the conservation values associated with wetlands in the Kerang Lakes area and the catchments of the Campaspe, Loddon, Avoca and Avon-Richardson rivers (1988–91).

1988
DEPARTMENT OF WATER RESOURCES

Project Officer, Environmental Planning Branch

Ms Heron assessed the conservation value of wetlands in south-east Victoria with WRAP (Wetlands Resource Assessment Package). She also undertook data collection, data entry into WRAP, and consultation with various conservation, lobby and community groups.

Bec Lillie

Ecologist

KEY SKILLS AND EXPERIENCE

Rebecca (Bec) Lillie is an ecologist in the Water and Environment group in KBR's Melbourne office.

Miss Lillie has experience in both broad and targeted ecological assessments and data analysis. She has a thorough understanding of state and federal policy and legislation pertaining to biodiversity, in particular the *Environment Protection and Biodiversity Conservation Act 1999*, *Flora and Fauna Guarantee Act 1988* and Victoria's Native Vegetation Management—A Framework for Action.

Since joining KBR, Miss Lillie has conducted aerial interpretation and field verification of wetlands within the North Central and Corangamite Management Regions and prepared a management plan for the Edithvale–Seaford Ramsar site. She has undertaken fieldwork assessing the applicability of spatial referencing for use in the Index of Stream Condition Method as well as for two wetland management plans in North Central Victoria.

Prior to joining KBR, Miss Lillie held ecological and research assistant appointments. Her experience includes detailed flora and fauna assessments (employing habitat–hectare and scattered tree methodologies), referrals under the *Environment Protection and Biodiversity Conservation Act*, targeted species searches, assessments by index of wetland condition, vegetation management plans, and offset implementation plans.

Miss Lillie graduated from the University of Melbourne in 2005 with a Bachelor of Science (First Class Honours), majoring in environmental science and geography. In her honours year, Miss Lillie specialised in freshwater ecology, researching the impact of disturbance (sedimentation) on the distribution of lotic macroinvertebrate egg masses on woody debris in streams of south-eastern Australia.

QUALIFICATIONS

- Graduate Certificate in River Health Management, University of Melbourne, currently completing
- Bachelor of Science (Honours), University of Melbourne, 2005

CURRENT POSITION

- Ecologist, Melbourne
- Joined the company 2008

PROFESSIONAL AFFILIATIONS AND APPOINTMENTS

- Environment Institute of Australia and New Zealand

OTHER TRAINING OR SPECIALIST KNOWLEDGE

- Rail Track Safety Awareness Level 1, 2007
- Ausrivas: Aquatic Macroinvertebrate Bioassessment, EPA Victoria, 2007
- Sustainable Rivers Audit, Murray–Darling Freshwater Research Centre, 2007
- Wild Grasses of Victoria, Dr Graham Lorimer, 2006
- Index of Stream Condition Assessment, Department of Sustainability and Environment, 2006
- Index of Wetland Condition Assessment, Department of Sustainability and Environment, 2006
- Senior First Aid (Level II, Intermediate First Aid), St Johns Ambulance Australia, 2006
- Red Card: Construction Industry Basic Induction Training, 2006

2008 TO PRESENT
KELLOGG BROWN & ROOT PTY LTD (formerly Kinhill), MELBOURNE

Bec Lillie is an ecologist for the Water and Environment Group of KBR's Melbourne office, where her experience includes the following projects.

Index of Stream Condition—remote sensing trial, Werribee, Victoria: the Index of Stream Condition provides a statewide benchmark of the condition of Victoria's major waterways. Remote sensing information was trialled as a new and rapid means of determining waterway condition and providing a more accurate description of the whole waterway. Miss Lillie assisted the research team to develop the method with ground-truthing and baseline data by undertaking field surveys of vegetative cover, understorey diversity and structure, tree cover, weeds and erosion of stream banks at 15 riparian sites in the Werribee River catchment. (Client: Department of Sustainability and Environment; 2008)

Dryland wetland management, north central Victoria: this project aimed to improve knowledge of dryland wetlands and their medium- to long-term management. Miss Lillie contributed to the development of an accurate wetland spatial database, categorising and prioritising wetlands identified through the mapping process, and providing a guide for future management of high priority wetlands. KBR also produced a detailed action plan for wetlands which will provide guidance for management of the selected high value wetlands. Miss Lillie was also involved in the fieldwork and preparation of these management plans. (Client: North Central Catchment Management Authority; 2008).

Corangamite wetland extent review, Victoria: to assist in the prioritising of wetland management, an audit to determine the extent of wetlands throughout the Corangamite Catchment Management region was undertaken. Miss Lillie worked on the development of a spatial database, categorising wetlands identified through the mapping processes. (Client: Corangamite Catchment Management Authority; 2008).

Management plan for the Edithvale–Seaford Ramsar Wetlands: Miss Lillie prepared a biodiversity conservation management plan for the Edithvale–Seaford Ramsar site. This plan provides for the future management of the wetlands, satisfies obligations under the Convention on Wetlands (Ramsar), and incorporates comments and considerations from key stakeholders. Miss Lillie also prepared a literature review, and contributed to client workshops. (Client: Melbourne Water; 2008)

Main line upgrade, Melbourne to Sydney: to improve the capacity and competitiveness of rail freight, the Australian Rail Track Corporation (ARTC) has entered into the South Improvement Alliance for upgrading the main line between Melbourne and Sydney with a works program which is currently estimated to be worth up to $1 billion. As a sub-alliance partner, KBR is undertaking the design of track and civil works and providing environmental services and construction support.

Seventeen passing lanes, each about 6.8 km long, are to be constructed along the single gauge rail line from Melbourne to Junee in NSW. Ms Lillie has undertaken desktop reviews of environmental data and assessments of flora, fauna and habitat for the passing lanes being constructed in Victoria. The data collection supports the preparation of applications for environmental and planning approvals for the passing lanes. (Client: South Improvement Alliance for ARTC; 2005–)

2006 TO 2008
EARTH TECH

As an ecologist at EarthTech, Ms Lillie worked on a variety of projects, including the following.

Goldfields Superpipe, Victoria: identified and mapped biological values such as ecological communities of conservation significance; identified areas containing or potentially containing species of conservation significance, potential habitat areas, and other special management zones; undertook habitat–hectare and net gain assessments of native vegetation which was to be removed and of potential offset sites, liaising with the Department of Sustainability and Environment on achieving the offsets.

Ms Lillie reported on the plans for the offset implementation and management for the vegetation of very high conservation significance which would be lost as a result of construction. She also prepared the plans for offset implementation and management for vegetation of high, medium and low conservation significance which would be lost. She advised on mitigation measures for managing particular biological values and prepared a referral under the *Environment Protection and Biodiversity Conservation Act*. (Client: Central Highlands Water)

Index of wetland condition assessments, Victoria: undertook field work and reporting for both the 2006 and 2007 programs of wetland condition assessment. (Client: Mallee Catchment Management Authority)

Vegetation management plan, Victoria: investigated a site proposed for industrial development and prepared a vegetation management plan. (Client: Head and Humphreys Pty Ltd)

Referral under the Environment Protection and Biodiversity Conservation Act, Victoria: investigated a site proposed for residential development and prepared a referral under the *Environment Protection and Biodiversity Conservation Act*. (Client: Redesign Developments Pty Ltd)

Targeted species searches, various locations, Victoria: undertook targeted searches for spiny rice flower individuals throughout sites proposed for residential or industrial development around the Melbourne metropolitan area. (Clients: Moreton Homestead, Orica, Toyota)

Flora and fauna assessments, various locations, Victoria: undertook and reported on flora and fauna assessments of sites proposed for industrial or residential development, including habitat–hectare and net gain assessments where required. (Clients: Toyota, Abacus Group, Peet & Co., GMR Engineering, Wellington Shire Council)

Frog survey, Holmesglen, Victoria: undertook call and playback surveys of frogs on a site proposed for industrial development. (Client: Hyder Consulting)

NOVEMBER 2003 TO FEBRUARY 2004
COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY, MELBOURNE

Research Assistant

During the 2003–04 long vacation, Ms Lillie undertook field work, data collection and analysis of approximately 80 streams throughout Victoria.

Appendix C

RAMSAR INFORMATION SHEET

The Ramsar Information Sheet (RIS) is currently being updated and will be available separately.

Appendix D

NON-PELAGIC WATERBIRD SPECIES THAT OCCUR AT THE RAMSAR SITE CLASSIFIED BY GUILD (BASED ON BOCA SURVEY DATA)

Appendix D

Non-pelagic waterbird species that occur at the Ramsar site classified by guild (based on BOCA survey data)

Common Name	Scientific Name	Breeding range	Local breeding	Main feeding habitat	Guild	CAMBA	JAMBA	ROKAMBA
Blue-billed Duck	*Oxyura australis*	A	W	FW	Duck			
Musk Duck	*Biziura lobata*	A		T, FW	Duck			
Freckled Duck	*Stictonetta naevosa*	A		FW	Duck			
Black Swan	*Cygnus atratus*	A	R	T, FW	Swan			
Cape Barren Goose	*Cereopsis novaehollandiae*	A	PI	G	Goose			
Feral Goose	*Anser anser*	A	PI	G	Goose (introduced to Australia)			
Australian Shelduck	*Tadorna tadornoides*	A	R	T, FW, G	Duck			
Australian Wood Duck	*Chenonetta jubata*	A	W	FW	Duck			
Mallard	*Anas platyrhynchos*	A		FW	Duck (introduced to Australia)			
Pacific Black Duck	*Anas superciliosa*	A	W	FW, T	Duck			
Australasian Shoveler	*Anas rhynchotis*	A		FW, T	Duck			
Grey Teal	*Anas gracilis*	A		FW, T	Duck			
Chestnut Teal	*Anas castanea*	A	R	T, FW	Duck			
Pink-eared Duck	*Malacorhynchus membranaceus*	A		FW	Duck			
Hardhead	*Aythya australis*	A		FW	Duck			
Australasian Grebe	*Tachybaptus novaehollandiae*	A	W	FW	Grebe			
Hoary-headed Grebe	*Poliocephalus poliocephalus*	A		T, FW	Grebe			
Great Crested Grebe	*Podiceps cristatus*	A		T, FW	Grebe			
Little Penguin	*Eudyptula minor*	A	R	O	Seabird			
Short-tailed Shearwater	*Ardenna tenuirostris*	A	R	O	Seabird		X	X

Common Name	Scientific Name	Breeding range	Local breeding	Main feeding habitat	Guild	CAMBA	JAMBA	ROKAMBA
Australasian Gannet	*Morus serrator*	A		O	Seabird			
Australasian Darter	*Anhinga novaehollandiae*	A		FW	Fisher			
Little Pied Cormorant	*Microcarbo melanoleucos*	A	W	T, FW	Fisher			
Black-faced Cormorant	*Phalacrocorax fuscescens*	A		T	Fisher			
Pied Cormorant	*Phalacrocorax varius*	A	R	T, FW	Fisher			
Little Black Cormorant	*Phalacrocorax sulcirostris*	A	W	FW, T	Fisher			
Great Cormorant	*Phalacrocorax carbo*	A	W	FW, T	Fisher			
Australian Pelican	*Pelecanus conspicillatus*	A	R	T, FW	Fisher			
White-faced Heron	*Egretta novaehollandiae*	A	R	T, FW	Large wading bird			
Little Egret	*Egretta garzetta*	A		T, FW	Large wading bird			
White-necked Heron	*Ardea pacifica*	A		FW, T	Large wading bird			
Eastern Great Egret	*Ardea modesta*	A		FW, T	Large wading bird	X	X	
Intermediate Egret	*Ardea intermedia*	A		FW, T	Large wading bird			
Cattle Egret	*Ardea ibis*	A		G	Large wading bird	X	X	
Nankeen Night Heron	*Nycticorax caledonicus*	A		FW	Large wading bird			
Australasian Bittern	*Botaurus poiciloptilus*	A		FW	Large wading bird			
Glossy Ibis	*Plegadis falcinellus*	A		FW	Large wading bird	X		
Australian White Ibis	*Threskiornis molucca*	A	W	T, FW, G	Large wading bird			
Straw-necked Ibis	*Threskiornis spinicollis*	A	W	G, FW	Large wading bird			
Royal Spoonbill	*Platalea regia*	A	W	T, FW	Large wading bird			
Yellow-billed Spoonbill	*Platalea flavipes*	A		FW	Large wading bird			
Eastern Osprey	*Pandion cristatus*	A		T	Other			
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	A	R	T, FW	Other	X		
Swamp Harrier	*Circus approximans*	A	W	FWM	Other			
Buff-banded Rail	*Gallirallus philippensis*	A	R	SM, FWM	Other			
Lewin's Rail	*Lewinia pectoralis*	A		FWM, SM	Other			

Common Name	Scientific Name	Breeding range	Local breeding	Main feeding habitat	Guild	CAMBA	JAMBA	ROKAMBA
Baillon's Crake	*Porzana pusilla*	A		FWM	Other			
Australian Spotted Crake	*Porzana fluminea*	A		FWM, SM	Other			
Spotless Crake	*Porzana tabuensis*	A		FWM, SM	Other			
Purple Swamphen	*Porphyrio porphyrio*	A	W	FWM	Other			
Dusky Moorhen	*Gallinula tenebrosa*	A	W	FWM	Other			
Black-tailed Native-hen	*Tribonyx ventralis*	A		FWM	Other			
Eurasian Coot	*Fulica atra*	A	W	FW	Other			
Latham's Snipe	*Gallinago hardwickii*	NH		FWM	Palaearctic migratory wader	X	X	X
Black-tailed Godwit	*Limosa limosa*	NH		T, FW	Palaearctic migratory wader	X	X	X
Bar-tailed Godwit	*Limosa lapponica*	NH		T	Palaearctic migratory wader	X	X	X
Whimbrel	*Numenius phaeopus*	NH		T	Palaearctic migratory wader	X	X	X
Eastern Curlew	*Numenius madagascariensis*	NH		T	Palaearctic migratory wader	X	X	X
Marsh Sandpiper	*Tringa stagnatilis*	NH		S	Palaearctic migratory wader	X	X	X
Common Greenshank	*Tringa nebularia*	NH		T, FW	Palaearctic migratory wader	X	X	X
Wood Sandpiper	*Tringa glareola*	NH		FW	Palaearctic migratory wader	X	X	X
Terek Sandpiper	*Xenus cinereus*	NH		T	Palaearctic migratory wader	X	X	X
Common Sandpiper	*Actitis hypoleucos*	NH		T	Palaearctic migratory wader	X	X	X
Grey-tailed Tattler	*Tringa brevipes*	NH		T	Palaearctic migratory wader	X	X	X
Ruddy Turnstone	*Arenaria interpres*	NH		T	Palaearctic migratory wader	X	X	X
Great Knot	*Calidris tenuirostris*	NH		T	Palaearctic migratory wader	X	X	X
Red Knot	*Calidris canutus*	NH		T	Palaearctic migratory wader	X	X	X
Sanderling	*Calidris alba*	NH		T	Palaearctic migratory wader	X	X	X
Red-necked Stint	*Calidris ruficollis*	NH		T, FW	Palaearctic migratory wader	X	X	X
Pectoral Sandpiper	*Calidris melanotos*	NH		FW	Palaearctic migratory wader	X	X	X
Sharp-tailed Sandpiper	*Calidris acuminata*	NH		FW, T	Palaearctic migratory wader	X	X	X
Curlew Sandpiper	*Calidris ferruginea*	NH		T, FW	Palaearctic migratory wader	X	X	X

Common Name	Scientific Name	Breeding range	Local breeding	Main feeding habitat	Guild	CAMBA	JAMBA	ROKAMBA
Broad-billed Sandpiper	*Limicola falcinellus*	NH		T	Palaearctic migratory wader	X	X	X
Ruff	*Philomachus pugnax*	NH		FW, T	Palaearctic migratory wader	X	X	X
Australian Painted Snipe	*Rostratula australis*	A		FW	Australasian breeding wader		TH	
Pied Oystercatcher	*Haematopus longirostris*	A	R	T	Australasian breeding wader			
Sooty Oystercatcher	*Haematopus fuliginosus*	A	PI	T	Australasian breeding wader			
Black-winged Stilt	*Himantopus himantopus*	A	W	FW	Australasian breeding wader			
Banded Stilt	*Cladorhynchus leucocephalus*	A		S	Australasian breeding wader			
Red-necked Avocet	*Recurvirostra novaehollandiae*	A		T, S	Australasian breeding wader			
Pacific Golden Plover	*Pluvialis fulva*	NH		T	Palaearctic migratory wader	X	X	X
Grey Plover	*Pluvialis squatarola*	NH		T	Palaearctic migratory wader	X	X	X
Ringed Plover	*Charadrius hiaticula*	NH		T	Palaearctic migratory wader	X	X	X
Red-capped Plover	*Charadrius ruficapillus*	A	R	T, S	Australasian breeding wader			
Double-banded Plover	*Charadrius bicinctus*	NZ		T, FW	Australasian breeding wader			
Lesser Sand Plover	*Charadrius mongolus*	NH		T	Palaearctic migratory wader	X	X	X
Greater Sand Plover	*Charadrius leschenaultii*	NH		T	Palaearctic migratory wader	X	X	X
Black-fronted Dotterel	*Elseyornis melanops*	A	W	FW	Australasian breeding wader			
Hooded Plover	*Thinornis rubricollis*	A	R	T, S	Australasian breeding wader			
Red-kneed Dotterel	*Erythrogonys cinctus*	A		FW	Australasian breeding wader			
Banded Lapwing	*Vanellus tricolor*	A	PI	G	Australasian breeding wader			
Masked Lapwing	*Vanellus miles*	A	R	T, G	Australasian breeding wader			
Oriental Pratincole	*Glareola maldivarum*	NH		T, G	Palaearctic migratory wader	X	X	X
Arctic Jaeger	*Stercorarius parasiticus*	NH		O	Seabird		X	X
Pacific Gull	*Larus pacificus*	A		T	Gull			
Kelp Gull	*Larus dominicanus*	A	PI	T	Gull			
Silver Gull	*Chroicocephalus novaehollandiae*	A	PI	T, S	Gull			
Gull-billed Tern	*Gelochelidon nilotica*	A		T, S	Fisher			

Common Name	Scientific Name	Breeding range	Local breeding	Main feeding habitat	Guild	CAMBA	JAMBA	ROKAMBA
Caspian Tern	*Hydroprogne caspia*	A	R	T, S	Fisher	X	X	
Crested Tern	*Thalasseus bergii*	A	PI	T	Fisher		X	
Common Tern	*Sterna hirundo*	NH		T	Fisher	X	X	X
Little Tern	*Sternula albifrons*	A		T	Fisher	X	X	X
Fairy Tern	*Sternula nereis*	A	R	T	Fisher			
Whiskered Tern	*Chlidonias hybrida*	A		FW	Other			
White-winged Black Tern	*Chlidonias leucopterus*	NH		FW	Other		X	X
Blue-winged Parrot	*Neophema chrysostoma*	A	R	SM, G	Land bird			
Orange-bellied Parrot	*Neophema chrysogaster*	A		SM	Land bird		TH	
White-throated Needletail	*Hirundapus caudacutus*	A		air	Land bird	X	X	X
Fork-tailed Swift	*Apus pacificus*	A		air	Land bird	X	X	X
Sacred Kingfisher	*Todiramphus sanctus*	A	R	SM	Land bird			
Southern Emu-wren	*Stipiturus malachurus*	A	R	SM	Land bird			
Striated Fieldwren	*Calamanthus fuliginosus*	A	R	SM	Land bird			
White-fronted Chat	*Epthianura albifrons*	A	R	SM	Land bird			
Australian Reed-Warbler	*Acrocephalus australis*	A	R	FWM	Land bird			
Little Grassbird	*Megalurus gramineus*	A	R	SM, FWM	Land bird			

Breeding range	
A	Includes Australia
NH	Northern Hemisphere
NZ	New Zealand
Main local feeding habitat	
FW	Freshwater wetlands
T	Tidal mudflats, beaches or sheltered waters
S	Saline inland lakes (elsewhere: these habitats are not represented in Western Port
G	Grassland (often near wetlands)
O	Open sea
SM	Saltmarsh
FWM	Freshwater marshes
Local breeding	
R	In Ramsar site or adjacent coast
W	In nearby wetlands
PI	On Phillip Island
Bilateral agreements	
X	listed
TH	Would be included by virtue of threatened status in Australia

Source: BOCA survey

Appendix E

COMMON INVERTEBRATES FOUND IN MARINE HABITATS

Appendix E

Common invertebrates found in marine habitats

Habitat	Epifauna/infauna	Common name	Species
Intertidal mudflats	Infauna	Bivalves	*Anadara trapezia*
			Katelysia rhytiphora
			Homalina deltoidalis
			H. mariae
			Laternula tasmania
		Mud yabby	*Callianassa*
		Shrimp	*Alpheus* sp.
	Epifauna	Grazing molluscs	Trochidae
			Rissoacea
		Gammaridean amphipods	
		Shrimp	*Macrobrachion* sp.
		Crabs	*Halicarcinus* sp.
			Litocheira bispinosa
		Sponges	Occasional
		Hydroids	Occasional
		Ascidiands	Occasional
Deep channels	Infauna	Polychaetes	
		Crustaceans	
		Bivalve molluscs	*Neotrigonia margaritacea*
			Pronuncula sp.
			Notocallista diemensis
			Bellucina crassillirata
			Venericardia bimaculata
		Rock boring bivalve	*Pholas australasiae*
		Gastropods	*Nassarius burchardi*
			Pterynotus triformis
			Amorena undulata
	Epifauna	Seapen	*Virgularia mirabilis*
		Gastropod	*Sigapatella calyptraeformis*
		Brachiopod	*Magellania australis*
		Sea stars	*Nectria ocellata*
			Patiriella brevispina
			Tosia magnifica
		Urchin	*Goniocidaris tubaria*
		Ascidian	*Pyura stolonifera*
		Sponges	Occasional
		Hydroids	Occasional
		Ascidians	Occasional

Beaches		Bloodworm	*Abarenicola*
Reefs and hard substrates	Epifauna	Sponges	*Ancorina corticata*
			Geodia sp.
			Ircinia sp.
		Ascidians	*Didemnum patulum*
			Amphicarpa diptycha
		Bryozoans	*Amathia bisrata*
			Bugula dentate
			Cellepraria prolifera
			Triphyllozoon monolifera
		Hydroids	*Pennaria* sp.
			Eudendrium generalis
			Aglaophenia plumosa
			Pumularia setacoides
			P. procumbens
			Setularia unduiculata
			S. lata
			Halopteris buskii

Source: EPA 1996

Appendix F

COMMON FISH ASSEMBLAGES IN WESTERN PORT

Appendix F

Common fish assemblages in Western Port

Assemblage	Family	Common name	Scientific name
Vegetated intertidal zones—Seagrass	*Moridae*	Rock Cod	*Pseudophycus bachus*
	Atherinidae	Hardy Heads	*Kestratherina brevirostris*
	Syngnathidae	Pipe Fishes	*Stigmatopora nigra*
			Stigmatopora argus
			Mitotichthys semistriatis
			Vanacampus phillipi
			Urocampus carinirostris
	Scorpaenidae	Soldierfish	*Gymnapistes marmoratus*
	Platycephalidae	Rock Flathead (adult)	*Platycephalus laevigatus*
	Apogonidae	Woods Siphon Fish	*Siphaemia cephalotes*
	Enoplosidae	Old Wife	*Enoplosus armatus*
	Odacidae	Blue Rock Whiting	*Haletta semifasciata*
	Clinidae	Weedfish	*Cristiceps australis*
			Heteroclinus adelaidei
			Heteroclinus perspicillatus
	Gobiidae	Gobies	*Arenigobius frenatus*
			Gobiopterus semivestitus
	Monacanthidae	Six Spined Leatherjacket	*Meuschenia freycineti*
		Bridled Leatherjacket	*Acanthaluteres spilomelanurus*
		Toothbrush Leatherjacket	*Acanthaluteres vittiger*
		Pygmy Leatherjacket	*Brachaluteres jacksonianus*
	Diodontidae	Globefish	*Diodon nicthemerus*
Unvegetated intertidal mudflat	*Elasmobranchs*	Sharks and rays	*Various (mostly undocumented)*
	Clupeidae	Sandy Sprat	*Hyperlophus vittatus*
	Platycephalidae	Sand Flathead	*Platycephalus bassiensis*
		Rock Flathead (juvenile)	*Platycephalus laevigatus*
	Sillaginidae	King George Whiting	*Sillaginodes punctatus*
	Gobiidae	Goby	*Favonigobius lateralis*
			Favonigobius tamarensis
			Arenigobius frenatus
			Pseudogobius olorum
	Pleuronectidae	Greenback Flounder	*Rhombosolea tapirina*
		Long Snouted Flounder	*Ammotretus rostratus*
	Tetraodontidae	Smooth Toadfish	*Tetractenos glaber*

Assemblage	*Family*	Common name	Scientific name
Drainage channels	*Urolophidae*	Banded Stinagree	*Urolophus cruciatus*
	Scorpaenidae	Gurnard Perch	*Neosebastes scorpaenoides*
	Platycephalidae	Sand Flathead	*Platycephalus bassiensis*
	Gobiidae	Goby	*Favonigobius lateralis*
Mobile/pelagic	*Carcharinidae*	School Shark	*Galeorhinus galeus*
		Gummy Shark	*Mustelus antarcticus*
	Callorhynchidae	Elephantfish	*Callorhinchus milii*
	Rajiformes	Rays	Various (mostly undocumented)
	Clupeidae	Sandy Sprat	*Hyperlophus vittatus*
		Pilchard	*Sardinops neopilchardus*
	Engraulidae	Australian Anchovy	*Engraulis australis*
	Hemiramphidae	Southern Sea Garfish	*Hyporhamphus nelanochir*
	Pomatomidae	Tailor	*Pomatomus saltarix*
	Carangidae	Silver Trevally	*Pseudocaranx dentex*
		Jack Mackeral	*Trachurus declivis*
Mobile	*Arripidae*	Australian Salmon	*Arripis truttacea*
	Sparidae	Snapper	*Chrysophrys auratus*
	Mugilidae	Yellow Eyed Mullet	*Aldrichetta forsteri*
	Gempylidae	Barracouta	*Thyrsites atun*
Beach	*Atherinidae*	Hardy Heads	*Leptatherima presbyteroides*
			Atherinosoma microstoma
	Platycephalidae	Sand Flathead	*Platycephalus bassiensis*
	Mugilidae	Yellow Eyed Mullet	*Aldrichetta forsteri*
	Pleuronectidae	Greenback Flounder	*Rhombosolea tapirina*
		Long Snouted Flounder	*Ammotretus rostratus*
	Tetraodontidae	Smooth Toadfish	*Tetractenos glaber*

Source: EPA 1996

Appendix G

ATLAS OF VICTORIAN WILDLIFE RECORDS THREATENED FAUNA SPECIES HISTORICALLY RECORDED WITHIN THE RAMSAR SITE

Appendix G

Atlas of Victorian Wildlife Records Threatened fauna species historically recorded within the Ramsar site

Common name	*Scientific name*	Year recorded	EPBC status	FFG status	DSE status
Australasian Bittern	*Botaurus poiciloptilus*	1953 1973 1974 1978 1991 1996		Listed	Endangered
Australasian Shoveler	*Anas rhynchotis*	1966 1974 1975 1976 1977 1978 1979 1980 1981 1982 1984 1985 1986 1987 1988 1990 1991 1992 1993 1994 1998 2002			Vulnerable
Australian Painted Snipe	*Rostratula australis*	1966 1974	Vulnerable	Listed	Critical
Azure Kingfisher	*Alcedo azurea*	1966 1977			Near threatened
Baillon's Crake	*Porzana pusilla*	1953 1975 1980 2006		Listed	Vulnerable
Barking Owl	*Ninox connivens*	1966 1978		Listed	Endangered
Bearded Dragon	*Pogona barbata*	1995			DD
Black Falcon	*Falco subniger*	1974 1975 1977 1978 1984			Vulnerable
Black-browed Albatross	*Thalassarche melanophris*	1971 1974 1975 1976 1977 1978 1980 1981 1994	Vulnerable		Vulnerable
Black-chinned Honeyeater	*Melithreptus gularis*	1977			Near threatened
Black-faced Cormorant	*Phalacrocorax fuscescens*	1974 1975 1976 1977 1978 1979 1980 1981 1983 1992 1994 1998 1999			Near threatened
Black-tailed Godwit	*Limosa limosa*	1967 1973 1974 1976 1977 1990			Vulnerable
Blue Petrel	*Halobaena caerulea*	1973 1980 1985 1998	Vulnerable		
Blue-billed Duck	*Oxyura australis*	1953 1966 1969 1971 1974 1977 1978 1979 1980 1981 1987 1992 2001		Listed	Endangered
Brittle Star Species	*Amphiura triscacantha*	1976		Listed	
Brown Quail	*Coturnix ypsilophora*	1953 1975 1977 1978 1979 1981 1990 1998			Near threatened
Cape Barren Goose	*Cereopsis novaehollandiae*	1977 1978 1979 1981 1985 1986 1992 1993 1994 1995 1997 1998 1999 2000 2006			Near threatened

Common Name	*Scientific name*	Year recorded	EPBC status	FFG status	DSE status
Caspian Tern	Hydroprogne caspia	1967 1970 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2004 2006		Listed	Near threatened
Chestnut-rumped Heathwren	*Calamanthus pyrrhopygius*	1953 1979 1981 1986		Listed	Vulnerable
Common Diving-petrel	*Pelecanoides urinatrix*	1974 1976 1985 1998			Near threatened
Common Sandpiper	*Actitis hypoleucos*	1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1984 1985 1986 1987 1990 1991 1992 1993 1997			Vulnerable
Eastern Curlew	*Numenius madagascariensis*	1953 1963 1964 1967 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2006			Near threatened
Eastern Great Egret	*Ardea modesta*	1966 1967 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2006		Listed	Vulnerable
Eucalliax Species 5255	*Eucalliax tooradin*	1965		Listed	
Fairy Prion	*Pachyptila turtur*	1960 1966 1974 1975 1977 1978 1979 1980 1981 1983 1998	Vulnerable		Vulnerable
Fairy Tern	*Sternula nereis*	1970 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1997 1998 2000 2002 2003 2004 2006		Listed	Endangered
Freckled Duck	*Stictonetta naevosa*	1977 1995		Listed	Endangered
Glossy Grass Skink	*Pseudemoia rawlinsoni*	1983 1996			Near threatened
Glossy Ibis	*Plegadis falcinellus*	1977 1980 1981			Near threatened
Great Knot	*Calidris tenuirostris*	1972 1973 1974 1975 1976 1977 1978 1979 1981 1982 1984 1985 1987 1988 1989 1990 1991 1992 1999 2002		Listed	Endangered

Common name	*Scientific name*	Year recorded	EPBC status	FFG status	DSE status
Greater Sand Plover	*Charadrius leschenaultii*	1966 1973 1974 1975 1976 1977 1978 1979 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1997 2000 2006			Vulnerable
Grey Goshawk	*Accipiter novaehollandiae*	1970 1980		Listed	Vulnerable
Grey Plover	*Pluvialis squatarola*	1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1990 1991 1992 1993 1994 1999			Near threatened
Grey-crowned Babbler	*Pomatostomus temporalis*	1899 1953 1974 1977 1978		Listed	Endangered
Grey-headed Albatross	*Thalassarche chrysostoma*	1974	Vulnerable	Listed	Vulnerable
Grey-headed Flying-fox	*Pteropus poliocephalus*	1952 1966 1981	Vulnerable	Listed	Vulnerable
Grey-tailed Tattler	*Heteroscelus brevipes*	1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1999 2000 2006		Listed	Critically endangered
Growling Grass Frog	*Litoria raniformis*	1788 1979	Vulnerable	Listed	Endangered
Gull-billed Tern	*Gelochelidon nilotica*	1975 1976 1977 1981 1982 1985 1986 2000		Listed	Endangered
Hardhead	*Aythya australis*	1953 1966 1971 1974 1975 1976 1977 1978 1979 1980 1981 1984 1986 1987 1988 1990 1991 1992 1993			Vulnerable
Helmeted Honeyeater	*Lichenostomus melanops cassidix*	1948	Endangered	Listed	Critically endangered
Hooded Plover	*Thinornis rubricollis*	1963 1970 1971 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1990 1991		Listed	Vulnerable
Hooded Robin	*Melanodryas cucullata*	1914 1953 1974 1979 1981		Listed	Near threatened
Humpback Whale	*Megaptera novaeangliae*	1985 1988 1996 2005	Vulnerable	Listed	Vulnerable
Intermediate Egret	*Ardea intermedia*	1975 1977 1978 1980 1981 2000		Listed	Critically endangered
King Quail	*Coturnix chinensis*	1972 1977 1980		Listed	Endangered
Lace Goanna	*Varanus varius*	1995			Vulnerable
Latham's Snipe	*Gallinago hardwickii*	1953 1973 1974 1975 1977 1978 1979 1980 1981 1987 1988			Near threatened

Common name	*Scientific name*	Year recorded	EPBC status	FFG status	DSE status
Lesser Sand Plover	*Charadrius mongolus*	1966 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1996 1997 2000 2006			Vulnerable
Lewin's Rail	*Lewinia pectoralis*	1966 1974 1975 1976 1977 1979 1980 1981 1988 1998 2006		Listed	Vulnerable
Little Button-quail	*Turnix velox*	1969			Near threatened
Little Egret	*Egretta garzetta*	1953 1973 1974 1975 1976 1977 1978 1979 1980 1981 1983 1984 1986 1987 1989 1992		Listed	Endangered
Little Tern	*Sternula albifrons*	1974 1975 1976 1981 1986 1987 1989 1991 1992 1993 1998 1999 2000		Listed	Vulnerable
Long-nosed Potoroo	*Potorous tridactylus*	1971 1976	Vulnerable	Listed	Endangered
Long-toed Stint	*Calidris subminuta*	1980			Near threatened
Magpie Goose	*Anseranas semipalmata*	1864 1987		Listed	Near threatened
Marine Opisthobranch	*Platydoris galbana*	1987		Listed	Vulnerable
Marine Opisthobranch	*Rhodope sp.*	1987		Listed	Vulnerable
Michelea Species 5256	*Michelea microphylla*	1965		Listed	
Musk Duck	*Biziura lobata*	1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 2000			Vulnerable
Nankeen Night Heron	*Nycticorax caledonicus*	1974 1975 1976 1977 1978 1981 1986 1987 1994			Near threatened
New Holland Mouse	*Pseudomys novaehollandiae*	1970		Listed	Vulnerable
Northern Giant-petrel	*Macronectes halli*	1974	Vulnerable	Listed	Near threatened
Orange-bellied Parrot	*Neophema chrysogaster*	1974 1975 1976 1977 1980 1981 1983 1984 1985 1987 1992 1994	Critically endangered	Listed	Critically endangered
Pacific Golden Plover	*Pluvialis fulva*	1966 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1996 1999 2000 2006			Near threatened

Common name	*Scientific name*	Year recorded	EPBC status	FFG status	DSE status
Pacific Gull	*Larus pacificus pacificus*	1953, 1967, 1968, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2006,			Near threatened
Pied Cormorant	*Phalacrocorax varius*	1953, 1962, 1966, 1967, 1970, 1972, 1973, 1974, 1975, 1976, 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2006			Near threatened
Powerful Owl	*Ninox strenua*	1978		Listed	Vulnerable
Red Knot	*Calidris canutus*	1974, 1975, 1976, 1977, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1999, 2002			Near threatened
Royal Albatross	*Diomedea epomophora*	1976	Vulnerable	Listed	Vulnerable
Royal Spoonbill	*Platalea regia*	1966, 1973, 1974, 1975, 1976, , 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2003, 2006			Vulnerable
Sanderling	*Calidris alba*	1974, 1975, 1980, 1981, 1987, 1989			Near threatened
Sea Cucumber 5052	*Apsolidium handrecki*	1980, 1983, 1989		Listed	
Shy Albatross	*Thalassarche cauta*	1974, 1977, 1978, 1979, 1980, 1981, 1994, 1998	Vulnerable	Listed	Vulnerable
Sooty Oystercatcher	*Haematopus fuliginosus*	1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1996, 1998, 2000, 2001			Near threatened
Southern Brown Bandicoot	*Isoodon obesulus obesulus*	1968, 1970, 1971, 1975, 1979, 1980	Endangered		Near threatened
Southern Elephant Seal	*Mirounga leonina*	1985	Vulnerable		
Southern Giant-petrel	*Macronectes giganteus*	1974, 1975, 1980, 1983, 1985	Endangered	Listed	Vulnerable
Southern Right Whale	*Eubalaena australis*	1984, 1992	Endangered	Listed	Critically endangered

Common name	*Scientific name*	Year recorded	EPBC status	FFG status	DSE status
Southern Toadlet	*Pseudophryne semimarmorata*	1979, 1980, 1995,			Vulnerable
Spotted Harrier	*Circus assimilis*	1966, 1977, 1981, 1985, 1997			Near threatened
Spotted Quail-thrush	*Cinclosoma punctatum*	1953, 1974, 1981			Near threatened
Square-tailed Kite	*Lophoictinia isura*	1983		Listed	Vulnerable
Stalked Hydroid Species	*Ralpharia coccinea*	1982		Listed	
Swamp Antechinus	*Antechinus minimus*	1995		Listed	Near threatened
Swamp Skink	*Egernia coventryi*	1981, 1996, 1997		Listed	Vulnerable
Swift Parrot	*Lathamus discolor*	1979, 1980, 1995	Endangered	Listed	Endangered
Terek Sandpiper	*Xenus cinereus*	1972, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1997, 1999, 2000		Listed	Endangered
Wandering Albatross	*Diomedea exulans*	1977, 1978, 1983	Vulnerable	Listed	Endangered
Whimbrel	*Numenius phaeopus*	1965, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1996, 1998, 1999, 2000			Vulnerable
Whiskered Tern	*Chlidonias hybridus*	1974, 1978, 1979, 1982, 1987, 1988, 1989			Near threatened
White-bellied Sea-eagle	*Haliaeetus leucogaster*	1971, 1974, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1987, 1989, 1990, 1994, 1995, 1996, 1998, 1999, 2000, 2001, 2003		Listed	Vulnerable
White-faced Storm-petrel	*Pelagodroma marina*	1978			Vulnerable
White-footed Dunnart	*Sminthopsis leucopus*	1968, 1974, 1984		Listed	Near threatened
White-fronted Tern	*Sterna striata*	1965, 1974, 1980, 1981, 1989, 1990, 1994			Near threatened
White-winged Black Tern	*Chlidonias leucopterus*	1974			Near threatened
Wood Sandpiper	*Tringa glareola*	1981			Vulnerable
Yellow-nosed Albatross	*Thalassarche chlororhynchos*	1977	Vulnerable	Listed	Vulnerable

Source: *DSE* *(2009d)*

Appendix H

PEST SPECIES KNOWN TO OCCUR WITHIN THE RAMSAR SITE

Appendix H

Pest species known to occur within the Ramsar site

Common name	Scientific name
FLORA	
African Box-thorn	Lycium ferocissimum
Algae	*Codium fragile tomentosoides, Ulva lactuca*
Asparagus	*Asparagus officinalis*
Blackberry	*Rubus fructicosus* spp. agg
Bluebell Creeper	*Sollya heterophylla*
Boneseed	*Crysanthemoides monilifera*
Bridal Creeper	*Myrsiphyllum asparagoides*
Cape Ivy	*Delairea odorata*
Cord Grass	*Spartina* spp.
Dipogon	*Dipigon lignosos*
Fescue	*Vulpia* spp.
Furze	*Ulex europaeus*
Gladiolus	*Gladiolus undulatus*
Large Quaking Grass	*Briza maxima*
Lesser Quaking Grass	*Briza minor*
Myrtle-leaf Milkwort	*Polygala myrtifolia*
One-leaf Cape Tulip	*Homeria flaccida*
Pampas Grass	*Cortaderia selloana*
Prickly Saltbush	*Salsola kali*
Sharp Rush	*Juncus acutus*
Spanish Heath	*Erica lusitanica*
FAUNA	
Common Blackbird	*Turdus merula*
Black Rat	*Rattus Rattus*
Common Myna	*Acridotheres tristis*
Common Starling	*Strumus vulgaris*
Domestic Dog	*Canis familiaris*
Domestic and Feral Cat	*Felis catus*
Feral Goat	*Capra hircus*
House Mouse	*Mus musculus*
House Sparrow	*Passer domesticus*
Northern Mallard	*Anas platyrhynchos*
Rabbit	*Oryctolagus cuniculus*
Red Fox	*Vulpes vulpes*
Ascidians	*Ascidiella aspersa, Ciona intestinalis, Styela clava, Styela plicata*
Asian Bivalve	*Theora lubrica*
Asian Mussel	*Musculista senhousia*
Cosmopolitan Bryozoans	*Bugula dentata, Bugula neritina, Watersipora subtorquata*

Common name	Scientific name
Dinoflagellate	*Alexandrium tamarense*
European Clam#	*Corbula gibba*
European Shore Crab	*Camicus maenus*
European fanworm#	*Sabella spallanzanii*
Pacific oyster#	*Crassostrea gigas*
Japanese kelp#	*Undaria pinnatifida*

 # Indicates those marine pests which are not self-sustaining (Parry and Cohen 2001)

Source: adapted from DSE 2003

Appendix I

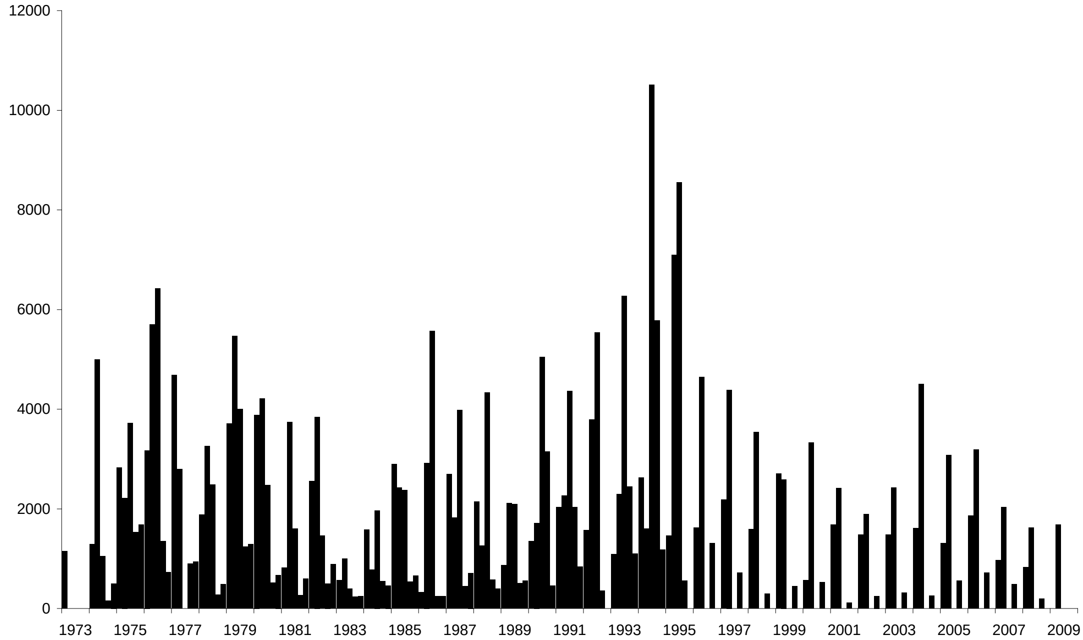
TOTAL SEASONAL COUNTS CATEGORISED BY SPECIES FOR A SELECTION THAT MEETS THE 1 PER CENT RAMSAR CRITERIA (BASED ON BOCA SURVEY DATA)

Appendix I

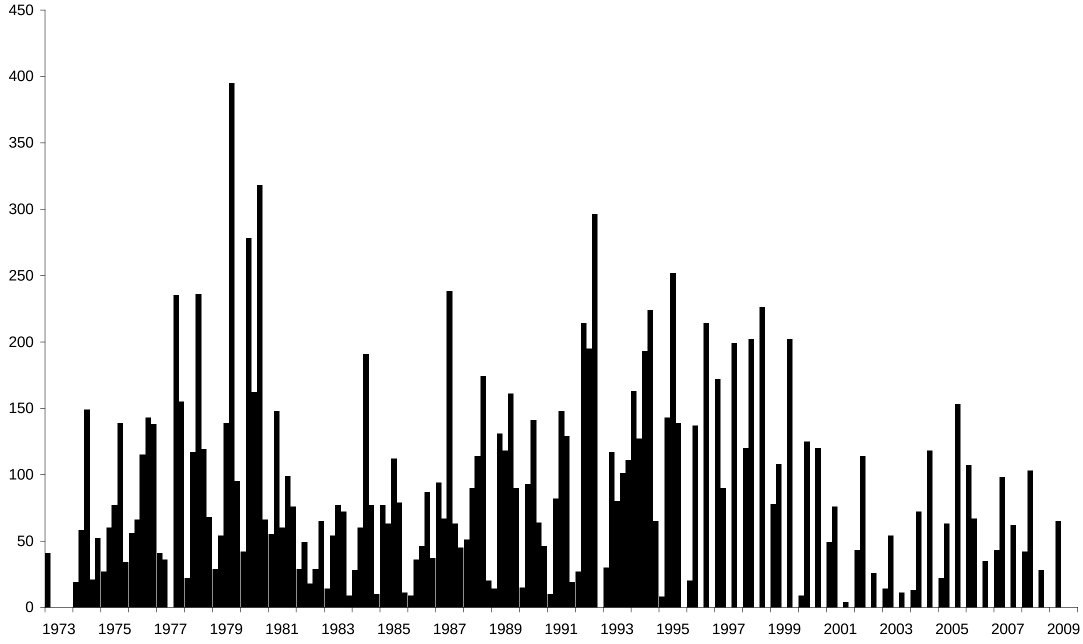
Total seasonal counts categorised by species for a selection that meets the 1 per cent Ramsar criteria (based on BOCA survey data)

Total seasonal count (extracted from the BOCA database) across all count sites in Western Port of waterbirds categorised by species (for a selection of species that meets the 1% Ramsar criterion). Order of counts in each year bin is December, February, Autumn, Winter and Spring (the exact month for each of the last three groupings may vary from year to year). Five counts were conducted each year until around 1995, at which time counts were reduced to three per year (two summer and one winter count). In each figure total count is on the Y-axis and count year is on the X-axis. Order of months / seasons is as specified above.

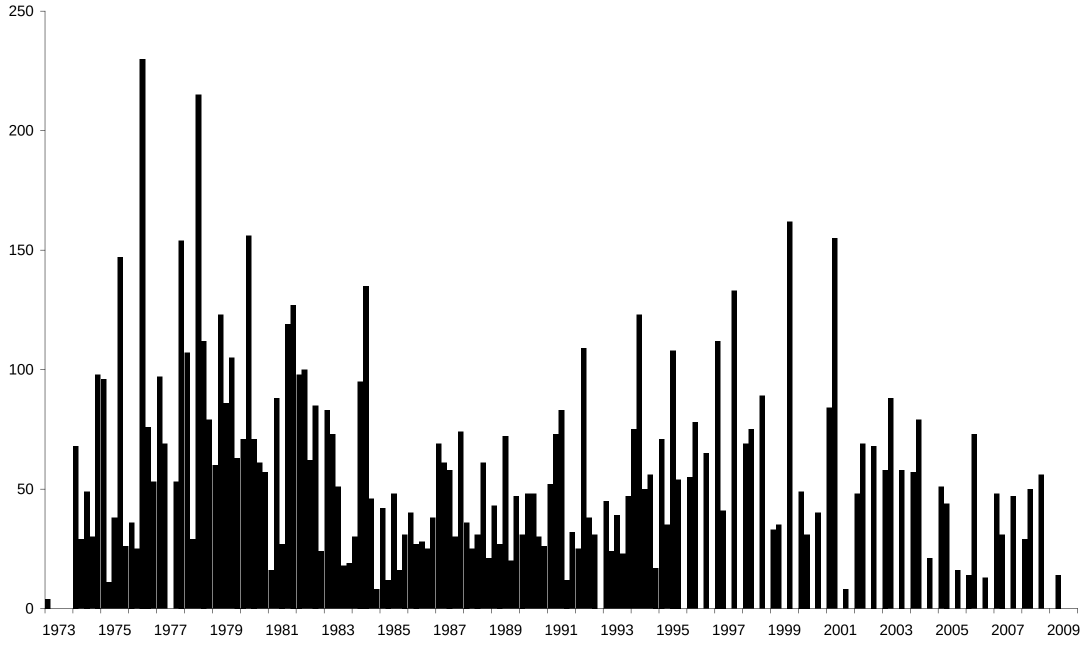
Black Swan



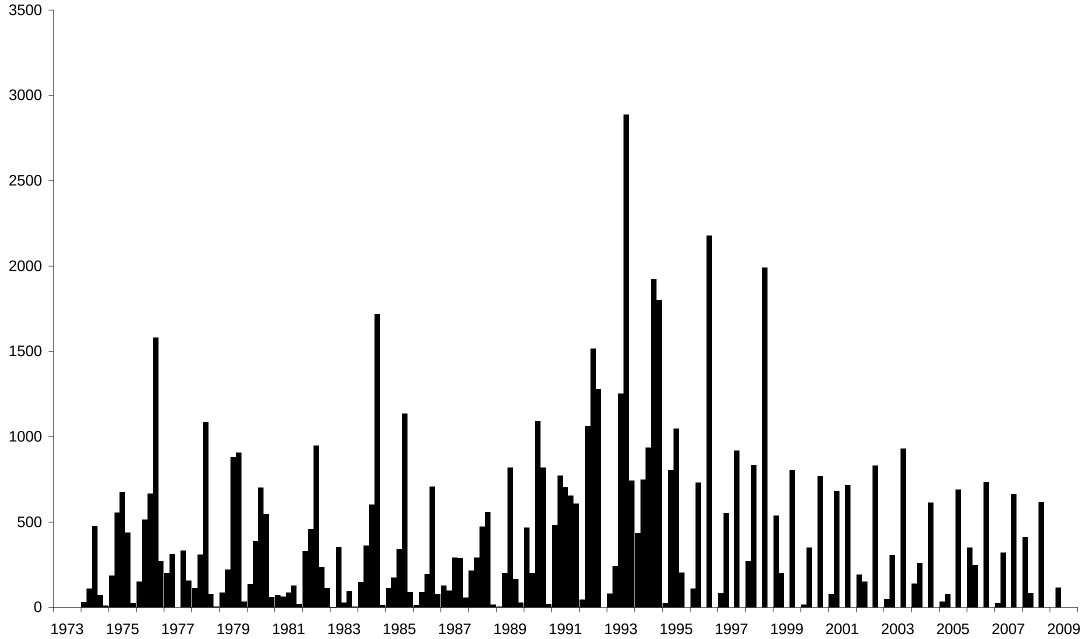
Royal Spoonbill



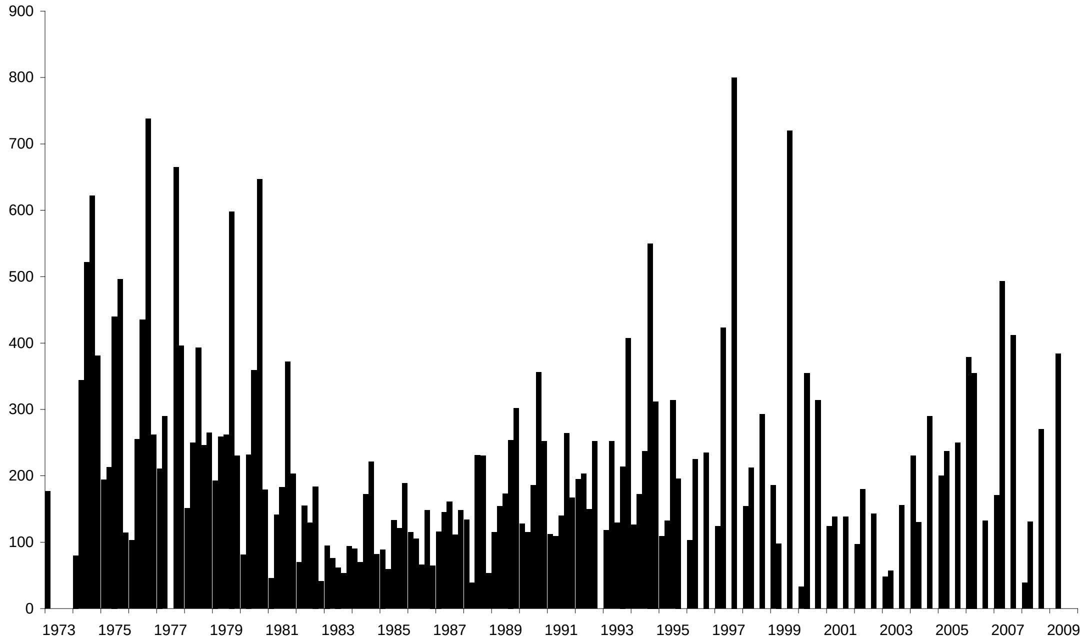
Pied Cormorant



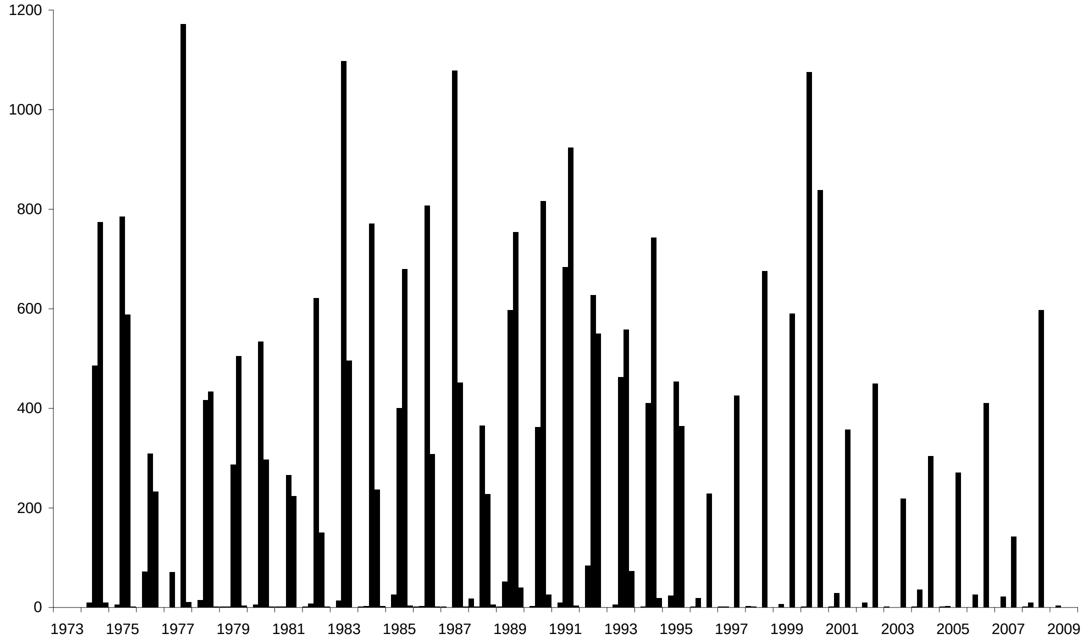
Chestnut Teal



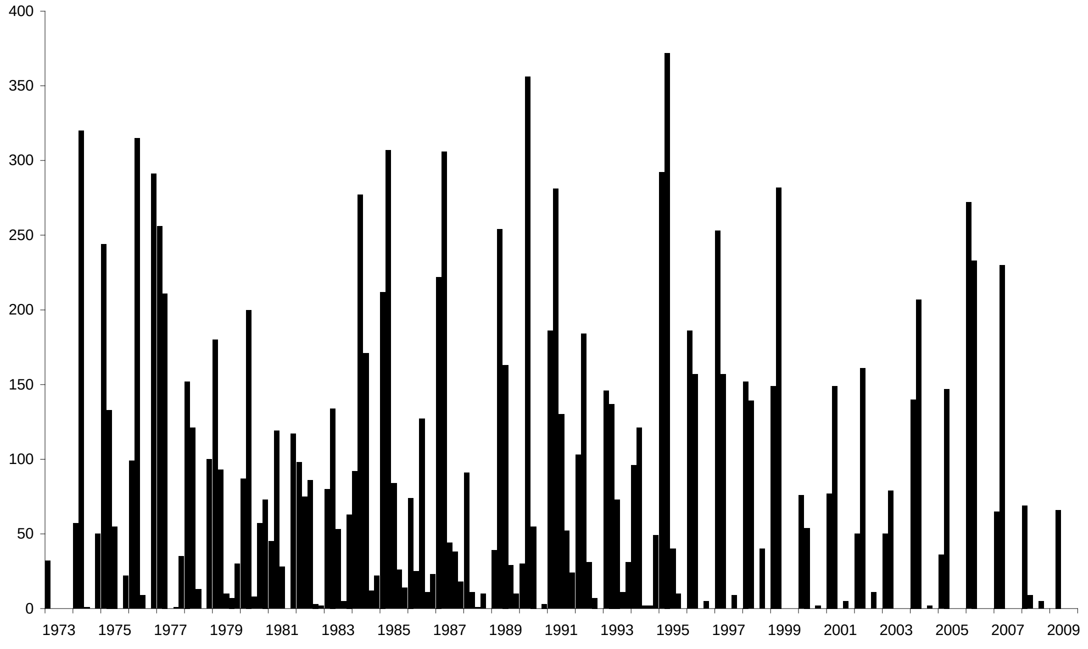
Pacific Gull



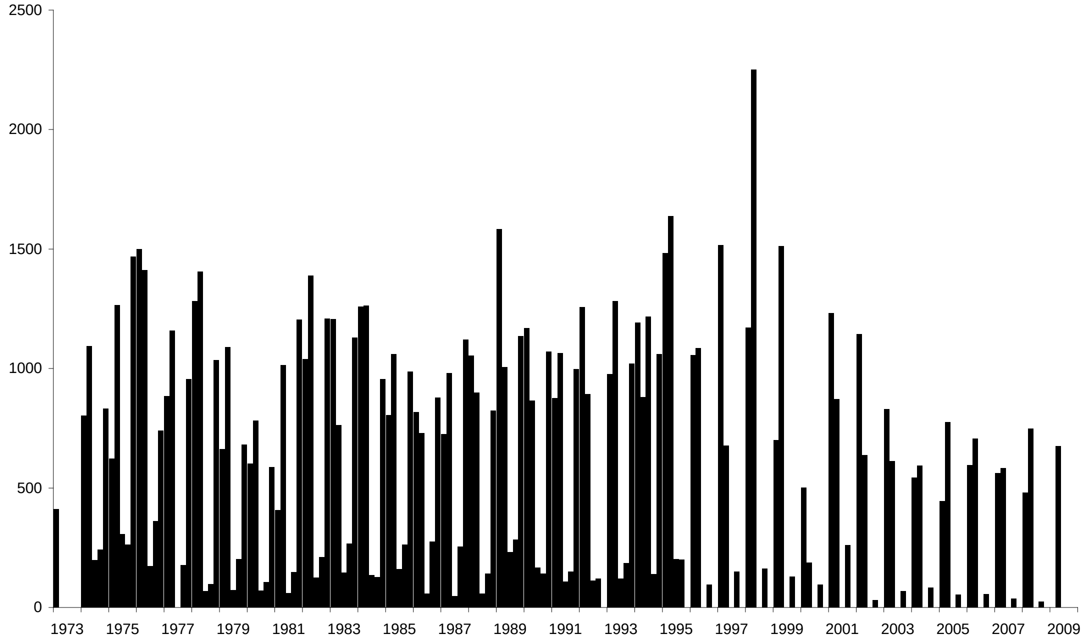
Double-banded Plover



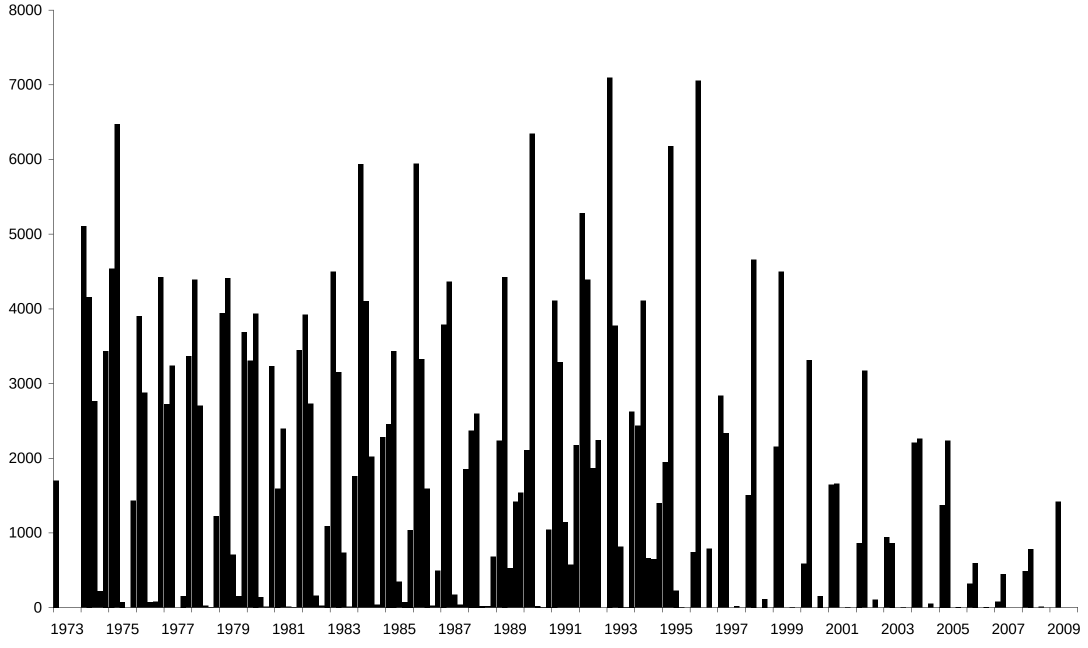
Common Greenshank



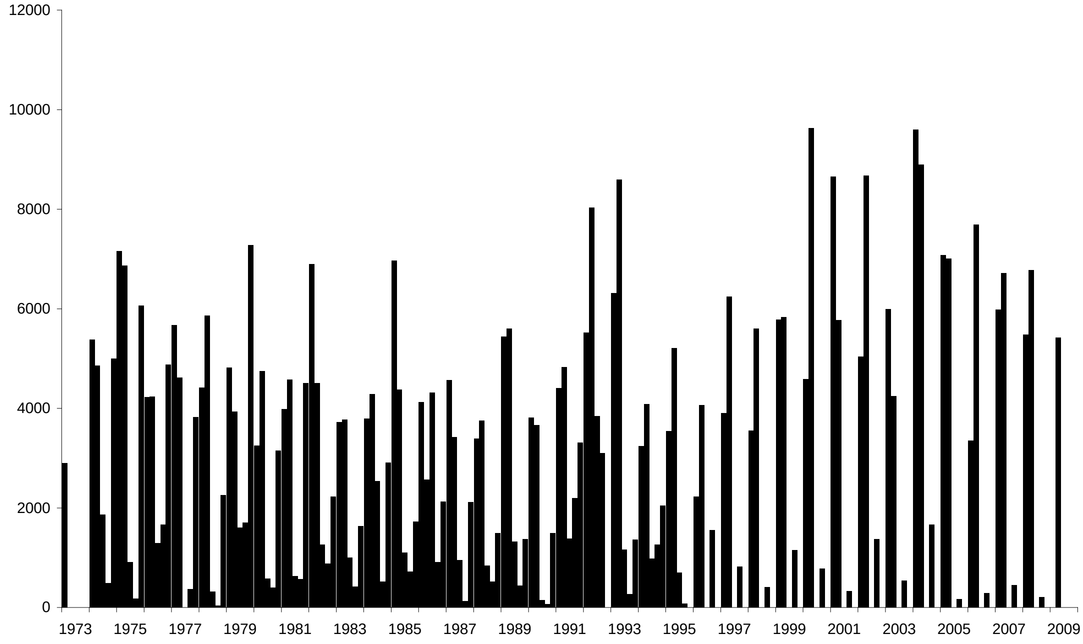
Eastern Curlew



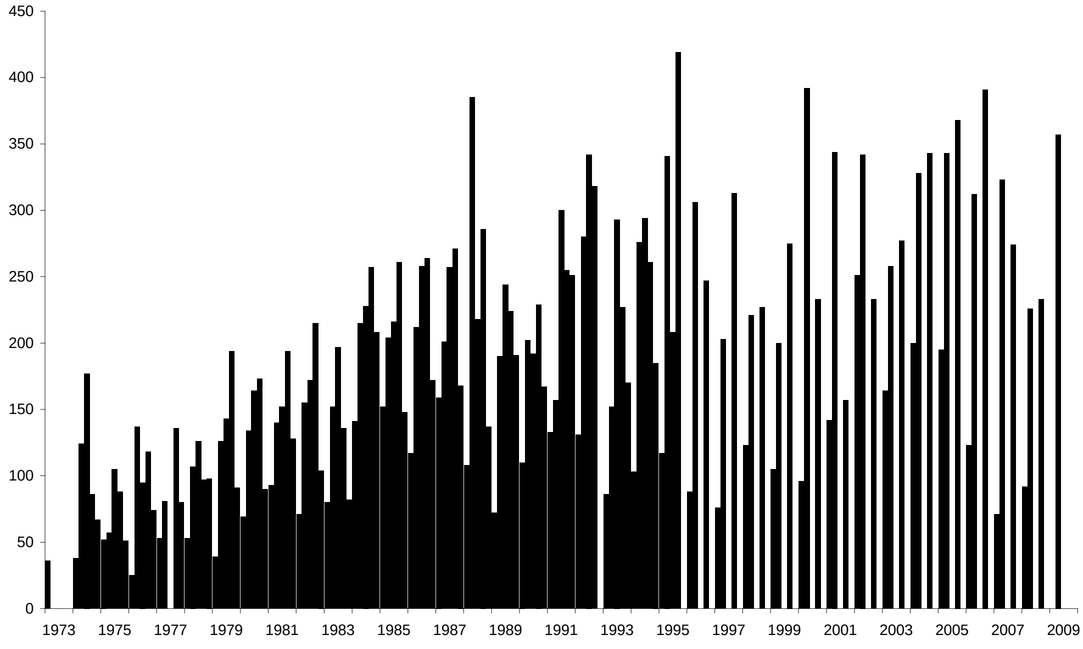
Curlew Sandpiper



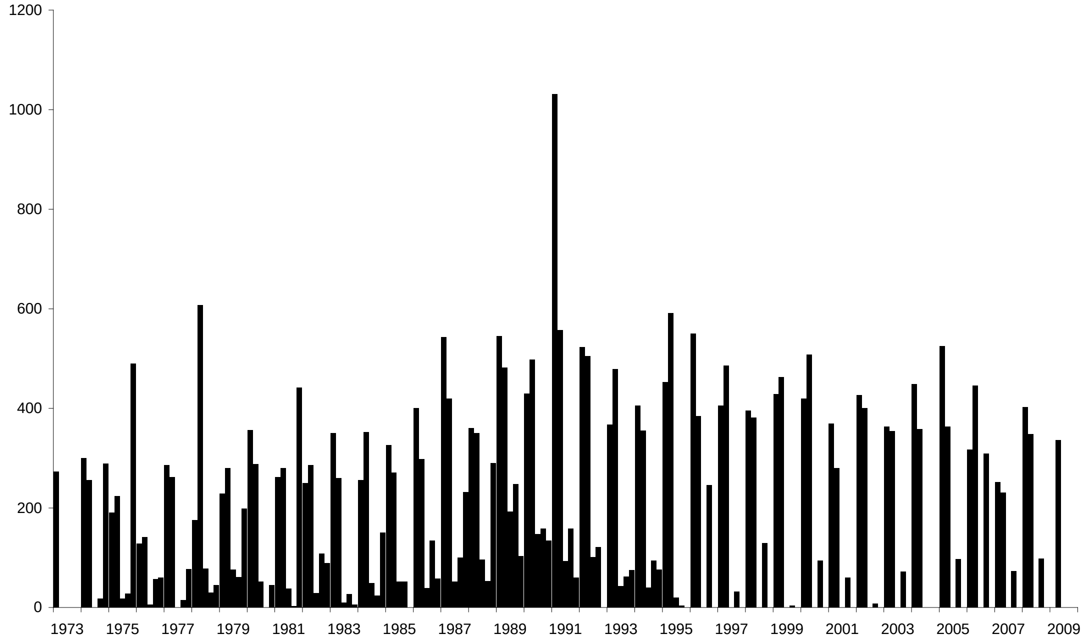
Red-necked Stint



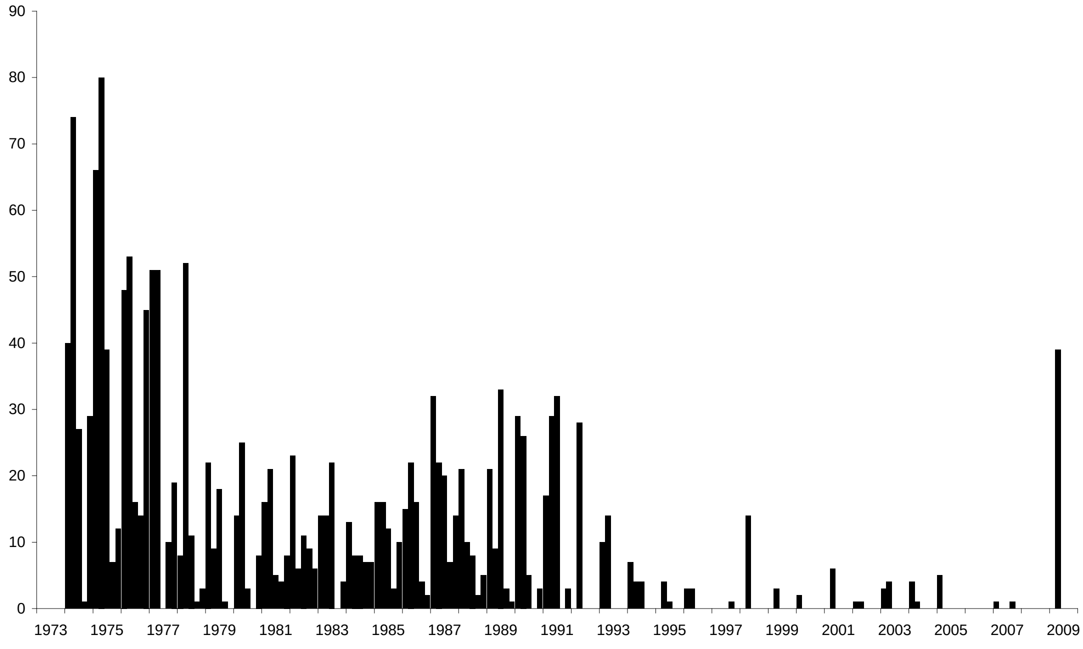
Pied Oystercatcher



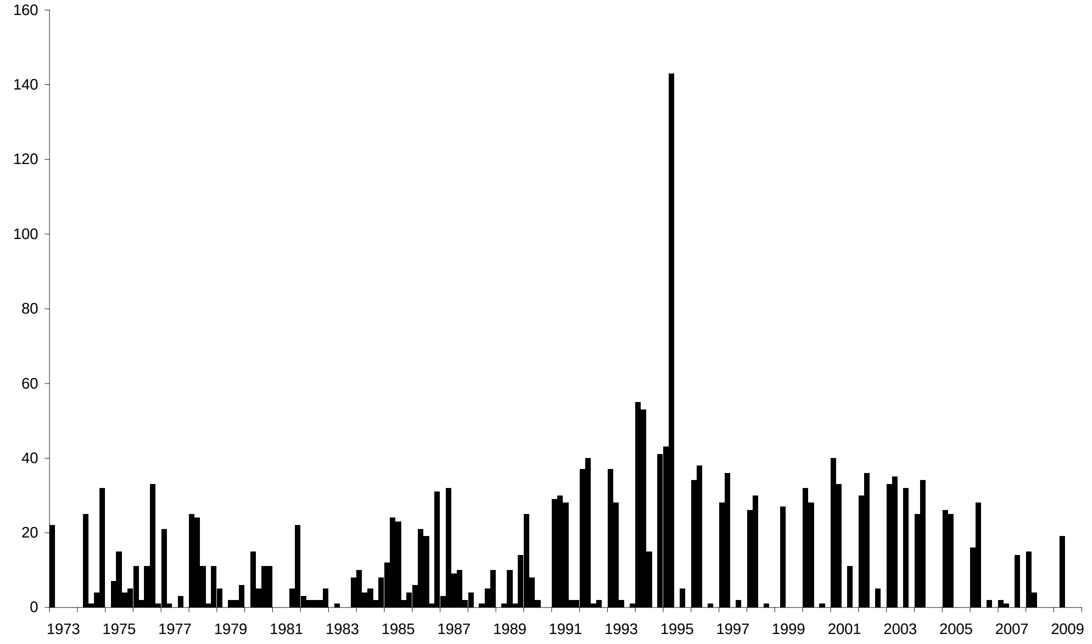
Bar-tailed Godwit



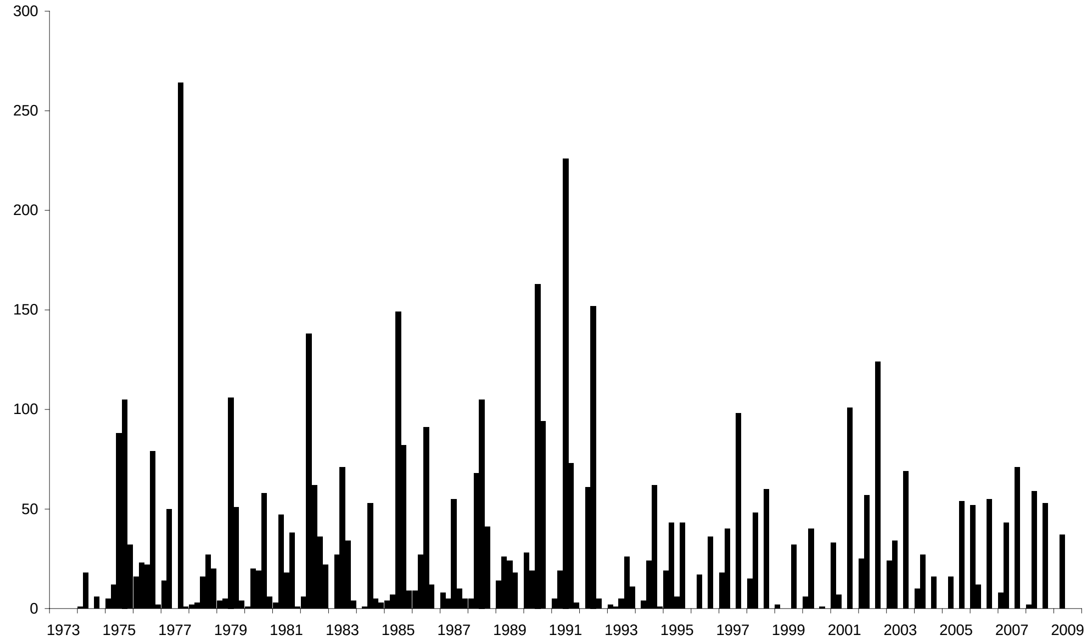
Grey-tailed Tattler



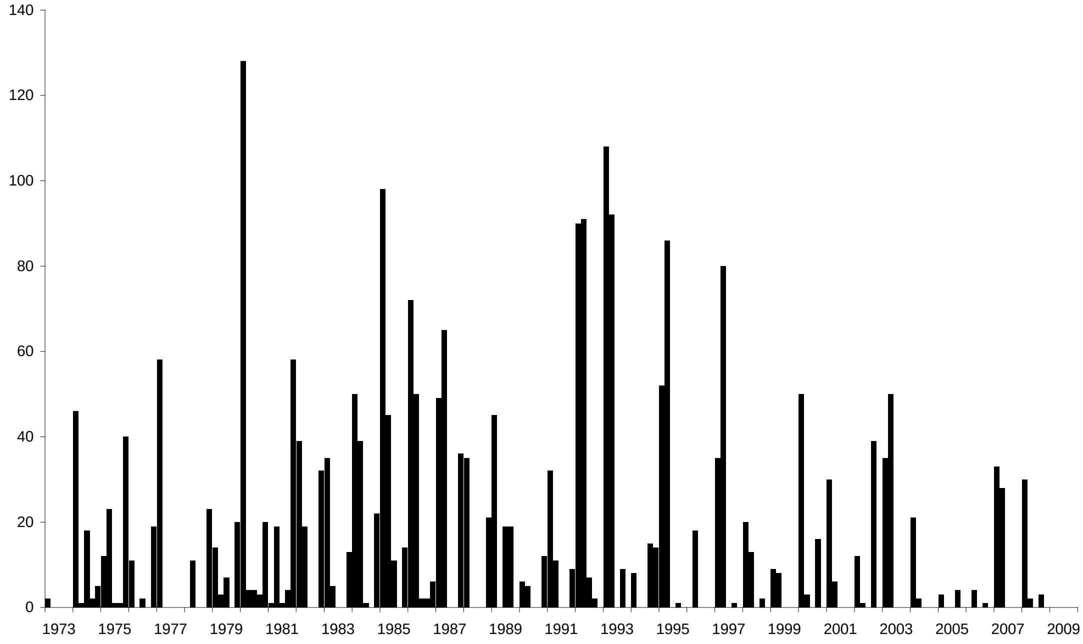
Whimbrel



Musk Duck



Fairy Tern



140
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