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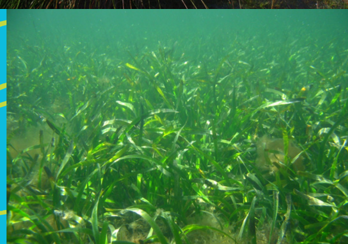

Corner Inlet

Ramsar Site

Ecological Character Description

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Australian Government
Department of Sustainability, Environment, Water, Population and Communities

Corner Inlet Ramsar site

Ecological Character Description

June 2011

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ACKNOWLEDGEMENTS

This report was prepared by BMT WBM Pty Ltd with expert input from Austecology Pty Ltd under contract to the Department of Sustainability, Environment, Water, Population and Communities. Paul Boon (Dodo Environmental) provided strategic advice to the project team and peer review comments on the draft report.

The consultant project team wish to express their thanks to the members of the Inter-Governmental Steering Group formed for the project for their assistance and guidance. Appendix A provides details about the Steering Committee.

Photos that appear in the report are supplied by BMT WBM or other organisations where noted. Figures that have been reproduced (without modification) from other sources have been referenced accordingly.

Guidance on the development of Ecological Character Descriptions, including Limits of Acceptable change, are areas of active policy development. Accordingly there may be differences in the type of information contained in this Ecological Character Description, to those of other Ramsar wetlands.

This information does not create a policy position to be applied in statutory decision making. Further it does not provide assessment of any particular action within the meaning of the *Environment Protection and Biodiversity Conservation Act 1999*, nor replace the role of the Minister or his delegate in making an informed decision on any action.

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.

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Use of terms and information sources: All definitions and terms used in this report were correct at the time of production in November 2010. Refer to Section 7 for works cited and Section 8 for a list of key terms and terminology used.

Citation: When finalised, this report can be cited as follows:

BMT WBM (2011). Ecological Character Description of the Corner Inlet Ramsar Site – Final Report. Prepared for the Australian Government Department of Sustainability, Environment, Water, Population and Communities. Canberra.

LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ANZECC/ARMCANZ:	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
ARI:	Arthur Rylah Institute for Environmental Research
CAMBA:	China-Australia Migratory Bird Agreement
CMA:	Catchment Management Authority
CMS:	Convention on Migratory Species
CSIRO:	Australian Commonwealth Scientific and Research Organization
DEM:	Digital Elevation Model
DEWHA:	Department of the Environment, Water, Heritage and the Arts (now DSEWPaC)
DoD:	Department of Defence
DSE:	Department of Sustainability and Environment (Victoria)
ECD:	Ecological Character Description
EPBC:	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ESO:	Environmental Significance Overlay
EVC:	Ecological Vegetation Class
EWR:	Environmental Water Reserve
FIS:	Flora Information System
GAP:	Global Action on Peatlands
GCB:	Gippsland Coastal Board
GMA:	Groundwater Management Area
HAT:	Highest Astronomical Tide
IMCRA:	Integrated Marine and Coastal Regionalisation of Australia
IUCN:	International Union for Conservation of Nature
JAMBA:	Japan-Australia Migratory Bird Agreement
LAC:	Limit(s) of Acceptable Change
MAFRI:	Marine and Freshwater Resources Institute
NLWRA	National Land and Water Resources Audit
NRM:	Natural Resource Management
RIS:	Ramsar Information Sheet
ROKAMBA:	Republic of Korea- Australia Migratory Bird Agreement
SEPP:	State Environment Protection Policy
DSEWPaC	Australian Government Department of Sustainability, Environment, Water, Population and Communities
sp.:	Species (singular)
spp.:	Species (plural)
VWCS	Victorian Wetland Classification Scheme
VWSG:	Victorian Wader Study Group
WGCMA:	West Gippsland Catchment Management Authority
WWTP:	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Corner Inlet is a large tide-dominated embayment located adjacent to the southernmost tip of the Australian mainland. The inlet consists of a submerged plain covered by sand or mud flats with well developed seagrass beds, and large sand islands. A radiating system of deeper channels supports efficient tidal exchange over the flats and the areas between the islands. Due to its large area and the diversity of habitats present, Corner Inlet supports internationally significant populations of a number of aquatic and semi-aquatic species. The inlet was listed as a Wetland of International Importance under the Ramsar Convention in 1982.

As part of its role as a Contracting Party to the Ramsar Convention on Wetlands, Australia is expected to manage its Ramsar sites so as to maintain the ecological character of each site and notify the Ramsar Secretariat of any change. Ecological character is defined by the Ramsar Convention as the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

This report provides the Ecological Character Description (ECD) for the Corner Inlet Ramsar site, prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (DEWHA 2008) (the National ECD Framework). In parallel with the preparation of the ECD, the Ramsar Information Sheet (RIS) for the site has been updated for submission to the Australian Government and Ramsar Secretariat. This report updates and replaces an unpublished draft ECD document for the site prepared by the Ecos Consortium in 2008 hereafter referenced as Ecos (unpublished).

Major topics covered include the background context and purpose of the ECD, relevant treaties, legislation and regulations, a site description and justification for the existing Ramsar listing of the inlet, project methodology, and a description of the critical components, processes and services/benefits supported by the site. Furthermore, a conceptual model of interactions between critical components, processes and services/benefits operating in the inlet is presented. The ECD also covers identification of any changes to the ecological character of the inlet since its Ramsar listing in 1982, natural variability and limits of acceptable change (LACs), likely threats and impacts, knowledge gaps, key monitoring needs and important communication, education, participation and awareness messages.

The major features of Corner Inlet that form its ecological character are its large geographical area, the wetland types present (particularly the extensive subtidal seagrass beds), diversity of aquatic and semi-aquatic habitats and abundant flora and fauna (including significant proportions of the total global population of a number of waterbird species). The critical and supporting components, processes and benefits/services that were determined as having a high influence on the ecology of Corner Inlet are presented in Table E-1. The way in which these components, processes and services/benefits interact is presented in this document through the use of a conceptual model.

The study has sought to define the natural variability and LACs for the critical components and services/benefits identified. A summary of the LACs is shown in Table E-2.

Table E-1 Summary of Critical Components, Processes and Services/Benefits

Critical Components	Critical Processes	Critical Services/Benefits
C1. Several key **wetland mega-habitat types** are present: • seagrass • intertidal sand or mud flats • mangroves • saltmarshes • permanent shallow marine water **C2.** Abundance and diversity of **waterbirds**	**P1. Waterbird breeding** is a key life history function in the context of maintaining the ecological character of the site, with important sites present on the sand barrier islands	**S1.** The site supports **nationally threatened fauna species** including: • orange-bellied parrot • growling grass frog • fairy tern • Australian grayling **S2.** The site supports **outstanding fish habitat values** that contribute to the health and sustainability of the bioregion
Supporting Components	**Supporting Processes**	**Supporting Services/Benefits**
Important **geomorphological features** that control habitat extent and types include: • sand barrier island and associated tidal delta system • the extensive tidal channel network • mudflats and sandflats. **Invertebrate megafauna** in seagrass beds and subtidal channels are important elements of biodiversity and control a range of ecosystem functions. The **diverse fish communities** underpin the biodiversity values of the site	**Climate**, particularly patterns in temperature and rainfall, control a range of physical processes and ecosystem functions Important **hydraulic and hydrological processes** that support the ecological character of the site includes**:** • Fluvial hydrology. Patterns of inundation and freshwater flows to wetland systems • Physical coastal processes. Hydrodynamic controls and marine inflows that affect habitats through tides, currents, wind, erosion and accretion. • Groundwater. For those wetlands influenced by groundwater interaction, the level of the groundwater table and groundwater quality. **Water quality** underpins aquatic ecosystem values within wetland habitats. The key water quality parameters for the site are salinity, turbidity, dissolved oxygen and nutrients Important **biological processes** include nutrient cycling and food webs.	The site supports **recreation and tourism values** (scenic values, boating, recreational fishing, camping, etc.) that have important flow-on economic effects for the region. The site provides a range of values important for **scientific research**, including a valuable reference site for future monitoring.

Table E-2 Limits of Acceptable Change for each Critical Component and Service/Benefit – Corner Inlet Ramsar Site

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[1]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
Critical Components						

C1	Seagrass extent	Long Term	• Total mapped extent of dense *Posidonia* will not decline by greater than 10 percent of the baseline value outlined by Roob et al. (1998) at a whole of site scale (baseline = 3050 hectares; LAC = mapped area less than 2745 hectares) on any occasion. (Note: the small degree of allowable change recognises that this seagrass species is a critical habitat resource and generally shows low natural variability.)
			• Total mapped extent of the dense and medium density Zosteraceae will not decline by greater than 25 percent of the baseline values outlined by Roob et al. (1998) at a whole of site scale on two sampling occasions within any decade.
			  • Dense *Zostera* - Baseline = 5743 hectares (LAC = mapped area less than 4307 hectares)
			  • Medium *Zostera* - Baseline = 1077 hectares (LAC = mapped area less than 807 hectares)
			(Note: the moderate degree of allowable change recognises that these seagrass species generally show moderate degrees of natural variability)
				Sampling to occur at least twice within the decade under consideration.
				
				Note that the seagrass assessment by Hindell (2008) did not produce mapping but did use similar sampling sites to Roob *et al*.
					Recent quantitative data describes seagrass condition at various sites but over a limited timeframe. It is thought that the Roob *et al*. (1998) study under-estimated the total available seagrass habitat (J. Stevenson, Parks Victoria, pers. comm. February 2011), hence a 10 per cent change from this baseline value would represent a larger actual change from the true baseline.
					Note: Prior to declaration, *Posidonia* covered approximately 44 per cent (11 900 hectares) of the site (Poore 1978). Morgan (1986) estimated that *Posidonia* meadows covered 11 900 hectares in 1965 and 9000 to 9500 square kilometres in 1983–84. There is uncertainty regarding these mapping data and therefore empirical LACs have not been developed from these data.
						S2

	Mangrove forest extent	Long term	• Based on EVC mapping, it is estimated that mangroves presently cover an area of 2137 hectares within the site (see Section 3.3.1). A 10 percent reduction in the total mapped mangrove area, observed on two sampling occasions within any decade, is an unacceptable change. (LAC – mapped area less than 1924 hectares). (Note: the small degree of allowable change recognises that mangroves are a critical habitat resource and generally shows low natural variability)	Sampling to occur at least twice within the decade under consideration.	No available data to determine changes in extent over time. It is unlikely that this has changed markedly since Ramsar listing. Note that there are uncertainties regarding the quality of existing mapping, and therefore the baseline value should be considered as indicative only.	S2
	Saltmarsh extent	Long term	• Based on EVC mapping, it is estimated that intertidal saltmarsh presently covers an area of 6500 hectares within	Sampling to occur at least twice within the	No available data to determine changes in extent over time. It is	S2

[1] Short Term – measured in years; Medium Term – five to 10 year intervals; Long term – 10+ year intervals.

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[1]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
			the site (see Section 3.3.1). A 10 percent reduction in the total mapped saltmarsh area, observed on two sampling occasions within any decade, is an unacceptable change (LAC – mapped area less than 5850 hectares). (Note: the small degree of allowable change recognises that saltmarsh is a critical habitat resource and generally show low natural variability)	decade under consideration.	unlikely that this has changed markedly since Ramsar listing. The note regarding data quality for mangroves applies also to saltmarsh.	
	Shallow subtidal waters	Long term	• A greater than 20 percent reduction in the extent of subtidal channel (areas mapped by NLWRA = 16 349 hectares), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 13 079 hectares). (Note: the moderate degree of allowable change recognises that shallow subtidal waters represent a critical habitat resource, generally show low natural variability, but data reliability is low)	Sampling to occur at least twice within the decade under consideration.	NLWRA mapping data describes wetland extent. This is coarse scale mapping and should be considered as indicative only. Note: there is a need to develop a condition-based LAC for this critical component. While some water quality data exists, this is presently insufficient to derive a LAC (i.e. whether a change in water quality represents a true change in ecological character of the wetland)	S2
	Inlet waters (intertidal flats)	Long term	• A greater than 20 percent reduction in the extent of permanent saline wetland – intertidal flats (areas mapped by DSE = 40 479 hectares, see Figure 3-1), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 36 431 hectares). (Note: the moderate degree of allowable change recognises that intertidal flats represent a critical habitat resource and generally show low natural variability. A loss of intertidal flat would also result in changes in seagrass)	Sampling to occur at least twice within the decade under consideration.	VMCS mapping data describes wetland extent. This is coarse scale mapping and should be considered as indicative only. Note: there is a need to develop a condition-based LAC for this critical component. While some water quality data exists, this is presently insufficient to derive a LAC (i.e. whether a change in water quality represents a true change in ecological character of the wetland)	S2
C2	Abundance and of waterbirds	Short term (All species)	• Mean annual abundance of migratory bird species - Birds Australia (2009c) notes that there is a maximum annual abundance of migratory species of 42 811 birds, with a mean annual abundance of migratory species being 31 487 birds (deriving from 28 years of data collection to September 2008). The annual abundance of migratory shorebirds will not decline by 50 per cent of the long-term annual mean value (that is, must not fall below 15 743 individuals) in three consecutive years. (Note: the large degree of allowable	At least four annual surveys (summer counts) within the decade under consideration.	Bird count data are available from a variety of programs, most notably Birds Australia monitoring programs	P2

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[1]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
			change recognises that these species can show high levels of natural variability, and that limitations of existing baseline data)			
		Short term (individual species)	• Mean annual abundance of migratory species that meet the one per cent criterion will not be less than 50 per cent of the long-term annual mean value in five years of any ten year period. These values are follows: o curlew sandpiper – baseline = 2588 birds, LAC = 1294 birds o bar tailed godwit – baseline = 9727 birds, LAC = 4863 birds o eastern curlew – baseline = 1971 birds, LAC = 985 birds o pied oystercatcher – baseline = 893 birds, LAC = 446 birds o sooty oystercatcher – baseline = 285 birds, LAC = 142 birds o double-banded plover– baseline = 523 birds, LAC = 261 birds There are insufficient baseline data to determine long-term average abundance of fairy tern and Pacific gull. (Note: the large degree of allowable change recognises that these species can show high levels of natural variability, and that limitations of existing baseline data)	At least five annual surveys (summer counts) within the decade under consideration.	Bird count data are available from a variety of programs, most notably Birds Australia monitoring programs	P2
Critical Processes						
P1	Waterbird breeding	Short Term	A greater than 50 per cent decrease in nest production at two or more monitoring stations (based on two sampling episodes over a five year period) within any of the following locations and species: • Clomel Island - fairy tern, hooded plover, Caspian tern, crested tern • Dream Island - fairy tern, hooded plover, crested tern • Snake Island and Little Snake Island - pied oystercatcher	Recommended baseline monitoring program should comprise a minimum two annual sampling periods separated by at least one year (and within a five year period).	The use of the site by these species is well documented. However, there are no empirical data describing nest or egg production rates. Baseline data will need to be collected to assess this LAC.	C2
Critical Services/Benefits						
S1	Threatened Species	N/A	For orange-bellied parrot and growling grass frog, an unacceptable change will have occurred should the site no longer support these species.	Based on multiple targeted surveys at appropriate levels of spatial and temporal replication (at least four annual surveys in preferred habitats) over a	Most site records are based on opportunistic surveys	P1, C3

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[1]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
				10 year period.		
		Short Term	For Australian grayling, an unacceptable change will have occurred should all of the drainages that drain into Corner Inlet no longer support this species.	Based on four annual surveys in a 10 year period at multiple sites located in all major catchments.	This species has been recorded in the major drainages that drain into the site. There are no data describing the population status of this species in the site. Abundance data are available for drainages that discharge into the site (Ecowise 2007; O'Connor *et al*. 2009). O'Connor *et al*. (2009) notes that collection of this species is difficult and requires targeted survey techniques. Few targeted empirical surveys have been undertaken in the site's drainages to date	P1, C1, C2
S2	Fish abundance (using fish catch of key species as a surrogate)	Medium term	An unacceptable change will have occurred if the long term (greater than five years) median catch falls below the 20th percentile historical baseline values in standardised abundance or catch-per unit effort of five or more commercially significant species (relative to baseline) due to altered habitat conditions within the site. The 25th percentile pre-listing baseline commercial catch per unit effort values for the site are as follows (units are tonnes per annum per number of boats – see Table 3-8): Australian salmon 379 rock flathead 316 southern sand flathead 373 greenback flounder 514 southern garfish 1452 yelloweye mullet 740 gummy shark 167 King George whiting 1347	Annual fish catch measured over a greater than five year period.	Commercial fish catch data. Note that there are presently no fisheries-independent baseline data (collected using empirical, systematic methods) describing patterns in the distribution and abundance of key species. Therefore, the limits of acceptable change should be treated with caution, noting socio-economic factors should be taken into account when assessing catch data underpinning this LAC.	S2

In the context of changes to ecological character of the site, the study has examined:

- current and future threats to ecological character
- changes that have been observed or documented since listing of the site as a wetland of International Importance in 1982.

A range of threats to the ecological character of Corner Inlet were identified as follows:

- poor water quality (nutrients, sediment loads, suspended sediments and water-column turbidity)
- invasive plants including spartina (*Spartina angelica* and *Spartina x townsendii*) and the green macroalga (*Codium fragile* ssp *tomentosoides*)
- invasive animals including the northern Pacific seastar (*Asterias amurensis*), European shore crab (*Carcinus maenas*), and Mediterranean fanworm (*Sabella spallanzanii*)
- oil spills
- land use and development
- flow modifications
- recreational impacts
- rising sea levels and increased frequency in storm surges
- changes in rainfall and runoff.

It is concluded that no changes to the ecological character of the site have occurred since listing, although some habitats, such as *Posidonia* seagrass meadows, appear to have suffered ongoing losses due to water quality degradation.

The ECD preparation process promotes the identification of information or knowledge gaps about the Ramsar site that are principally derived through interrogation of the nominated ecosystem components, processes and services/benefits and associated understanding of natural variability and limits of acceptable change.

In analysing the information gaps identified in the ECD, the following thematic information gaps are identified as priority areas for future investment:

- baseline water quality characteristics within representative habitats throughout the site. This is considered to represent the most critical information gap in terms of identifying potential future impacts to most critical services and components
- additional research and monitoring expenditure to establish an ecological character baseline for the key waterbodies/wetland habitats, with a priority on habitats such as seagrass and fringing littoral vegetation, which support important flora and fauna species, habitats and life-history functions (for example, breeding sites, roosting sites, spawning sites, etc.) that are at most risk of future ecological change
- the need for better information and data sets about the presence and natural history of critical wetland species and their habitat; and more systematic surveys of important avifauna and fish species and populations

- better information and understanding about the natural variability of critical wetland fauna populations and key attributes and controls on those populations (including whether or not any non-avian fauna species meet the one per cent population requirement in Ramsar nomination criterion 9)
- the ecological character thresholds of particular habitats and communities for changes in key attributes/controls such as water quality and hydrology need additional investigation. Noting that any interim limits of acceptable change stated in the ECD should be revised as improved information becomes available
- resilience of habitats, community structure and key species to acute or prolonged impacts from water quality degradation such as nutrient enrichment, increased levels of salinity and sedimentation/turbidity (for example similar to the approach in ANZECC for toxicants). This is important in the context of defining threshold-based limits of acceptable change
- more specific assessment of the vulnerability of the site to the impacts of climate change and adaptation options that could be explored to reduce the impacts.

Monitoring recommendations that would fill these information gaps and identify unacceptable changes to character are provided.

A combined set of communication, education, participation and awareness messages relevant to the ECD have been presented and can be used to communicate the importance of the site, why it was listed, possible changes to ecological character, the threats to the site and future actions required. These messages should be considered as part of existing objectives and strategic actions about community awareness in the Ramsar Strategic Management Plan (DSE 2003).

1 INTRODUCTION

1.1 Background

The Corner Inlet Ramsar site, which covers 67 186 hectares, is located approximately 200 kilometres south-east of Melbourne and is the most southerly marine embayment and intertidal system of mainland Australia (Figures 1-1, 1-2 and 1-3). Corner Inlet is one of 64 wetland areas in Australia that have been listed as a Wetland of International Importance under the *Convention on Wetlands of International Importance especially as Waterfowl Habitat* or, as it is more commonly referred to, the Ramsar Convention (the Convention). Corner Inlet was listed as a Ramsar site under the Convention in December 1982 in recognition of its outstanding coastal wetland values and features.

The Convention sets out the need for contracting parties to conserve and promote wise use of wetland resources. In this context, an assessment of ecological character of each listed wetland is a key concept under the Ramsar Convention. Under Resolution IX.1 Annex A: 2005, the ecological character of a wetland is defined as:

The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

The definition indicates that ecological character has a temporal component, generally using the date of listing under the Convention as the point for measuring ecological change over time. As such, the description of ecological character should identify a wetland's key elements and provide an assessment point for the monitoring and evaluation of the site as well as guide policy and management, acknowledging the inherent dynamic nature of wetland systems over time.

This report provides the ECD for the Corner Inlet Ramsar site. In parallel with the preparation of the ECD, the Ramsar Information Sheet (RIS) for the site is being updated for submission to the Australian Government and Ramsar Secretariat.

The report has been prepared in accordance with the requirements of the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (DEWHA 2008) (hereafter referred to as the National ECD Framework). Further information about the requirements of the Framework is contained in Section 1.2.

This ECD report has been prepared over a period of six months by the consultant study team led by BMT WBM Pty Ltd under contract with DSEWPAC. This has occurred with input from a Project Steering Committee made up of officials from DSEWPAC, the Victorian Department of Sustainability and Environment (DSE), Parks Victoria, the Gippsland Coastal Board (GCB), the Department of Defence (DoD) and the West Gippsland Catchment Management Authority (WGCMA) (see Appendix A).

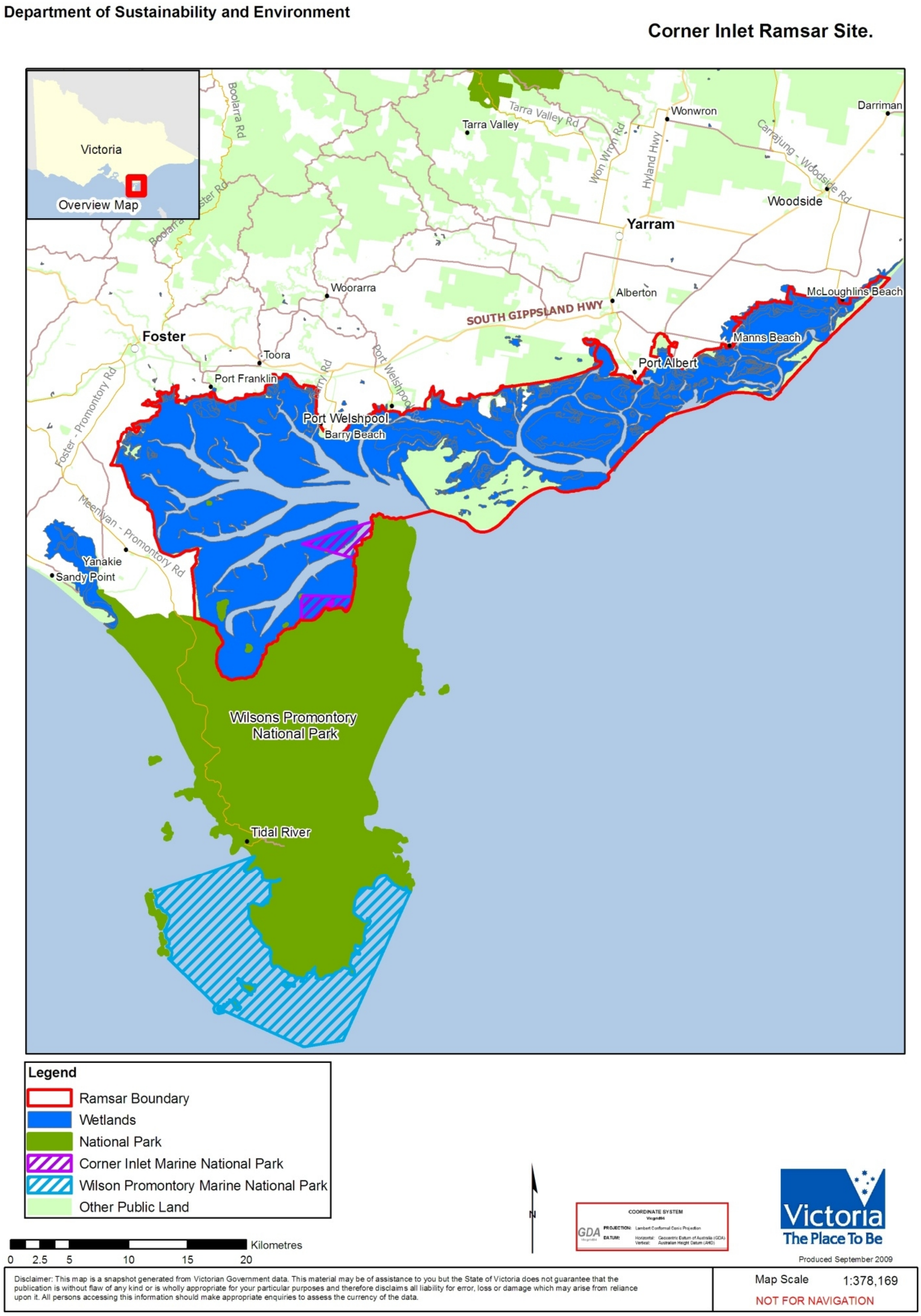
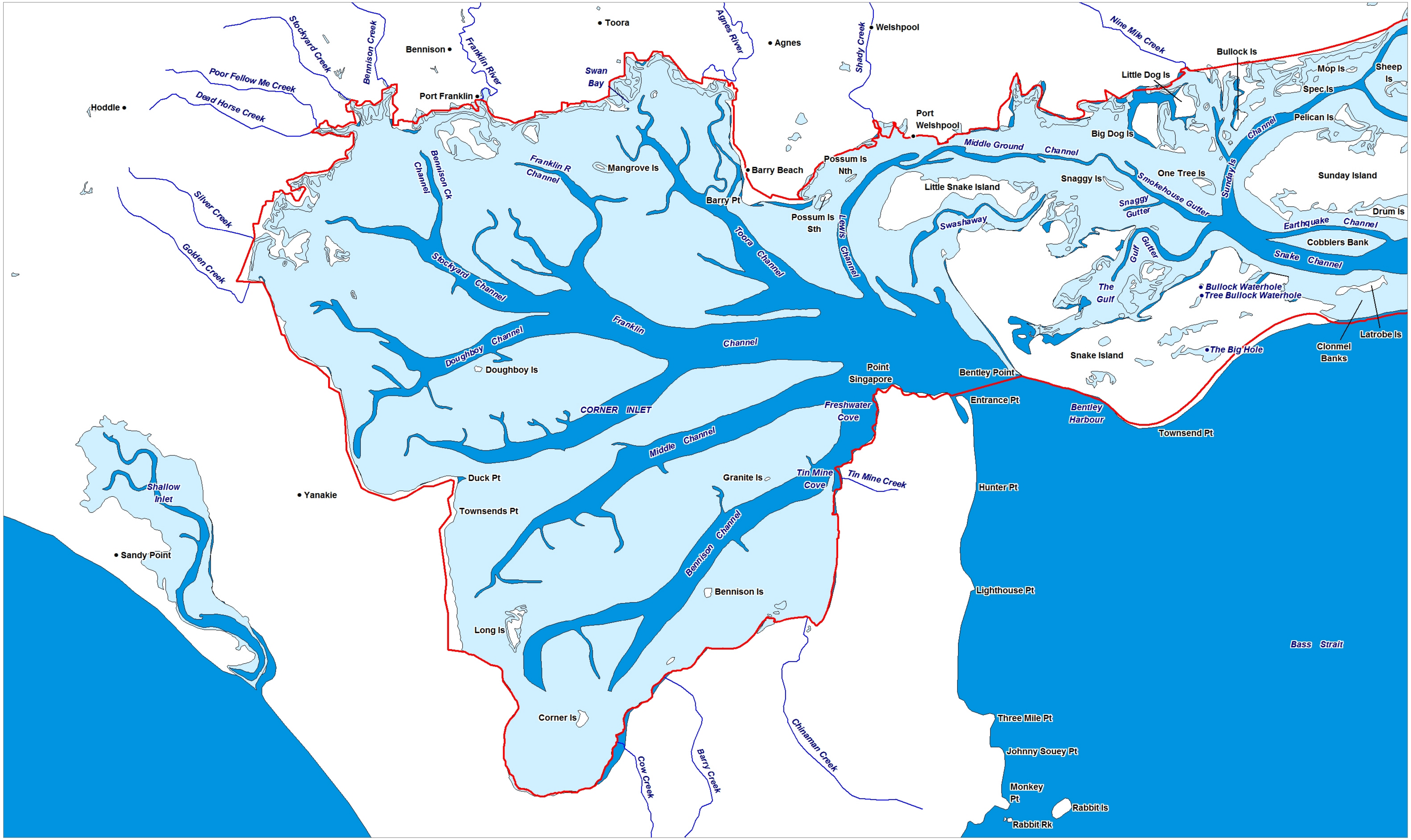


Figure 1-1 Locality plan showing key locations referred to in this document (Source: DSE unpublished)



LEGEND

Corner Inlet RAMSAR Site

Title:

Locality Plan Showing Western Portion of the Site

Figure: **1-2**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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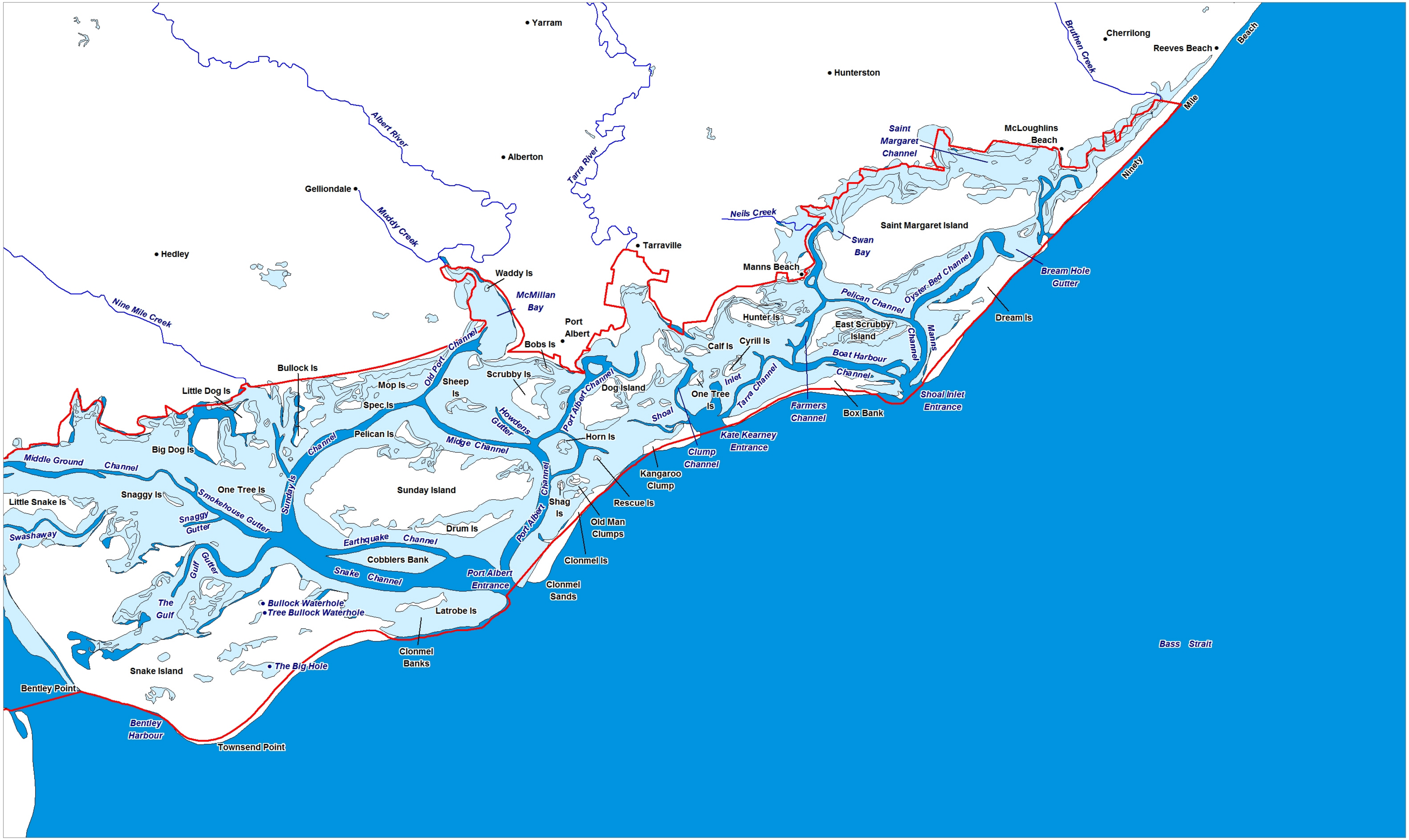

LEGEND

Corner Inlet RAMSAR Site

Title:

Locality Plan Showing Eastern Portion of the Site

Figure: 1-3

Rev: A

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1.2 Scope and Purpose

Figure 1-4 shows the key steps of the ECD preparation process from the National ECD Framework document which forms the basis for ECD reporting.

Based on the National ECD Framework (DEWHA 2008), the key purposes of undertaking an ECD are as follows:

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 (Commonwealth):*

    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 Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (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.*

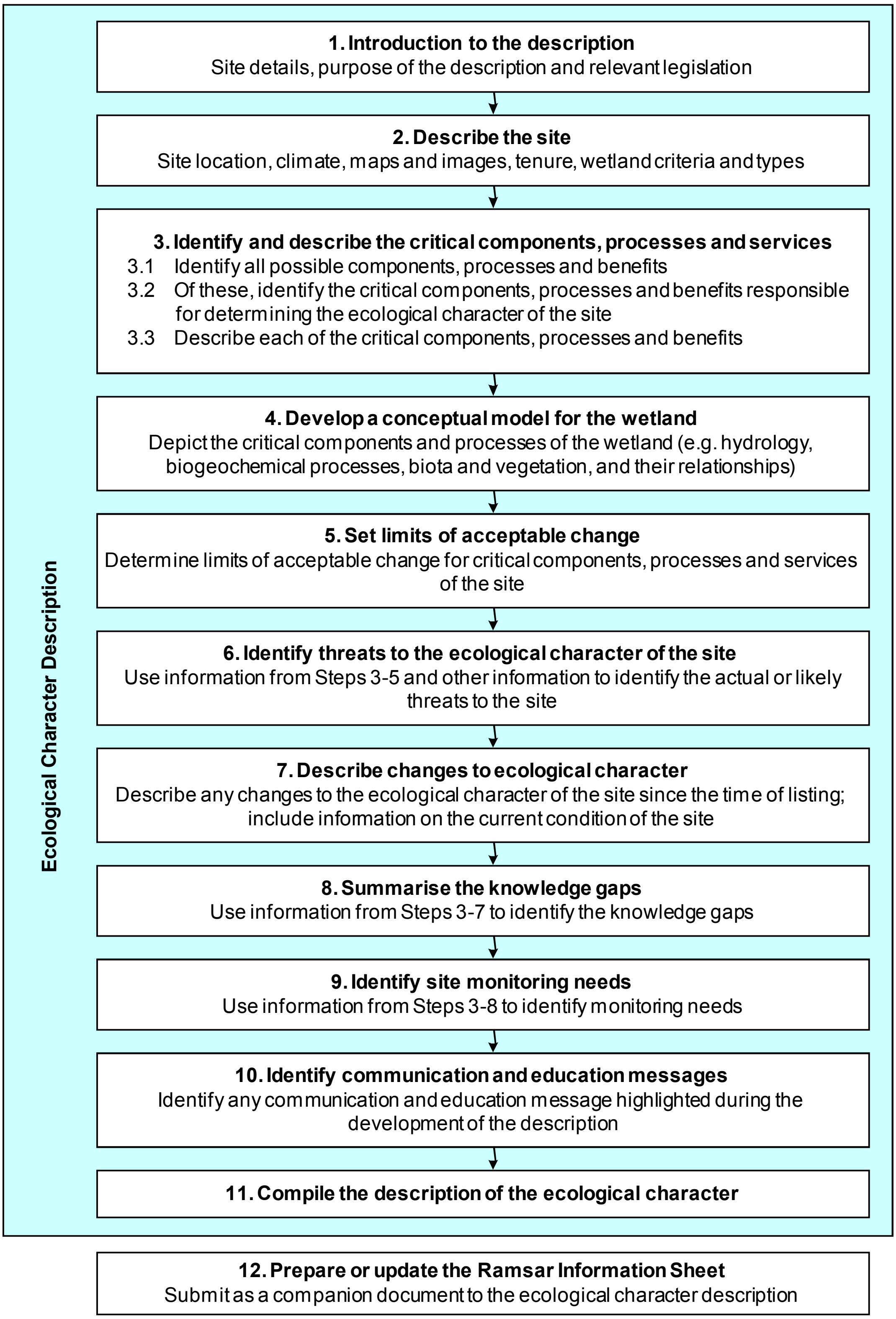


Figure 1-4 Key steps in preparing an Ecological Character Description

(Source: National ECD Framework, DEWHA 2008)

1.3 Relevant Treaties, Legislation and Regulations

This section provides an overview of the treaties, legislation and regulations at various levels of government relevant to the Corner Inlet Ramsar site.

1.3.1 Australian Government Legislation or Policy Instruments

International - Ramsar Convention

The Convention on Wetlands of International Importance (Ramsar, Iran, 1971) or as it is more commonly known, the Ramsar Convention, is an intergovernmental treaty dedicated to the conservation and sustainable use of wetlands (EA 2001). Australia was one of the first 18 countries to become a signatory to the Convention in 1971 and the Convention entered into force in Australia in 1974. The Ramsar Convention Secretariat maintains a List of Wetlands of International Importance that includes 64 existing Australian sites.

Australia's obligations to protect and maintain the ecological character of its Ramsar sites is recognised in Commonwealth Legislation through the EPBC Act.

Ramsar Wetlands and the EPBC Act

Under the EPBC Act (refer s16) an action that has, will have, or is likely to have, a significant impact on the ecological character of a Ramsar wetland (one of the eight matters of National Environmental Significance), must be referred to the Australian Government Minister for Environment and undergo an environmental assessment and approval process. EPBC Act Policy Statements provide specific guidance to help assess the significance of an action. An action is likely to have a significant impact on the ecological character of a Ramsar wetland if there is a real chance or possibility that it will result in:

- areas of the wetland being destroyed or substantially modified
- a substantial and measurable change in the hydrological regime of the wetland - for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland
- the habitat or lifecycle of native species dependent upon the wetland being seriously affected
- a substantial and measurable change in the physico-chemical status of the wetland - for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health
- an invasive species that is harmful to the ecological character of the wetland being established in the wetland.

The EPBC Act also established a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles set out in the *Environment Protection and Biodiversity Conservation Regulations 2000* (see DEWHA 2008).

International Conventions on Migratory Species

Australia is a signatory to four international conventions on migratory species. The conventions are:

- The Convention on Migratory Species (CMS) also known as the Bonn Convention.
- The Japan-Australia Migratory Birds Agreement (JAMBA).
- The China-Australia Migratory Birds Agreement (CAMBA).
- The Republic of Korea-Australia Migratory Birds Agreement (ROKAMBA).

Convention on Migratory Species (CMS)

The CMS was adopted in 1979 and aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, under the United Nations Environment Program, concerned with the conservation of wildlife and habitats on a global scale.

Japan-Australia Migratory Birds Agreement (JAMBA), China-Australia Migratory Birds Agreement (CAMBA) and Republic of Korea-Australia Migratory Birds Agreement (ROKAMBA)

JAMBA and CAMBA are bilateral agreements between the governments of Japan and Australia and China and Australia, which seek to protect migratory birds listed in the two agreements. The two agreements list terrestrial, water and shorebird species that migrate between Australia and the respective countries. In both cases the majority of listed species are shorebirds. Both agreements require the parties to protect migratory birds from take or trade except under limited circumstances, protect and conserve habitats, exchange information, and build cooperative relationships. The JAMBA agreement also includes specific provisions for cooperation on conservation of threatened birds.

In April 2002, Australia and the Republic of Korea also signed a bilateral migratory bird agreement similar to the JAMBA and CAMBA. The ROKAMBA agreement obliges its Parties to protect bird species which regularly migrate between Australia and the Republic of Korea, and their environment. The Annex to the ROKAMBA contains the list of species or subspecies of birds for which there is reliable evidence of migration between the two countries.

EPBC Act and protection of species listed under international conventions

The particular species that are the subject of the agreements or conventions are listed as migratory species under the EPBC Act, and thus are considered to be a matter of National Environmental Significance. Therefore, any action or potential action that may affect these species or species listed as rare or threatened must be referred to the Australian Government Minister for the Environment for assessment. The Minister will decide whether the action will, or is likely to, have a significant impact on the listed species and whether the action will require approval under the EPBC Act. If approval under the EPBC Act is required, then an environmental assessment of the action must be carried out. The Minister decides whether to approve the action, and what conditions (if any) to impose, after considering the environmental assessment.

1.3.2 Victorian Government Legislation or Policy Instruments

Catchment and Land Protection Act 1994

Under the Act, Victoria is divided into ten catchment regions, and a Catchment Management Authority (CMA) is established for each region. CMAs form a major part of the framework for achieving sustainable management of Victoria's land and water resources.

Coastal Management Act 1995

The Act was enacted to establish the Victorian Coastal Council, provide for the establishment of Regional Coastal Boards and co-ordinate strategic planning and management for the Victorian coast. It also provides for the preparation and implementation of management plans for coastal Crown land and a co-ordinated approach to approvals for the use and development of coastal Crown land.

The Act aims to plan for and manage the use of Victoria's coastal resources on a sustainable basis for recreation, conservation, tourism, commerce and similar uses in appropriate areas while protecting and maintaining areas of environmental significance on the coast including its ecological, geomorphological, geological, cultural and landscape features. The Act also aims to facilitate the development of a range of initiatives that improve recreation and tourism, to maintain and improve coastal water quality, to improve public awareness and understanding of the coast and to involve the public in coastal planning and management.

Crown Land (Reserves) Act 1978

This Act provides for reservation of Crown Land Reserves for a variety of public purposes, the appointment of committees of management to manage reserves and for leasing and licensing of reserves for purposes approved by the Minister administering the Act.

Environmental Protection Act 1970

This Act establishes the Environment Protection Authority and makes provision for the Authority's powers, duties and functions. These relate to improving the air, land and water environments by managing waters, control of noise and control of pollution. The Act provides for a ‘works approval’ process for actions that may lead to water, noise and air pollution, in addition to the usual planning permit requirements or where the planning scheme may not apply.

State Environment Protection Policies (SEPPs) are subordinate legislation made under the provisions of the Act to provide more detailed requirements and guidance for the application of the Act to Victoria. The SEPPs aim to safeguard the following environmental values and human activities (beneficial uses) that need protection in the State of Victoria from the effect of waste:

- human health and well-being
- ecosystem protection
- visibility
- useful life and aesthetic appearance of buildings, structures, property and materials
- aesthetic enjoyment and local amenity.

Fisheries Act 1995

The Act provides a legislative framework for the regulation, management and conservation of Victorian fisheries including aquatic habitats. The Fisheries Act seeks to protect and conserve fisheries resources, habitats and ecosystems, including the maintenance of aquatic ecological processes and genetic diversity and at the same time promote the sustainable use of those resources.

Flora and Fauna Guarantee Act 1988

The Act provides a legislative and administrative framework for the conservation of biodiversity in Victoria. The Act provides for the listing of threatened taxa, communities and potentially threatening processes. It requires the preparation of action statements for listed species, communities and potentially threatening processes and sets out the process for implementing interim conservation orders to protect critical habitats. The Act also seeks to provide programs for community education in the conservation of flora and fauna and to encourage co-operative management of flora and fauna.

National Parks Act 1975

The Act provides for the establishment and management of national, State and other parks in Victoria to preserve and protect natural values and provide for their public use and enjoyment. Based on information from the National Park Act Annual Report 2009, there are 133 managed areas covering a total of over 3.32 million hectares.

Planning and Environment Act 1987

The *Planning and Environment Act 1987* is the basis for the direction and control of land use and development in Victoria. Under the Act planning schemes are required which set out policies and provisions for the use, development and protection of land for local government areas. Each municipality in Victoria is covered by a planning scheme. Planning schemes provide local councils with the means of controlling land use and development to protect wetlands and waterways. These are legal documents prepared by the local council or the Minister for Planning, and approved by the Minister.

The State Planning Policy Framework states that: “Planning and responsible authorities must ensure that any changes in land use or development would not adversely affect the habitat values of wetlands and wetland wildlife habitats designated under the Convention on Wetlands of International Importance”.

Water Act 1989

The *Water Act 1989* establishes rights and obligations in relation to water resources and provides mechanisms for the allocation of water resources (the ‘bulk entitlement’ process). This includes the consideration of environmental water needs of rivers and wetlands as well as for human uses such as urban water supply and irrigation.

Waterway management and general river health management is the responsibility of Catchment Management Authorities and Melbourne Water (Part 10 of the Act).

The Act also provides for the establishment of an Environmental Water Reserve (EWR). The EWR can be held in storage and released to a river, it can be run-of-river flow and it can be groundwater. The EWR is defined in section 4A of the Water Act and comprises water set aside for the environment through:

- environmental entitlements
- bulk entitlements held by the Minister for Environment
- conditions on bulk entitlements and water licences
- provisions in Water Supply Protection Area management plans
- any other provision of the *Water Act 1989* or regulations, including for example permissible consumptive volumes.

Wildlife Act 1975

The purposes of this Act are to protect and conserve wildlife, prevent wildlife taxa from becoming extinct, promote the sustainable use of and access to wildlife, and to manage activities concerning or related to wildlife. The Act regulates the protection, management and use of wildlife.

2 SITE DESCRIPTION

2.1 Description of the Site

2.1.1 General Features of the Site and Surrounds

Corner Inlet Ramsar site is located approximately 200 kilometres south-east of Melbourne and is the southern-most marine embayment and intertidal flat location on mainland Australia. The site is located at latitude 38 degrees south within the temperate *warm summer – cool winter* climatic zone (Bureau of Meteorology 2011). A locality map of Corner Inlet is shown in Figure 1-1. Summary details of the site for the purposes of the ECD are provided in Table 2-1. The broad study region for this ECD includes the marine waters and foreshores of Corner Inlet, its sand barrier islands and adjoining catchment areas. The Inlet is bounded by:

- the South Gippsland coastline to the west and north
- a series of barrier islands, sandy spits and Bass Strait to the south-east
- the hills of Wilsons Promontory to the south.

The site and its catchment areas are a component of the broader West Gippsland Catchment Management Authority (WGCMA) region, which is legislatively defined by the Victoria *Catchment and Land Protection Act 1994*. The WGCMA region has an area of 17 164 square kilometres (almost eight per cent of Victoria's total area), and extends from the Gippsland Lakes to west of Warragul, and from the Great Dividing Range to Wilsons Promontory.

Guidelines under the Ramsar Convention favour the use of international or national biogeographic regions in the context of interpretation of Ramsar Nomination criteria and other aspects of the Convention. Different biogeographic schemes apply to the site, depending on whether marine, terrestrial/freshwater environments are considered. In this context, Corner Inlet occurs within the following biogeographic regions:

- for marine areas (IMCRA v4.0) – the Southeast IMCRA Transition Bioregion
- for freshwater and terrestrial areas (Australian Drainage Divisions) – the Southeast Coast Drainage Division.

The site is essentially one large area of marine embayment, tidal channels and sandy barrier islands that includes: marine/estuarine areas within Corner Inlet; land areas (above the high water mark) covering the sand islands and spits along the south eastern site boundary; and nearshore coastal areas fringing the mainland (see Figures 1-1, 1-2, 1-3). The site excludes most of the rivers and creeks that flow into the Inlet from the mainland catchments, but does include river and creek mouths. Mainland drainages that flow into the site include (counter-clockwise from northern tip of the site): Bruthen Creek, Neils Creek, Tarra River, Albert River, Muddy Creek, Nine Mile Creek, Shady Creek, Agnes River, Franklin River, Bennison Creek, Stockyard Creek, Poor Fellow Me Creek, Dead Horse Creek, Silver Creek, Golden Creek, Cow Creek, Barry Creek, Chinaman Creek and Tin Mine Creek (Figures 1-1, 1-2, 1-3). Drainages and other freshwater wetland systems on the sand barrier islands are also included in the site.

Table 2-1 Summary of Key Features of the Corner Inlet Ramsar Site

Attribute	Description
Ramsar Site Name and Number	Corner Inlet, Victoria; Site No. 261
Location in Coordinates	Latitude: 38° 36' to 38° 55'S Longitude: 146° 11' to 146° 53'E
Biogeographic Region	Marine areas (IMCRA v4.0) – Southeast IMCRA Transition Bioregion. Freshwater and terrestrial areas (Australian Drainage Divisions and River Basins) – South Gippsland Basin (South-east Coast Division).
Area	67 186 hectares
Date of Ramsar Site Designation	15 December 1982
Date the Ecological Character Description Applies	1982 (time of listing); 2011 (time of preparation of the ECD)
Status of Description	This is the first ECD undertaken for the site.
Date of Compilation	March 2011
Compiler's Name	BMT WBM Pty Ltd, with expert input from Austecology Pty Ltd and Dodo Environmental, under contract with DSEWPAC
Ramsar Information Sheet	Last updated 1999 (by Parks Victoria). Refer to Ramsar sites information service, Ramsar sites database: http://ramsar.org/ris/key_ris_index.htm Ramsar Site No.: 261 Wetlands International Site Reference No.: 5AU013 RIS updated as part of current ECD by BMT WBM (2011).
Management Plan	The main management plan for the site is the Corner Inlet Ramsar Site Strategic Management Plan (Department of Sustainability and Environment 2002). Other relevant statutory plans include: • Corner Inlet Marine National Park Management Plan (Parks Victoria 2005) • Corner Inlet and Nooramunga Marine and Coastal Park Draft Management Plan (1996) • Wilsons Promontory National Park Management Plan (2002) • West Gippsland Fishery Management Plan 2008 (Department of Primary Industries 2008)
Management Authority	The Ramsar site predominantly includes Victorian waters that are contained within Corner Inlet Marine and Coastal Park, Nooramunga Marine and Coastal Park and Corner Inlet Marine National Park. These areas are managed by Parks Victoria under the provisions of the *National Parks Act* and *Regulations*. Land areas above high water mark on Doughboy Island, Bennison Island, Granite Island, Long Island and Corner Island, together with the intertidal area in the southern section of Corner Inlet, form part of Wilsons Promontory National Park. The Park is managed by Parks Victoria under the provisions of the *National Parks Act* and *Regulations*. The barrier islands are part of the Nooramunga Wildlife Reserve managed by Parks Victoria under the *Wildlife Act* but will be incorporated into Nooramunga Marine and Coastal Park when the park is permanently reserved. Other mainland areas of Crown Land will also be incorporated into the park when it is permanently reserved.

Attribute	Description
	Land and waters within Port areas (Port Welshpool and Port Albert) are managed by Gippsland Ports under the *Crown Land Reserves Act*. Parts of Sunday Island, Dog Island, Little Dog Island, Hunter Island and Bullock Island are privately owned and managed as grazing properties. The remaining areas of the Ramsar site are either freehold land, unreserved Crown Land or are included in various public purposes or coastal reserves. In addition, the Department of Environment and Sustainability is a lead agency for planning and management of wetlands in Victoria, and other State and local agencies also play a cooperative role in the management of wetland resources within and adjacent to the site.

The site is an open marine/coastal system and contains a range of species that have a wide home range that extends to other areas outside the site boundaries. Consequently, many of the more mobile species (particularly migratory birds and many fish species) will only use the areas within the site from time to time. Likewise, threats and controls on these species and habitats may also be occurring outside the boundaries of the site, and as such, maintenance of ecological character can be highly reliant on other conservation and management regimes.

2.1.2 Overview of Wetland Types

2.1.2.1 Information Sources

The Corner Inlet Ramsar site is composed of a complex network of coastal wetland types. Wetland types present range from intertidal marshes and forests, to intertidal flats, sandy shores and subtidal aquatic beds. For this report, the Ramsar Classification System for Wetland Types (approved by Recommendation 4.7 and amended by Resolutions VI.5 and VII.11 of the Conference of the Contracting Parties) has been adopted.

The 1982 nomination RIS (Victorian Ministry for Conservation 1980) specifically identifies the following wetland types as being represented at the time of site listing:

- type A - Permanent shallow marine waters typically less than six metres at low tide; includes sea bays and straits
- type G - Intertidal mud, sand or salt flats
- type H - Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes
- type I - Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.

Victorian Ministry for Conservation (1980) also notes that the site supported extensive seagrass meadows, which is the equivalent to wetland type B.

To date, no mapping according to Ramsar wetland typology has been undertaken for Corner Inlet, either prior to or after Ramsar site declaration. However, some of the Ramsar wetland types are

analogous to habitat types used in other mapping programs. Key data sources that document wetland types at the time of site listing include:

- Victorian Wetlands Database (1994). This database maps habitat types according to the Victorian Wetland Classification Scheme (VWCS), which is based on the scheme developed by Corrick and Norman (1980)
- Morgan (1986). This study documented seagrass, saltmarsh, mangroves and macrobenthos communities in Corner Inlet in 1983–1984. Broad-scale mapping of *Posidonia* seagrass was undertaken.

More recent studies, together with high level analysis undertaken in this report, identify wetland types presently represented in the site. Of particular note is Ecological Vegetation Class (EVC) mapping (2005; Figure 2-2), seagrass assessments undertaken by Roob *et al*. (1998), and the environmental inventory undertaken by Plummer *et al*. (2003). These data sources have been considered for this report in order to determine Ramsar wetland types present within the site.

Although there are few direct overlaps in the wetland typologies used in the EVC, VWCS and Ramsar wetland classification systems, the most likely equivalent wetland types were determined and are presented in Table 2-2. Using the VWCS mapping, a map of broad wetland types within the Ramsar site was generated (refer Figure 2-1) and areas of each wetland type were calculated (refer Table 2-2) using equivalent Ramsar wetland types.

Based on VWCS mapping and other information sources, fourteen Ramsar wetland types are considered to have been represented at the site at the time of listing, and continue to be supported at present (Table 2-2). In addition to the five wetland types outlined in the Victorian Ministry for Conservation (1980) (Types A, B, G, H and I), at least five other marine/coastal Ramsar wetland types (Types D, E, F and K) and four inland Ramsar habitat types (Types N, Tp, Ts, W and Xf) are presently represented in the site. Further details and descriptions of these wetland types are provided below. Note that there are some uncertainties regarding the extent and distribution of most wetland types due to the lack of a consistent, systematic mapping of Ramsar wetland habitat types within the site. Where such uncertainties exist, these have been identified in the following sections.

Table 2-2 Ramsar Wetland Types, as translated from the Victorian Wetland Classification System (VWCS) Wetland Types, within the Ramsar site

Wetland Type	Time of listing			Present day	Representative examples
	Interpreted VWCS Category	VWCS Area (hectares)	Other Sources		
A - Permanent shallow marine waters typically less than six metres at low tide; includes sea bays & straits.	No equivalent VWCS category, but within: • permanent saline – intertidal flats • permanent saline – island • permanent saline - shallow	40 479 4967 58	Present - Victorian Ministry for Conservation (1980)	Present – refer to DEM (Figure 2-2)	Dendritic channels in the south eastern sections of the site.
B - Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows.			Present – Roob *et al*. (1998) based on 1980-1981 aerial photography	Present – Roob *et al*.(1998), Hindell *et al*. (2007)	Present throughout site – see Section 3.3.1
D - Rocky marine shores; includes rocky offshore islands, sea cliffs.	No equivalent VWCS category		Present - Morgan (1986)	Present – Plummer *et al*. (2003) EVC mapping (2005) (Rocky Shore)	Small areas near Tin Mine and Freshwater Coves, and near Bennison Island (Morgan 1986).
E - Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems and humic dune slacks.	No equivalent VWCS category, but within: Permanent saline – intertidal flats	See above for Wetland Type A and B	Present - Morgan (1986)	Present – Plummer *et al*. (2003) EVC mapping (2005) (Sandy Beach)	Present on sand barrier islands including Snake, Sunday, Shag Islands (Morgan 1986).
G - Intertidal mud, sand or salt flats.			Present - Morgan (1986)	Present – Plummer *et al*. (2003), see also Figure 2-3	Present throughout site – see Section 3.3.1
H - Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.	• semi-permanent saline – salt flats • semi-permanent saline – salt meadow • semi-permanent saline – salt pan	211 406 49	Present - Morgan (1986)	Present – Plummer *et al*. (2003) EVC mapping (2005) (Coastal Saltmarsh)	Extensive areas along north-eastern shoreline between Manns Beach and McLoughlins Beach, including the northern shoreline of Saint Margaret Island
I - Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.	Permanent saline - mangroves	2061	Present - Morgan (1986)	Present – Plummer *et al*. (2003) EVC mapping (2005) (Mangrove Shrubland)	Mostly located along the northern shoreline of Corner Inlet.
F - Estuarine waters; permanent water of estuaries and estuarine systems of deltas.	Permanent saline - shallow	58	Present - Morgan (1986)	Present – Plummer *et al*. (2003); EVC mapping (2005) (part of Estuarine	Agnes, Albert, Tara Rivers, and various estuarine creeks along length of western shoreline.

Wetland Type	Time of listing			Present day	Representative examples
	Interpreted VWCS Category	VWCS Area (hectares)	Other Sources		
				Wetland)	
K - Coastal freshwater lagoons; includes freshwater delta lagoons.	No equivalent VWCS category, but within deep freshwater marsh – open water	162	N/A	DSE Online Interactive Map EVC mapping (2005) (part of Water Body – Fresh)	Present - Bullock and Tree Bullock Waterholes, The Big Hole (Snake Island)
Tp - Permanent freshwater marshes/pools; ponds (below eight hectares), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season.	No specific VWCS category, but within shallow freshwater marsh, deep freshwater marsh	See K	N/A	EVC mapping (2005) (part of Water Body – Fresh, Wetland Formation, Wet Heath) EVC mapping (2005)	Present – Snake Island
Ts - Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.					Present – Snake Island
W - Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.	Freshwater meadow and shallow freshwater marsh	None mapped	N/A	EVC mapping (2005) (part of Wet Heath)	Present - Snake Island
Xf - Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils.	No specific VWCS category	N/A	N/A	EVC mapping (2005)(part of Damp Woodland EVCs)	Present - Snake Island
N - Seasonal/intermittent/irregular rivers/streams/creeks.	No specific VWCS category	None mapped	N/A	DSE Online Interactive Map EVC mapping (2005) (part of Water Body – Fresh)	Present - small, unnamed watercourses mapped by DSE on Snake and Sunday Islands.

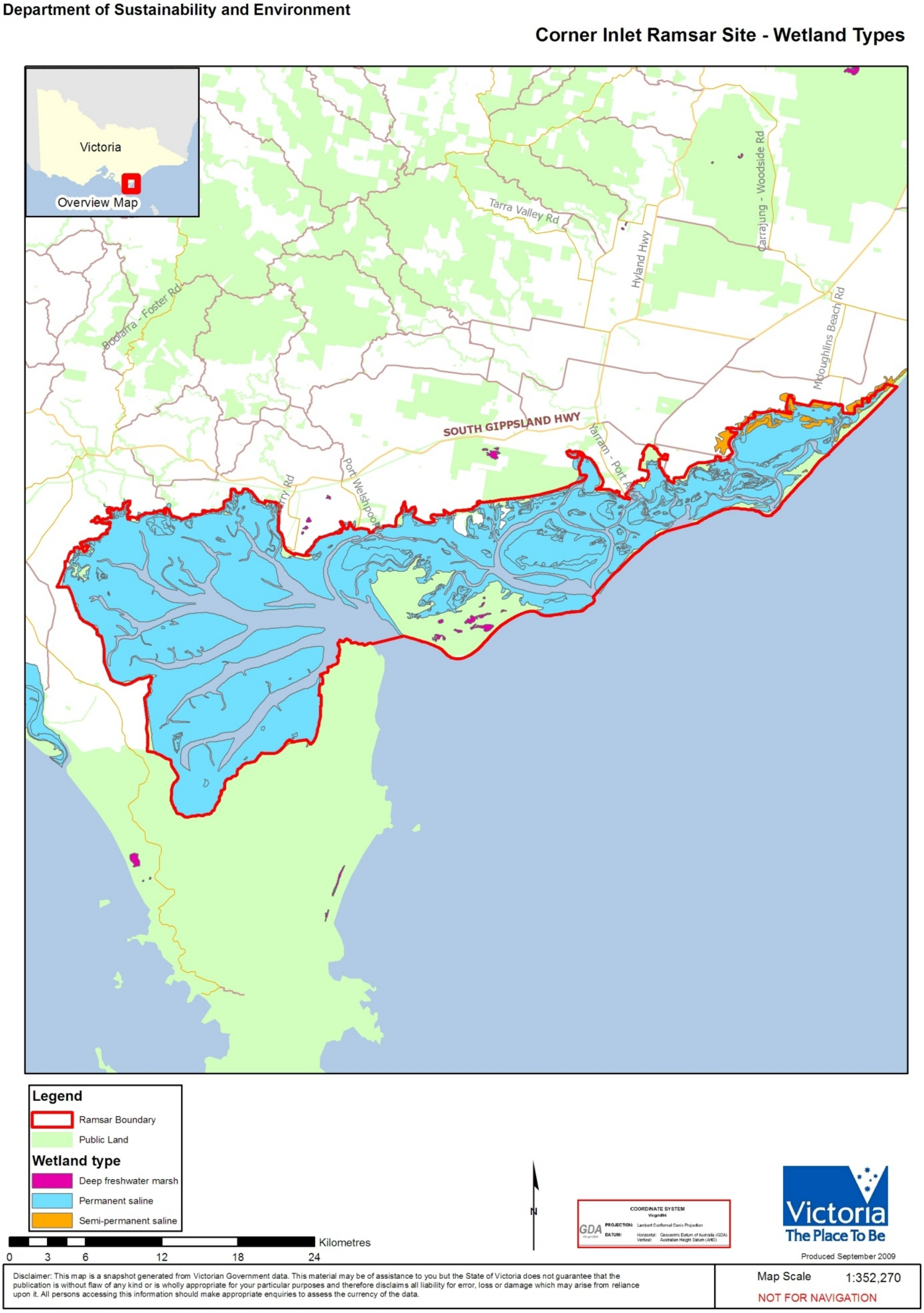


Figure 2-1 Victorian Wetland Classification System Wetland Types within the Corner Inlet Ramsar Site (Source: DSE unpublished)

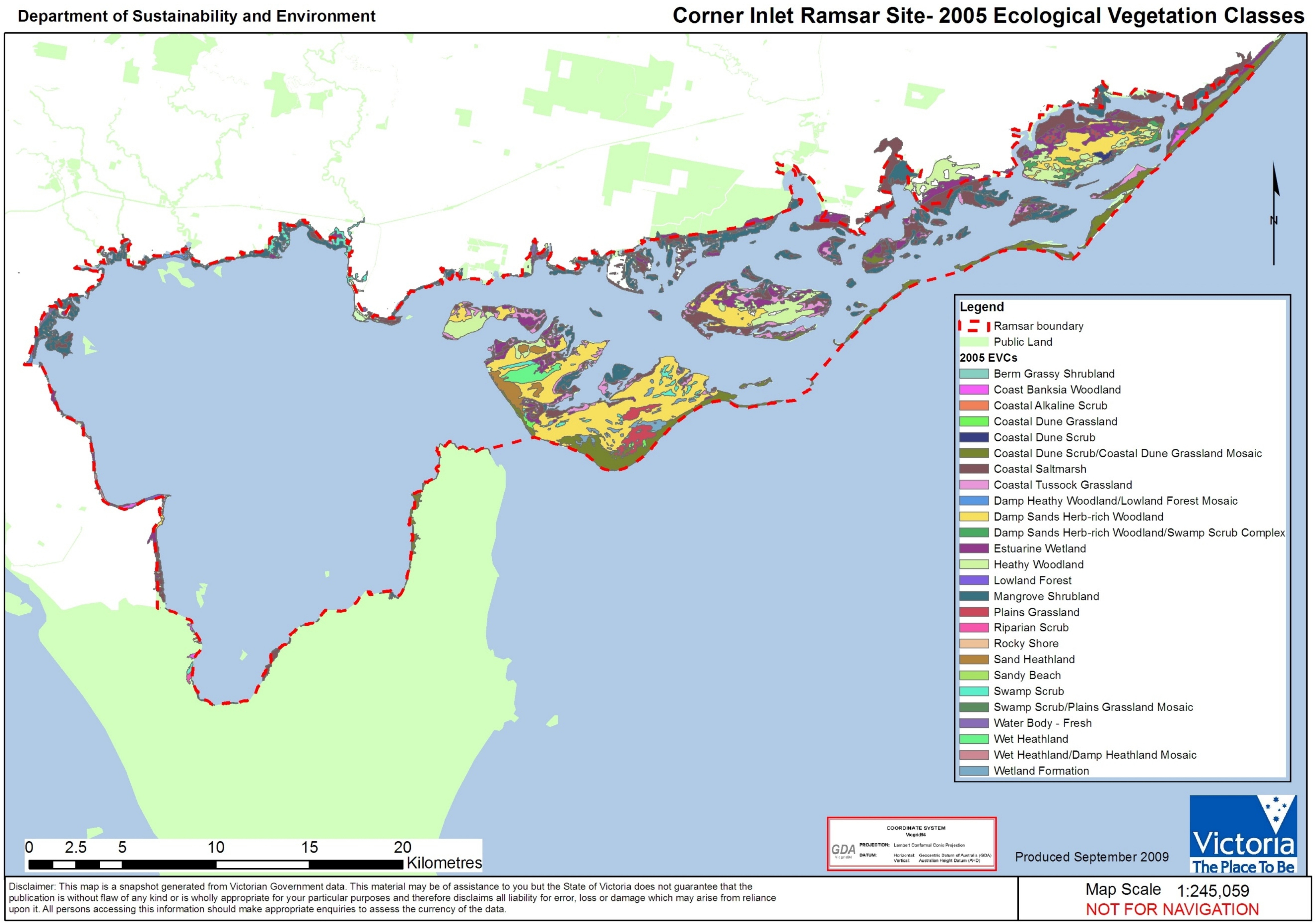


Figure 2-2 EVC (2005) Map for the Corner Inlet Ramsar Site (Source: DSE unpublished)

2.1.2.2 Marine/Coastal Wetland Types

Figure 2-3 is a digital elevation model (DEM) showing the bathymetry of Corner Inlet and surrounding waters. The DEM shows that approximately 540 square kilometres of the total 630 square kilometres area of the site is water or intertidal flats with the remainder comprising island and fringing wetlands.

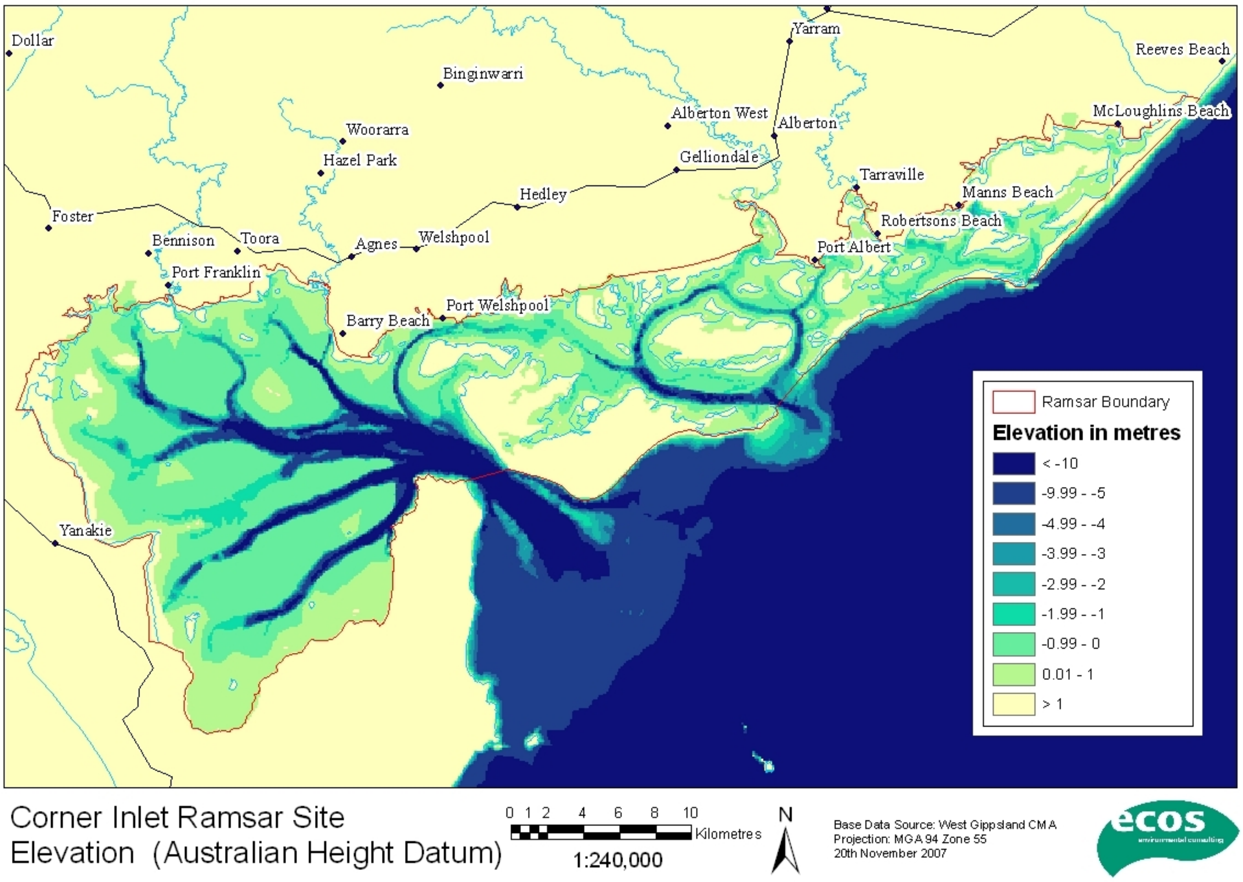


Figure 2-3 DEM Showing Bathymetry of Corner Inlet (Reproduced from Ecos unpublished)

The receiving waters of Corner Inlet are mostly a shallow intertidal environment comprising extensive mud and sandflats and seagrass beds (about 385 square kilometres of the inlet is shallower than 1.0 metre) (Ecos unpublished). The embayment is dissected by a network of deeper channels that drain and fill from the entrance to the east. The three main channels (Franklin, Middle and Bennison) are three to 10 metres deep becoming shallower in the northern and western areas of the inlet. Channels near the centre and entrance of the inlet are deeper, reaching depths of about 40 metres, although in the Marine National Park the maximum depth is 20 metres (Plummer *et al.* 2003).

The following sections provide a discussion on the Ramsar wetland types found at the site.

Wetlands Identified in the Ministry for Conservation (1980) RIS

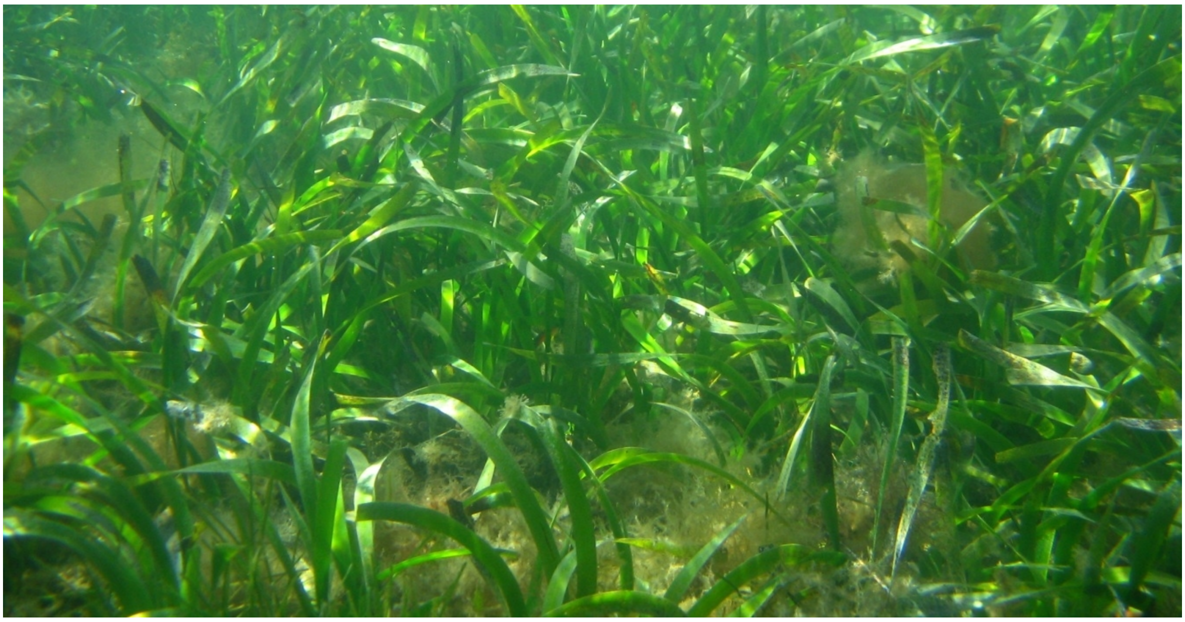
Type A: Permanent Shallow Marine Waters

This wetland type incorporates marine waters that are less than six metres deep at low tide, including sea bays and straits. Large areas of shallow marine waters are located within the eastern half of the Corner Inlet Ramsar site.

Shallow permanent waters and sandy beach wetland types - Corner Inlet (Photo: Parks Victoria)

Type B: Marine Subtidal Aquatic Beds

This wetland type is represented within the Corner Inlet Ramsar site by seagrasses that form meadows in clear, low energy, shallow waters. Seagrass beds are present throughout the whole embayment, varying in species composition and abundance, and covering a total area of approximately 14 800 hectares (Roob *et al*. 1998), although abundance and extent can vary greatly over time (see Section 3.3.1). The site contains extensive beds of *Posidonia australis* (Frood 1986, Morgan 1986), with other species present including *Zostera muelleri* and *Halophila australis* (Roob *et al*. 1998) and *Heterzostera tasmanica* (O'Hara et al. 2002). The seagrass beds have a high primary productivity, and provide food and habitat for commercially and recreationally important fish and invertebrate species.



***Posidonia australis* meadow - Corner Inlet (Photo: Parks Victoria)**

Type G: Intertidal Mud, Sand or Salt Flats

This wetland type encompasses habitats comprised of alluvial deposits of sand and mud that accumulate on intertidal flats. The most extensive intertidal flats in Victoria are present within the Ramsar site, covering an area in excess of 38 700 hectares (NLWRA 2001) to 40 479 hectares based on VWCS (Table 2-2). Many invertebrate species inhabit these intertidal flats, and when exposed at low tides, these represent an important food resource for shorebirds.

Intertidal flats - Corner Inlet (Photo: Parks Victoria)

Type H: Intertidal Marshes

This wetland type is represented in the Ramsar site by saltpan vegetation on marine clay plains, as well as saline or brackish sedgelands. Saltmarsh typically occurs in the upper-intertidal zone as a band along the landward edge of the mangrove zone, covering an area of approximately 2613 hectares within the site (EVC mapping; see Figure 2-6). In particular, saltmarsh communities are notable along the northern mainland shore of Ramsar site, and on most of the islands including Franklin Island and Snake Island. Characteristic vegetation communities are samphire herblands dominated by *Sarcocornia quinqueflora* (beaded glasswort), with other species including sea rush (*Juncus kraussii*), shiny swamp-mat (*Selliera radicans*) and creeping brookweed (*Samolus repens*) (Davies *et al*. 2001).

Intertidal marshes - Corner Inlet (Photo: Parks Victoria)

Type I: Intertidal Forested Wetlands

This wetland type is represented within the Ramsar site by mangrove shrublands to low closed forest. Dense mangrove stands are found along the northern mainland shore of the Ramsar site, and scattered patches occur along the southern shore, the islands and within the estuarine environments. In total, mangroves occupy an area of approximately 2137 hectares within the site (2005 EVC mapping; see Figure 2-6). These communities are comprised of a single mangrove species, namely white mangrove (*Avicennia marina*), representing the most southerly distribution of this species on a global scale (Ball in Plummer et al. 2003). Mangroves are important roosting and sheltering sites for a variety of shorebirds, and provide nursery grounds for fish and a diversity of invertebrate fauna.

Mangroves and intertidal seagrass meadows at Toora - Corner Inlet (Photo: Parks Victoria)

Confirmed Additional Marine/Coastal Ramsar Wetland Types

Type D: Rocky Marine Shores

This wetland type is characterised by exposed rocky marine shores, including rocky offshore islands and sea cliffs. Plummer *et al*. (2003) recorded small sections of this habitat type near Tin Mine Cove and Freshwater Cove in the northern section of the Corner Inlet Marine National Park and near Bennison Island in the southern section of the Marine National Park, which are located within the site (Figure 1-2). EVC mapping by DSE (in 2005) shows that approximately 0.002 hectares of rocky shore are mapped within the site (Figure 2-6). Rocky shores provide habitats for a wide range of algae, marine invertebrates and fish species.

Subtidal reef - Corner Inlet (Photo: Parks Victoria)

Type E: Sand, Shingle or Pebble Shores

This wetland type includes sand, shingle or pebble shores, as well as sand bars, spits, sandy islets, dune systems and humid dune slacks. Sand barrier islands are fringed by sandy beach habitats, including Snake, Sunday and Shad islands (Figure 1-2 and 1-3), with a total of 29 hectares of sandy beach mapped within the site in 2005 EVC mapping by DSE (Figure 2-6). Additionally, there are numerous intertidal sand spits within the coastal sand barrier complex that represents the eastern boundary of the site.

Sandy beach wetland type - Corner Inlet (Photo: Parks Victoria)

Type F: Estuarine Waters

This wetland type includes permanent water of estuaries and estuarine systems of deltas. Determining the extent and distribution of estuarine waters is to a large extent dependent on the definition of an estuary. In broad terms, the definition of estuary could apply to all marine/coastal waters within the site, since it is an enclosed waterbody that represents a mixing zone between freshwater and marine waters. However, for the purposes of this study, estuarine waters are considered here to include the freshwater/marine interface area within creeks and rivers. Notable examples within the site include Agnes, Albert, Franklin and Tarra Rivers, Bruthen Creek and the smaller estuarine creeks along length of western shoreline.

Estuarine creek mouth - Corner Inlet (Photo: Parks Victoria)

Type K: Coastal Freshwater Lagoons

This wetland type consists of coastal freshwater lagoons. Based on DSE mapping, there appear to be several freshwater lagoons within the site. Representative examples of coastal freshwater lagoons include Big Hole, Tree Bullock and Bullock Waterholes on Snake Island, and unnamed waterholes on Saint Margaret Island (Figure 1-2).

Big Hole, a coastal freshwater lagoon on Snake Island - Corner Inlet (Photo: Parks Victoria)

2.1.2.3 Inland Wetland Types

Confirmed Additional Inland Ramsar Wetland Types

Type N: Seasonal Rivers/Streams/Creeks

This wetland type incorporates seasonal rivers, streams and creeks. This wetland type is represented within the Ramsar site by small, unnamed watercourses mapped by DSE on Snake and Sunday Islands.

Type Tp: Permanent Freshwater Marshes/Pools and Type Ts: Seasonal/Intermittent Freshwater Marshes/Pools on inorganic soils

These wetland types include marshes and swamps with emergent vegetation that is waterlogged for at least most of the growing season. Within the Ramsar site, this wetland type consists of herblands, sedgelands and rushlands that are associated with standing water ranging from permanent to ephemeral water bodies. Characteristic species include water ribbons (*Triglochin procerum*), yellow bladderwort (*Utricularia australis*), tall spike-sedge (*Eleocharis sphacelata*) and tall rush (*Juncus procerus*) (Davies *et al*. 2001). This wetland type is mapped in the southern area of Snake Island, and covers an area of 1405 hectares within the Ramsar site according to 2005 EVC mapping by DSE (noting that permanent and seasonal marshes cannot be differentiated in this mapping).

Freshwater marsh on Snake Island - Corner Inlet (Photo: Parks Victoria)

Type W: Shrub-dominated Wetlands

This wetland type includes shrub swamps and shrub-dominated freshwater marshes. It is represented within the Corner Inlet Ramsar site by wet heathland that is mapped as covering approximately 220 hectares within the Ramsar site (EVC mapping by DSE based on EVC 8 and 686). This wetland type occurs on infertile sands that are subject to prolonged water logging, and is present on Snake Island. Shrub species that may be present include prickly tea-tree (*Leptospermum*

continentale), common heath (*Epacris impressa*), coral heath (*Epacris microphylla*) and smooth parrot-pea (*Dillwynia glaberrima*) (Davies *et al*. 2001).

Type Xf: Freshwater Tree-dominated Wetlands

This wetland type includes freshwater swamp forests, seasonally flooded forests and wooded swamps. It is represented within the Ramsar site by swamp scrubs on poorly drained soils that are inundated during the wetter months. This vegetation community is typically dominated by swamp paperbark (*Melaleuca ericifolia*). The understorey varies in composition depending on the duration of water logging and the density of the canopy, and may include mosses, grasses (for example, common reed *Phragmites australis*), sedges (for example, tall sedge *Carex appressa* and common spike-sedge *Eleocharis acuta*) and/or herbs (for example, slender knotweed *Persicaria decipiens*) (Davies *et al*. 2001). Within the Ramsar site, large areas of Snake Island and smaller patches along the western and northern mainland shores contain freshwater tree-dominated wetlands.

Potential Additional Ramsar Wetland Types Requiring Ground-truthing

Type U: Non-forested Peatlands and Type Xp: Forested Peatlands

Although peat soils have been recorded within the Ramsar site (for example, Davies *et al*. 2001; CSIRO 2005), it is uncertain whether peat swamp is present. If present, it is likely that areas mapped as wetland types Tp/Ts, W and Xf also contain this wetland type.

As outlined in the Ramsar Guidelines for Global Action on Peatlands (GAP), peatlands are increasingly being recognised as an important wetland resource at the global level through their role in contributing to global biodiversity, as an important carbon sink and through the retention of paleo-environmental information about previous landscapes and climate states.

Artificial Wetland Types

There are also likely to be several man-made wetland types present within the Ramsar site, although there are no data to determine their presence and extent. Man-made wetland types potentially within the site include:

- Type 2: Ponds, including farm ponds, stock ponds and small tanks
- Type 9: Canals and drainage channels.

2.1.3 Uses and Tenure

2.1.3.1 Adjacent Land Use

Agriculture and Forestry

The catchments that drain into the Corner Inlet Ramsar site (the catchment) have a combined area of approximately 2100 square kilometres (CSIRO 2005). The catchment of Corner Inlet is predominantly privately owned land. Since European settlement in the mid to late 1800's, most of the catchment has been cleared of forest vegetation, and is now mainly used for agricultural purposes, most notably for dairying and grazing (Figure 2-4). Plantation forestry activities have included native (for example, Tasmanian blue gum *Eucalyptus globulus*) and exotic (for example, radiata pine *Pinus radiata*) species (DSE 2003).

Urban

The wider region includes two municipalities: Wellington and South Gippsland Shires. For the period 1991 to 2004, Australian Bureau of Statistics (ABS) census figures showed that the population of South Gippsland Shire increased by approximately four per cent, or 0.3 per cent per annum. By 2031 it is estimated that the population of the Shire will increase to 31 934, which represents a growth rate of approximately 1.4 per cent per annum. There is limited urban development within the catchments of the site, with most of the population dispersed between several regional centres in the vicinity of the main highways (for example, Yarram, Woodside and Foster). The main coastal settlements adjacent to the site include Manns Beach, Roberstons Beach, and McCoughlins Beach.

Conservation Estate

Land to the south of the site is predominantly contained within Wilsons Promontory National Park. Areas of conservation reserve also occur throughout the wider catchment area (Figure 2-5).

2.1.3.2 Tenure

The site has complex tenure arrangement and multiple site managers (DNRE 2002). Ecos (unpublished) provides a detailed account of tenure, which is summarised as follows:

- Most public lands and waters within the site are managed by Parks Victoria (Figure 2-5). In this regard:
  - Most public land and waters within the site (89 per cent of the total site area) are contained within Corner Inlet Marine and Coastal Park (27 848 hectares), Nooramunga Marine and Coastal Park (30 101 hectares) and Corner Inlet Marine National Park (1641 hectares). These areas are managed by Parks Victoria under the provisions of the *National Parks Act* and *Parks Regulations*.
  - Land areas above high water mark on Doughboy Island, Bennison Island, Granite Island, Long Island and Corner Island (Figure 1-2), together with the intertidal area in the southern section of Corner Inlet, form part of Wilsons Promontory National Park. The Park is managed by Parks Victoria under the provisions of the *National Parks Act* and *Parks Regulations*.

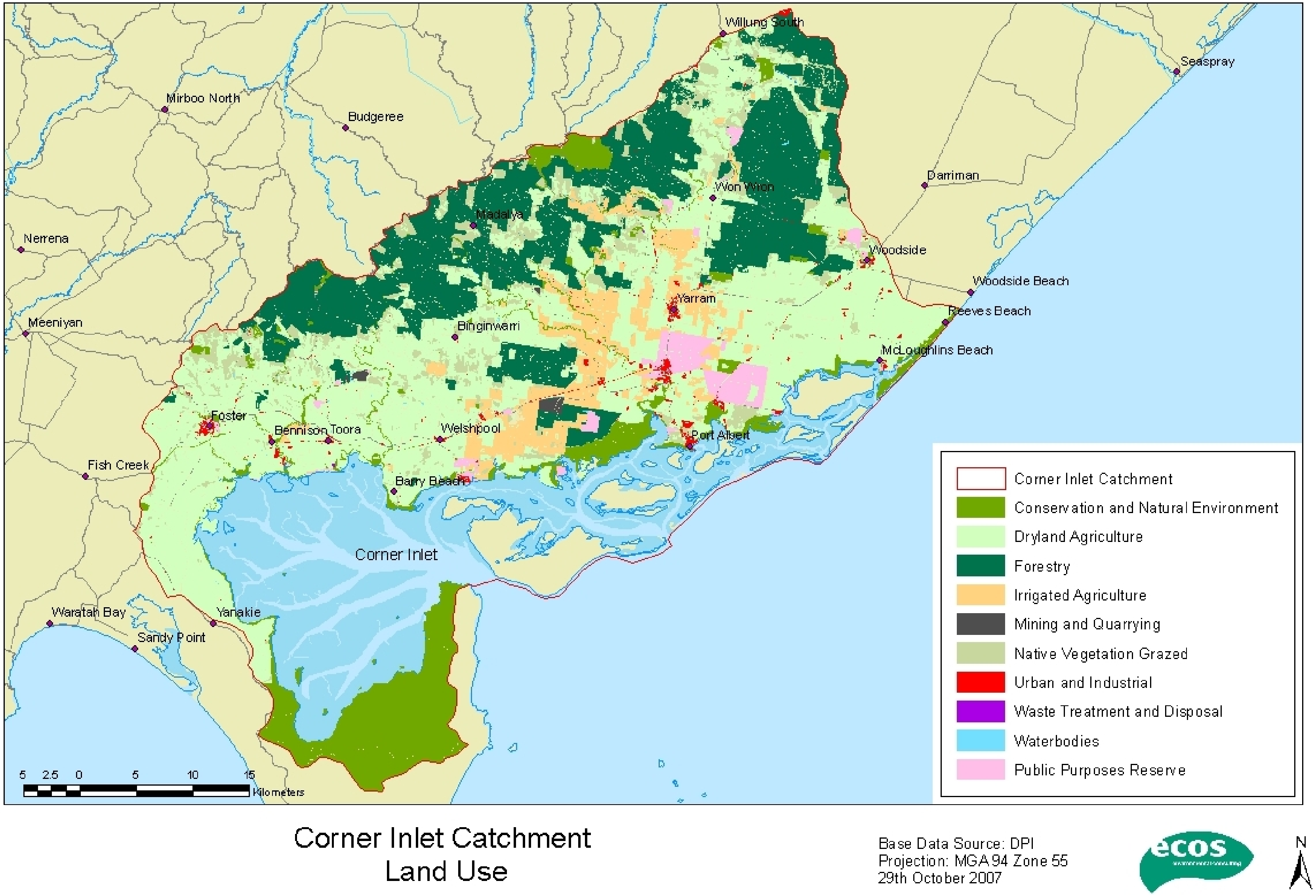


Figure 2-4 Corner Inlet Catchment and Land Use (Reproduced from Ecos unpublished)

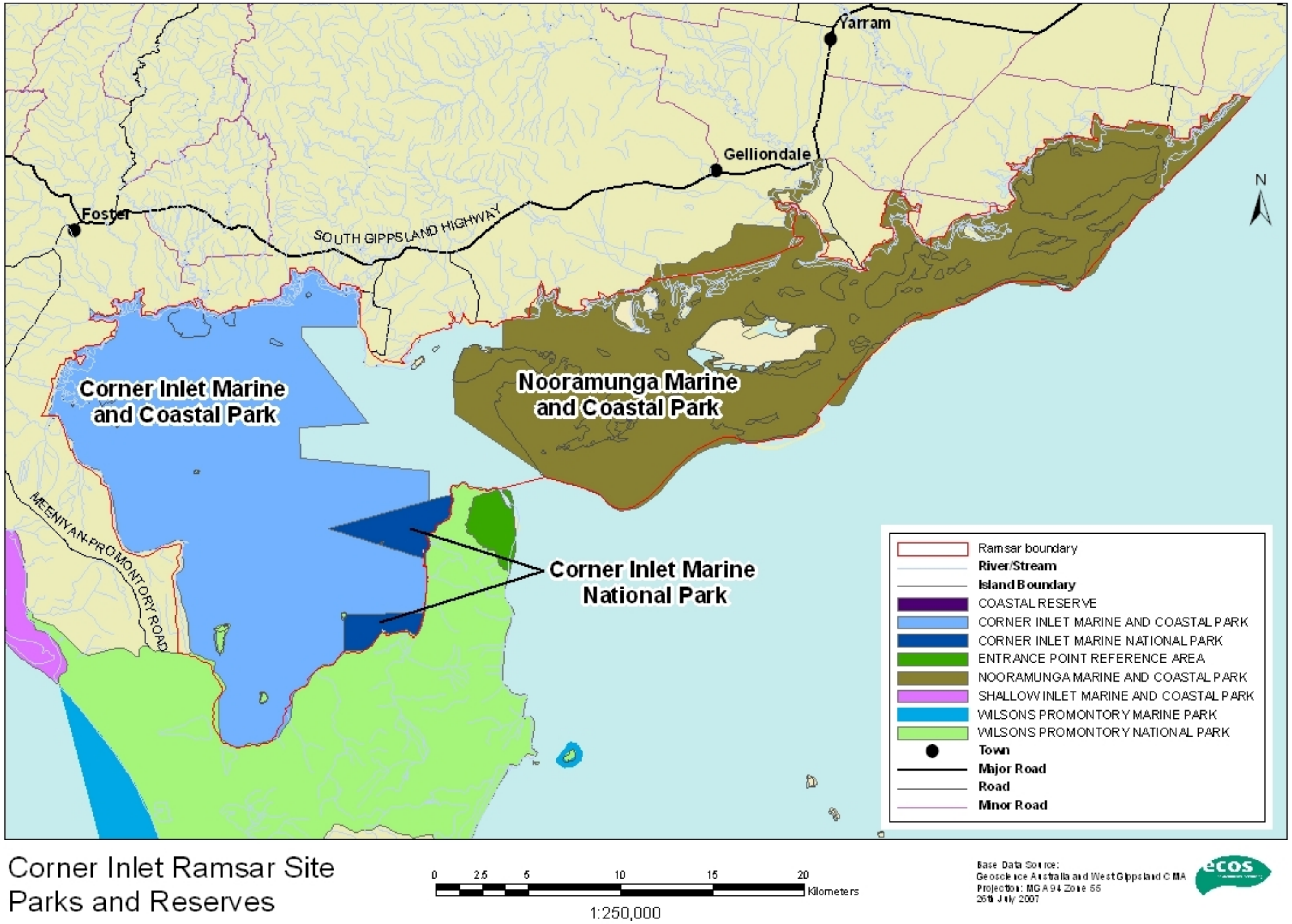


Figure 2-5 Parks, Reserves and Other Land Tenure within and Surrounding the Corner Inlet Ramsar Site (Reproduced from Ecos unpublished)

- Land and waters within Port areas (Port Welshpool and Port Albert) are managed by Gippsland Ports under the *Crown Reserves Act*
- Sunday Island, Dog Island, Little Dog Island, Hunter Island and Bullock Island are privately owned and managed
- The remaining areas of the Ramsar site are either unreserved Crown Land or are included in various public purposes or coastal reserves.

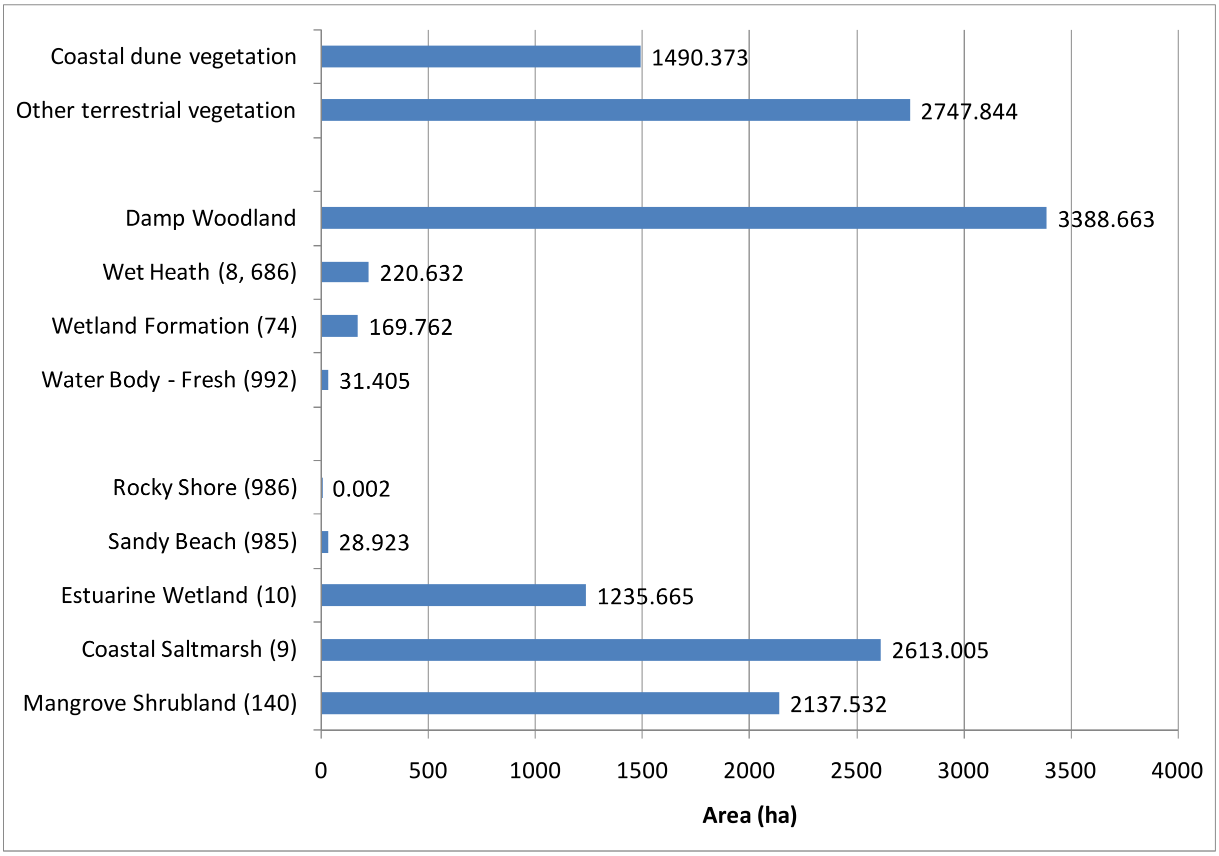
2.1.4 Natural Values

The Ramsar site has notable natural values afforded by the diversity of marine, estuarine and freshwater wetland habitats, most of which are presented in a near-natural condition. Marine flora communities within the Ramsar site are especially noteworthy due to their unique status in the bioregion. In particular, the Ramsar site has the largest *Posidonia* seagrass beds in Victoria (Frood 1986, Morgan 1986) and elsewhere in the Southeast Coast IMCRA Transition bioregion (West et al. 1985).

The site has high biodiversity values, which are summarised by DNRE (2002) as follows:

- Approximately 390 species of indigenous flora and approximately 160 species of indigenous terrestrial fauna have been recorded at the site
- To date, 24, 26 and 27 bird species listed under JAMBA, CAMBA and ROKAMBA, respectively, have been recorded at the site
- A total of 25 bird species listed under the Bonn convention have been recorded at the site
- Over 390 species of marine invertebrates have been recorded in the site. Three invertebrate species appear to be restricted to Corner Inlet, and have been recommended for listing as vulnerable species under the Victorian *Flora and Fauna Guarantee Act 1988*
- A wide variety of marine mammals occur in the site including bottlenose dolphins and Australian fur seals, as well as occasional records of common dolphins, New Zealand fur seals, leopard seals and southern right whale.

Vegetation mapping by DSE for the year 2005 identifies 28 EVCs within the site. Figure 2-6 summarises the total mapped area of individual wetland-associated EVCs, as well as total area of terrestrial vegetation EVCs (pooled). Notwithstanding the limitations of this broad-scale mapping, it is apparent that the largest vegetation community type by area is damp sands herb-rich woodland (EVC 3; 34 per cent of mapped vegetation), followed by coastal saltmarsh (EVC 9; 19 per cent of mapped vegetation) and mangrove shrublands (EVC 140; 15 per cent of mapped vegetation). This mapping does not include seagrass vegetation or open marine waters.



Note: Vertical axis indicates EVC number and name. Some EVCs are pooled as follows: Coastal dune vegetation (EVC 1, 2, 160, 163), Damp Woodland (EVC 3, 878, 1106), Other Terrestrial (EVC 6, 48, 53, 83, 132, 163, 311, 687, 16)

Figure 2-6 Vegetation Communities within the Site (Source: EVC mapping by DSE)

In terms of noteworthy terrestrial flora, two nationally vulnerable orchid species have been recorded within the Ramsar site (*Caladenia tessellata* and *Pterostylis cucullata*), but these species have not been considered in the context of this ECD as they are not wetland-dependent species. It is possible that other flora species of conservation significance that are wetland-dependent exist within the site, but have not been recorded due to lack of survey effort.

In terms of functional values, the extensive tidal flats, together with fringing wetland habitats, provide important roost sites, feeding and breeding areas for shorebirds. The 'unvegetated' tidal flats are in fact important habitats for microphytobenthos, which are unicellular algae that are key drivers of ecosystem processes in the Inlet. These tidal flats, together with deeper waters areas, are also habitats for a wide range of benthic invertebrate and fish species.

The marine, estuarine and freshwater habitats of the site support a wide range of fish species at different stages of their life-cycle and for different functions (that is, larvae, post-larvae, spawning, feeding, shelter, migratory routes etc.).

Corner Inlet also provides a number of important functions that contribute to the maintenance of the wetland and surrounding ecosystems, including (DNRE 2002):

- Saltmarsh and mangrove communities filter pollutants, stabilise sediments, trap and process nutrients and protect the shoreline from erosion

- The site provides food, nesting and nursery areas for many animals including a variety of reptiles, amphibians, mammals, fish and birds, including threatened species
- The intertidal area depends on surrounding beaches and catchment inputs for the nutrients that sustain invertebrate populations.

In addition it is noted that terrestrial freshwater runoff can supply a significant proportion of organic matter, which can settle or be filtered into the intertidal sediments. Another labile source of organic material is microalgae growing on or in the sediments of intertidal flats. The breakdown of this organic material by bacteria can lead to a significant release of nutrients.

West Gippsland CMA (2007) examined the comparative environmental values of ‘significant wetlands’ in the west Gippsland region. Environmental values were assessed on the basis of a range of metrics describing wetland significance, wetland rarity, significant flora, significant fauna, vegetation intactness, hydrology and habitat values. Corner Inlet was ranked fourth of 23 wetlands.

2.1.5 Socio-Economic and Cultural Values

The following provides a summary of the uses and cultural/socio-economic values of the site.

Ports and Harbours

Corner Inlet encompasses four ports: Port Albert, Port Franklin, Port Welshpool, and Barry’s Beach. These ports service the commercial fishing industry, minor coastal trade, offshore oil and gas production and boating visitors. Barry’s Beach marine terminal is the main launch facility to the Bass Strait oil field platforms (DSE 2003), whereas the other three ports predominantly service the commercial fishing industry.

Fishing

Corner Inlet is one of only three estuaries or bays where commercial fishing is allowed in Victoria (DPI 2008). In economic terms, the commercial bay and inlet fishery has an estimated wholesale value of approximately 5 to 8 million dollars annually. The commercial fishery also produces economic flow-on effects to the wider community. Victoria DPI (2008) suggests that these fisheries supply high priced product for niche markets. The Inlet is also a popular recreational fishing area (Gunthorpe and Hammer 2000). Most recreational fishing is boat based due to limited shoreline access (DCNR 1995). Refer to Sections 2.2.2 and 3.7.2 for details.

Recreation and Tourism

DNRE (2002) states that “Corner Inlet is a popular visitor destination attracting an estimated 150 000 visitor days per year”. Tourism and recreational values of the Ramsar site and surrounds predominantly relate to nature-based activities. The Ramsar site includes important terrestrial and aquatic environments for tourism and recreational activities including recreational fishing, boating/yachting, sightseeing, horse riding, scuba diving, bird watching, and bushwalking.

The proximity of the Ramsar site to Victoria’s capital city, Melbourne, as well as the LaTrobe Valley, highlights the importance of the site for regional residents and visitors, both for tourism and recreational purposes, and the need to ensure conservation and wise use of the area (that is,

management of impacts from tourism and recreation). DNRE (1996) suggest that the tourist values of the site could increase with increased promotion of tourism opportunities.

Cultural Heritage

The seascape has high cultural significance to indigenous groups (Parks Victoria 2005). DNRE (2002) states that "the Brataulong Clan of the Gunai/Kurnai Tribe has strong cultural traditions and practices associated with the area". Numerous sites have been recorded in the area including scarred trees, burial sites, artefact scatters, camps and shell middens. Several indigenous groups are asserting traditional ownership over the site (Parks Victoria 2005). Groups identifying the area as their Traditional Country include the Boon Wurrung, Bunurong and Gunai/Kurnai.

Casanelia (1999) and DNRE (2002) identify shipwrecks as key cultural heritage features within and adjacent to the site. DNRE (2002) estimates that 31 shipwrecks occur in the site, 23 of which occur around Port Albert. These features illustrate aspects of European settlement, including the history of trade, ship building and propulsion. Historic coastal port townships of Port Albert and Port Welshpool are also key European cultural heritage features of the area DNRE (2002).

Research and Education

The site does not contain any scientific research stations. However, the Inlet is used as a site for scientific research programs by several institutions including:

- Arthur Rylah Institute for Environmental Research (ARI), the research arm of DSE, based in Heidelberg (Melbourne) Victoria. Arthur Rylah is a centre for applied ecological research, with an emphasis on flora, fauna and biodiversity issues. Research themes include wetland health and ecology, threatened species, and mapping and measuring biodiversity (including wetland condition). ARI's main focus is on providing strategic research and management advice to answer key questions affecting ecologically sustainable land or water management and resource use policies

- Marine and Freshwater Resources Institute - Victoria Department of Primary Industries, based in Queenscliff, who have conducted seagrass studies in Corner Inlet

- CSIRO Marine and Atmospheric Research, based in Aspendale (Melbourne), Victoria whose research in the area has covered areas such as marine pests, and who have also conducted a shark tagging study that has recorded White Sharks (*Carcharodon carcharias*) in waters near Corner Inlet.

Other universities and colleges use Corner Inlet for research and education, including University of Melbourne and Victoria University.

2.2 Ramsar Nomination Criteria

2.2.1 Original Criteria under which the Site was Listed

Each site nominated under the Ramsar Convention must address some or all of the Ramsar nomination criteria established by the Convention. At the time of listing in 1982, the Corner Inlet Ramsar site was identified as meeting some of these criteria.

The 'original' nomination documentation indicated that the site met criteria 1(a), 1(b), 1(c), 2(b) and 3 of the 'recommended criteria to be used in identifying wetlands of international importance' (Victorian Ministry For Conservation 1980). The criteria at this time related to those adopted as part of the First Meeting of the Conference of Contracting Parties for the Ramsar Convention assembled in Cagliari, Sardinia (CoP 1 Criteria).

The relevant 'Cagliari' criteria met by the site were as follows:

- *1. A wetland should be considered internationally important if it:*
    - *(a) regularly supports either 10 000 ducks, geese and swans; or 10 000 coots; or 20 000 waders.* This criterion is broadly analogous of the present day criterion 5 (see Section 2.2.2).
    - *(b) regularly supports one per cent of the individuals in a population of one species or subspecies of waterfowl.* This criterion is broadly analogous of the present day criterion 6 (see Section 2.2.2).
    - *(c) regularly supports one per cent of the breeding pairs in a population of one species or subspecies of waterfowl.* This criterion does not have a direct analogue to present-day criterion.
- *2. A wetland should be considered internationally important if it:*
    - *(b) is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna.* This criterion is broadly analogous of the present day criterion 3 (see Section 2.2.2).
- *3. A wetland should be considered internationally important if it is a particularly good example of a specific type of wetland characteristic of its region.* This criterion is broadly analogous of the present day criterion 1 (see Section 2.2.2).

The documentation supporting the original listing (Victorian Ministry for Conservation 1980) outlines the following justification for criterion 1 (noting that no justification was provided to support criteria 2 (b) and 3):

Corner Inlet regularly supports an estimated 29 0000 waders (migratory and non-migratory) which represent 21.5 per cent of the total known Victorian wader population and include(s) the majority of Victoria's population of less abundant wader species. For the species grey plover, bar-tailed godwit, red knot and great knot, the Corner Inlet populations represent the largest in southern Australia (greater than one per cent of the "flyway or biogeographical region", according to the Royal Australasian Ornithologoists Union (RAOU)), while for the eastern curlew, Corner Inlet supports the largest populations yet discovered in Australia. It is estimated that 50 per cent of the overwintering migratory waders in Victoria occur in Corner Inlet.

The southern portion of Corner Inlet periodically supports up to approximately 2000 chestnut teal, estimated by the RAOU to be between 12 and 18 per cent of the Victorian population. Corner Inlet also supports breeding colonies of the fairy tern, crested tern and short-tailed shearwaters.

Since the time of listing, the Ramsar nomination criteria under the Convention have been modified (Table 2-3). As shown in Table 2-3, the 1999 Corner Inlet RIS (Casanelia 1999) indicated that the site met the following criteria relevant at that time (that is, based on the Ramsar Convention Criteria adopted at the 1996 Conference of Parties – CoP 6 criteria):

- criteria 1a, 1b and 1c, which are analogous to present day criterion 1
- criterion 2b, which is the equivalent of present day criterion 3
- criterion 2c, which is the equivalent of present day criterion 4
- criterion 3a, which is the equivalent of present day criterion 5
- criteria 3b and 3c, which are the equivalent of present day criterion 6.

2.2.2 Assessment Based on Current Information and Ramsar Criteria

Further changes were subsequently made to the Ramsar criteria since the 1999 RIS prepared by Casanelia (1999). As such, there is a need to re-assess the status of the site against the 'new' criteria for the site as part of the current study. The nomination criteria met by the site as outlined in the earlier RISs (Victorian Ministry for Conservation 1980, Casanelia 1999) have been reconsidered in this ECD, with specific reference to more up to date requirements outlined in "Handbook 14 Designating Ramsar Sites" (Ramsar Convention Secretariat 2007) and the National ECD Framework (DEWHA 2008), as well as consideration of more up to date data.

Based on the present study, the site is considered to meet six of the Ramsar nomination criteria (Table 2-3). In summary:

- Criteria 1, 4, 5 and 6 are considered to be met by the site, consistent with the 1980 and 1999 RISs (using analogous criteria)
- Criterion 2 is considered to be met by the site, which is not consistent with the 1980 and 1999 RISs
- Criterion 8 is considered to be met by the site, which is not consistent with Casanelia (1999) (noting that this criterion did not have an equivalent analogue in the 1980 RIS)
- Criterion 3 is not considered to be met by the site, which is not consistent with the 1980 and 1999 RISs (using analogous criteria).

The nomination criteria and accompanying statements of justification are discussed below.

Table 2-3 Comparison of Current and Pre-1999 Ramsar Nomination Criteria

Notes: no shading indicates nomination criterion met by the Ramsar site, grey shaded indicates criterion not met, green shading indicates that there was no equivalent criterion

Present study using existing (COP 9) criteria	Casanelia (1999) RIS using COP 7 criteria	Victorian Ministry for Conservation (1980) RIS using COP 1 criteria
Criterion 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)** it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region	**3.** it is a particularly good example of a specific type of wetland characteristic of its region.
	1(b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region	
	1(c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of an major river basin or coastal system, especially where it is located in a trans-border position	
	1(d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.	
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	**2(a)** it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species.	**2(a)** it supports an appreciable number of a rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species.
Criterion 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	**2(b)** it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna	**2(b)** it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna.
	2(d) it is of special value for one or more endemic plant or animal species or communities	**2(d)** it is of special value for one or more endemic plant or animal species or 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.	**2(c)** it is of special value as the habitat of plants or animals at a critical stage of their biological cycle.	**2(c)** it is of special value as the habitat of plants or animals at a critical stage of their biological cycles.
Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.	**3(a)** it regularly supports 20 000 waterfowl.	**1(a)** it regularly supports either 10 000 ducks, geese and swans; or 10 000 coots; or 20 000 waders.
Criterion 6: A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of waterbird.	**3(c)** where data on populations are available, it regularly supports one per cent of the individuals in a population of one species or subspecies of waterfowl.	**1(b)** it regularly supports one per cent of the individuals in a population of one species or subspecies of waterfowl.

Present study using existing (COP 9) criteria	**Casanelia (1999) RIS using COP 7 criteria**	**Victorian Ministry for Conservation (1980) RIS using COP 1 criteria**
	3(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity.	**1(c)** it regularly supports one per cent of the breeding pairs in a population of one species or subspecies of waterfowl.
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	**4(a)** it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	No equivalent criterion
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.	**4(b)** 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.	No equivalent criterion
Criterion 9: 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 wetland-dependent non-avian animal species.	No equivalent criterion	No equivalent criterion

Criterion 1 - Met

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.

Criterion 1 considers habitat types and their representativeness within a given biogeographic region (bioregion). Corner Inlet occurs within the following biogeographic regions:

- Marine (IMCRA v4.0) – South-east IMCRA Transition Bioregion. This bioregion extends just west of Corner Inlet to near Nowra in southern NSW
- Freshwater/Terrestrial (Basins) – South-east Coast Drainage Division. This drainage division extends from around the Queensland-NSW border to near the Murray River mouth in South Australia.

Corner Inlet is a substantially unmodified site that is considered to represent an example of a near-natural wetland. According to the Ramsar definition, near natural wetlands are those "which continue to function in what is considered an almost natural way". The definition includes clarification that the wetland is not required to be in pristine condition, only that it retains values of international importance. Activities occurring within Corner Inlet and the surrounding catchment (port activity, catchment run off, wastewater discharge and tourism) have potential to impact the condition of the inlet and do affect isolated areas of the site. However, these activities are small in scale, scope and area compared to the size of the inlet and do not prevent the inlet as a whole from continuing to function in an almost natural way. The 2001 National Land & Water Resources Audit (NLWRA 2001) classifies Corner Inlet as being in a "Largely Unmodified" condition (refer Appendix B).

The site has a complex range of estuarine habitats that are representative of those in the marine bioregion. Corner Inlet is considered a very good example of a wetland enclosed by barrier islands in the bioregion, and represents the second largest back barrier system in the IMCRA bioregion (NLWRA 2001). Corner Inlet also contains the most extensive intertidal flats and tidal sand banks in the bioregion (NLWRA 2001; refer Appendix B).

The sand barrier islands and tidal channel complex plays an important role in the natural functioning of this major coastal system. In particular, the sand islands protect the mainland coast from oceanic swells, which is a key determinant of the distribution and extent of wetland habitats within the site.

The site supports extensive *Posidonia* beds, which are among the largest in the IMCRA bioregion (West *et al*. 1985; Morgan 1986).

Based on the above, the site meets this criterion.

Criterion 2 - Met

A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

The original nomination documentation and Casanelia (1999) do not identify that the Corner Inlet Ramsar site meets this criterion. However, the current assessment proposes that the Ramsar site meets this criterion.

The Corner Inlet Management Plan notes that six nationally (EPBC Act) and/or globally (IUCN) endangered and vulnerable species[2] have previously been recorded within the Ramsar site: southern right whale (*Eubalaena australis* - EPBC endangered), leathery turtle (*Dermochelys coriacea* - EPBC vulnerable), swift parrot (*Lathamus discolor* - EPBC vulnerable) and orange-bellied parrot (*Neophema chrysogaster* - EPBC endangered)[3]. Plummer *et al.* (2003) notes that shy albatross (*Thalassarche cauta cauta* - EPBC vulnerable) has also been recorded at the site. A search of the EPBC protected matters online database, which is based on species geographic distribution mapping for listed species, identifies that several other threatened species could potentially also occur within the site (primarily marine pelagic seabirds and non-wetland dependent species).

The ECD Framework (DEWHA 2008) indicates that 'wetland' flora and fauna species should be considered. This has been interpreted here as 'wetland-dependent' species, and therefore does not include terrestrial species that are not reliant on aquatic/wetland habitats (see Appendix A).

Species known to occur within the site, that are internationally or nationally threatened and considered as wetland dependent species are as follows:

- orange-bellied parrot (*Neophema chrysogaster*). This species is listed as critically endangered under the EPBC Act and IUCN Red List (IUCN 2010). The current total wild population of orange-bellied parrots is unlikely to exceed 150 individuals (OBPRT 2006). Current data indicates that a significant proportion of the known orange-bellied parrot population congregates at three sites in Victoria (around Port Phillip Bay and the Bellarine Peninsula) (Birds Australia 2009b). In the Gippsland area, there have been rare records at Jack Smith Lake, fringes of Corner Inlet and several islands within Corner Inlet, Andersons Inlet, and from the Powlett River mouth (DEWHA 2009b; Birds Australia 2009b)

- growling grass frog (*Litoria raniformis*). This species is listed as vulnerable under the EPBC Act and endangered under the IUCN Red List (2010). The most recent record with the DSE database is 1995, with earlier records in 1977 and 1982 (DSE 2009)

- fairy tern (*Sterna nereis nereis*). This species is listed as vulnerable under the IUCN Red List (IUCN 2010). Nesting, feeding and roosting areas occur within the site, with key breeding areas including Clonmel, Boxbank and Dream Islands (refer Figure 1-2 and 1-3), and barrier islands in the Nooramunga area (Minton in Bell 1998; Ecos unpublished). The Birds Australia Atlas contains records of this species in 1977, 1979, 1980, 1981, 2000, 2001, 2003 and 2007

- Australian grayling (*Prototroctes maraena*). This species is listed as vulnerable under the EPBC Act and near threatened on the 2010 IUCN Red List (IUCN 2010). This species has been recorded in the freshwater streams that feed directly into the site (that is, Franklin, Agnes, Albert

[2] Note that numerous other flora and fauna are considered as threatened under state legislation. Consistent with Ramsar listing requirements, unless these species are also considered internationally or nationally threatened, they can not be considered under this criterion.

[3] Bog gum *Eucalyptus kitsoniana* occurs in the site, but is listed as Rare under the EPBC Act 1999, and therefore does not meet this criterion. Little tern *Sterna albifrons* (EPBC – Migratory and Marine) and hooded plover *Thinornis rubricollis* (EPBC – Marine) are not considered as threatened under the Act.

and Tarra Rivers – see Backhouse *et al*. 2008), and is almost certain to be present in the site (see Section 3.7 for detailed discussion).

Based on the above, the site meets this criterion.

Criterion 3 – Not Met

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.

The key elements underpinning this criterion are outlined in Section 70 of the *Ramsar Handbook for Wise Use of Wetlands 14* (Ramsar Convention Secretariat 2007), namely that sites meeting this criterion:

1. are "hotspots" of biological diversity and are evidently species-rich even though the number of species present may not be accurately known and/or
2. are centres of endemism or otherwise contain significant numbers of endemic species and/or
3. contain the range of biological diversity (including habitat types) occurring in a region and/or
4. contain a significant proportion of species adapted to special environmental conditions (such as temporary wetlands in semi-arid or arid areas) and/or
5. support particular elements of biological diversity that are rare or particularly characteristic of the biogeographic region.

Corner Inlet supports approximately 171 fish species, at least 24 species of migratory shorebirds, and more than 390 native flora species (DSE 2003; see Section 2.1.4). There is no evidence to suggest that the site represents a 'hot-spot' of biological diversity within the South-east IMCRA Transition bioregion, and unlike southern Tasmania, for example, the site is not located in a centre of local endemism. While the site does support high biodiversity values at more local scales (for example, within Victorian waters) and a wide diversity of wetland types (see Section 2.1.2), there is presently insufficient information to determine whether the site supports the range species or habitats occurring in the bioregion. The site does not support a large proportion of species adapted to special environmental conditions.

Casanelia (1999) suggests that this criterion was met on the basis that the site contains the most southerly occurrence of white mangrove (*Avicennia marina*) in the world. However, in the context of other areas in the South-east IMCRA Transition bioregion, the presence of this mangrove species is not considered unusual. This element is not considered to represent any of the key biodiversity elements outlined for criterion 3 in Ramsar Convention Secretariat (2007), and is therefore not considered to represent justification for inclusion of the site for this criterion.

Based on the above, the site does not support this criterion.

Criterion 4 – Met

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.

Based on *Ramsar Handbook for Wise Use of Wetlands 14* (Ramsar Convention Secretariat 2007), there are two components that need to be considered:

1. Section 74. Whether the site has high proportions of the population of mobile or migratory species gathered in small areas at particular stages of their life-cycle

2. Section 75. For non-migratory species, whether the site supports habitats for species that are unable to evade unfavourable climatic or other conditions (that is, the site contains critical refugia areas).

The Ramsar site meets the requirements of Section 74 in terms of its function as a habitat for migratory shorebirds at a critical life-stage. In this regard, the following are relevant:

- The site supports non-breeding habitats for 24 migratory shorebird species known to occur within the site (Martindale 1982; Ecos unpublished; DSE 2009; Birds Australia 2009a and c).

- The site supports in excess of 40 000 shorebirds at times, and counts of in excess of 20 000 shorebirds have been regularly recorded (Ecos unpublished; Birds Australia 2009c). During the austral winter, approximately 50 per cent of the over-wintering birds (predominately juveniles) remain whilst adults migrate to northern hemisphere breeding grounds (Martindale 1982 in Casanelia 1999; Clemens et al. 2007; Ecos unpublished).

The Ramsar site meets Section 75 requirements in terms of its function as a habitat for non-migratory species, in respect to provision of the following values:

- The site provides breeding habitat for a variety of waterbirds, including several species listed as threatened at the State level and/or occurring in significant numbers

- Habitat for significant aggregations of waterbirds during post-breeding, and as a refuge during adverse environmental conditions - black swan (*Cygnus atracus*), grey teal (*Anas gracilis*), and chestnut teal (*Anas castanea*). The western part of Corner Inlet, where areas of seagrass, mangroves and coastal saltmarsh provide habitat are likely to support highest values for these species (Norman 1982; Clemens et al. 2007; DSE 2003; Ecos unpublished).

Based on the above, the site meets this criterion.

<u>Criterion 5 - Met</u>

A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.

A wetland can be declared as internationally significant if it regularly supports 20 000 waterbirds. Based on *Ramsar Handbook for Wise Use of Wetlands 14* (Ramsar Convention Secretariat 2007), this criterion can apply to a total waterbird assemblage, or to individual species, but should not include non-native waterbirds.

With regards to shorebirds, annual counts have been undertaken since 1981 (Birds Australia 2009c). Consistently, counts between 1981 and 2003 indicate that the site has supported in excess of 40 000 shorebirds at times (Ecos unpublished; Birds Australia 2009c). Based on DSE count data, maximum annual migratory shorebird counts in the period 1986 to 1990 exceeded 20 0000 birds in all but one

of these years (range = 19 940 to 29 007), thereby meeting this criterion. Birds Australia (2009c) also recorded a maximum annual abundance of migratory species of 42 811 birds, with the mean annual abundance of migratory species being 31 487 birds (derived from 28 years of data collection from 1980 to 2008).

Non-shorebirds species that are present in notable (potentially significant) abundance include black swan (*Cygnus atracus*), grey teal (*Anas gracilis*) and chestnut teal (*Anas castanea*) (Norman 1982; Peter 1991; Ecos unpublished). Refer to Section 3.3.2 for further details.

Based on the above, the site meets this criterion.

Criterion 6 – Met

A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of waterbird.

Existing data demonstrates that the one per cent species population threshold has been regularly exceeded for a variety of waterbird species within the site (Minton 1997; Taylor and Minton 2006; Wetlands International 2006; Bamford et al. 2008; Ecos unpublished; Birds Australia 2009c), including:

- pied oystercatcher (*Haematopus ostralegus*): one per cent = 110 birds; regular counts averaging 893 birds (Ecos unpublished); maximum annual count exceeded one percent threshold in four of five years between 1988 to 1992 (DSE 2009)
- sooty oystercatcher (*Haematopus fuliginosus*): one per cent = 40 birds; regular counts averaging 285 birds (Ecos unpublished); maximum annual count exceeded one percent threshold in three of the five years between 1984 to 1988 (DSE 2009)
- Pacific gull (*Larus pacificus*): one per cent = 50 birds; counts of between 100 and 400 birds recorded (Ecos unpublished); maximum annual count exceeded one percent threshold in three of the five years between 1977 to 1981 (DSE 2009)
- fairy tern (*Sterna nereis nereis*): one per cent = 25 birds; counts of up to 82 birds recorded; maximum annual count exceeded one percent threshold in four of the five years between 1987 to 1991 (DSE 2009)
- red knot (*Calidris canutus*): one per cent = 2200 birds; counts between 1500 and 9000 birds recorded with an average of 2842 birds (Ecos unpublished); maximum annual count exceeded one percent threshold in three of the five years between 1987 to 1991 (DSE 2009)
- red-necked stint (*Calidris ruficollis*): one per cent = 3250 birds; regular counts averaging 13 765 birds (Ecos unpublished), maximum annual count exceeded one percent threshold in three of the five years between 1986 to 1990 (DSE 2009)
- chestnut teal (*Anas castanea*): one per cent = 1000 birds; counts exceeding this recorded on three occasions (Ecos unpublished); maximum annual count exceeded one percent threshold in all years between 1980 to 1992 (DSE 2009)

Data also indicates that additional species have been present in numbers exceeding the one per cent population threshold, though data deficiencies prevent confirmation that such species have “regularly” occurred on the site in such abundances so as to fulfil the criterion requirements. These species include the following (Wetlands International 2006; OBPRT 2006; Bamford et al. 2008; Ecos unpublished; BA 2009c):

- curlew sandpiper (*Calidris ferruginea*): one per cent = 1800 birds; regular average annual count = 2588 birds (Ecos unpublished), maximum annual count exceeded one per threshold in one of five years between 1988 to 1992 (DSE 2009)
- bar-tailed godwit (*Limosa lapponica*): one per cent = 3250 birds; regular counts averaging 9727 birds (Ecos unpublished); maximum annual count exceeded one percent threshold in two of the five years between1986 to 1990 (DSE 2009)
- eastern curlew (*Numenius madagascariensis*): one per cent = 1400 birds; regular counts averaging 1971 birds (Ecos unpublished); maximum annual count exceeded one percent threshold in one of the five years between1985 to 1989 (DSE 2009)
- double-banded plover (*Charadrius bicinctus*): one per cent = 500 birds; regular counts recorded between 500 and 950 birds (Ecos unpublished); maximum annual count exceeded one percent threshold in one of the five years between 1982 to 1986 (DSE 2009)
- black swan (*Cygnus atracus*): one per cent = 10 000 birds; maximum annual counts were at or greater than 10 0000 birds in two years (1977 and 1990) but below this value in all other years (DSE 2009).

Based on the above, the site meets this criterion. Refer to Section 3.3.2 for further details.

Criterion 7 – Not Met

A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

The *Ramsar Handbook for Wise Use of Wetlands 14* (Ramsar Convention Secretariat 2007) emphasises that the term diversity under this criterion can encompasses number of life-history stages, species interactions and complexity of fish-environmental interactions.

Corner Inlet contains an appreciable number of fish species, with approximately 171 fish species represented (Ecos unpublished). Furthermore, the site also supports a wide variety of life-history stages for many species (that is, eggs, larvae, recruitment sites, spawning sites). The fish assemblages of the site are comprised of species with different life-history characteristics, including potadromous (entirely freshwater) species, to catadromous (requiring marine and freshwaters to complete life-cycle) and fully marine species.

While the site provides habitat for a wide range of fish species that is undoubtedly important a local scale, there is insufficient data to assess the significance of this level of biodiversity at a provincial

bioregional scale. Until such time that biodiversity data become available for other estuaries in the bioregion, this part of the criterion can not be directly assessed.

Ramsar Handbook for Wise Use of Wetlands 14 (Ramsar Convention Secretariat 2007) also considers endemism as an important element of biodiversity. No fish species that are endemic to the Southeast IMCRA Transition bioregion are known to occur exclusively at the site.

In reference to the above key elements, it is assessed that there is insufficient data to determine the applicability of the criterion.

Criterion 8 – Met

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.

Corner Inlet provides important habitats, feeding areas, dispersal and migratory pathways, and spawning sites for numerous fish species of direct and indirect fisheries significance. These fish have important fisheries resource values both within and external to the site.

Section 70 of the *Ramsar Handbook for Wise Use of Wetlands 14* (Ramsar Convention Secretariat 2007) recognises two key elements under criterion 8:

1. Identification of shallow coastal wetland habitats that are important spawning, nursery and feeding grounds.

2. Identification of riverine, swamp and lake fish habitat that are important spawning and migratory pathways.

With respect to the first element, it is noted that the site supports numerous species of direct fisheries importance including King George whiting (*Sillaginodes punctatus*), blueweed whiting (*Haletta semifasciata*), Australian salmon (*Arripis* spp.), greenback flounder (*Rhombosolea tapirina*), southern garfish (*Hyporhamphus melanochir)*, yelloweye mullet (*Aldrichetta forsteri*), silver trevally (*Pseudocaranx dentex*), black bream (*Acanthopagrus butcheri*), sand flathead (*Platycephalus bassensis)*, dusky flathead (*Platycephalus fuscus*), rock flathead (*Leviprora laevigatus*), leatherjackets (several species), snook (*Sphyraena novaehollandiae*), short-finned eel (*Anguilla australis*) and gummy shark (*Mustelus antarcticus*). Notable shellfish species include calamari and arrow squid, whereas the sand crab fishery is highly variable and largely opportunistic (see Section 3.7.2).

All of the above species are either estuarine residents or depend on estuaries in some way during their life cycle. Many of the fish and crustacean species listed above spend their juvenile stages in shallow nearshore waters of the site, particularly around seagrass and intertidal habitats. These species also spawn in inshore waters, particularly near the surf zone and in sandy channels within the boundaries of the Ramsar site (see Section 3.7.2). The threatened Australian grayling (*Prototroctes maraena),* which has a marine juvenile life-history stage, would also use the site to complete its life-cycle (see Section 3.7.1).

Based on the above, the site meets this criterion. Note that Section 3.7.2 provides a more detailed account of fish habitat values of the site.

Criterion 9 – Not Met

A wetland should be considered internationally important if it regularly supports one per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Criterion 9 relates to non-avian wetland taxa including, *inter alia*, mammals, reptiles, amphibians, fish and aquatic macro-invertebrates.

In interpreting the application of criterion 9 to the Ramsar site, the *Ramsar Handbook for Wise Use of Wetlands 14* (Ramsar Convention Secretariat 2007) indicates that reliable population size limits from published sources must be included in the justification for the application of this criterion. While Corner Inlet may support more than one per cent of the individuals in a biogeographic population of several non-avian species, there is insufficient published data about populations across the biogeographic region to verify this (a stated requirement in the *Ramsar Handbook for Wise Use of Wetlands 14* (Ramsar Convention Secretariat 2007)). Additionally, investigation of survey data for key non-avian wetland species within Corner Inlet as part of the current study has shown such data is largely incomplete and forms an information gap.

On this basis, justification for inclusion of the site on the basis of criterion 9 has not been recommended at this time.

3 CRITICAL COMPONENTS, PROCESSES AND SERVICES/BENEFITS

3.1 Background

As wetlands are highly complex ecosystems, a complete inventory and assessment of the physical, chemical and biological components and processes for even the simplest of wetlands would be extensive and difficult to conceptualise. Of primary importance to wetland management is having an understanding of the key components that characterise the wetland and their initial state, and the basic rules that link the key components and cause changes in state.

A primary purpose of an ECD is to identify, describe and where possible, quantify the critical components, processes, benefits and services that together make up the ecological character of the site. These are the aspects of the wetland that if altered, would result in a change to the character of the wetland.

Figure 3-1 from the National ECD Framework document shows a generic conceptual model of the interaction between ecosystem components, processes and services/benefits for a wetland. In general terms, the model shows how wetland ecosystem processes interact with wetland components to generate a range of wetland services/benefits. These services/benefits can be broadly applicable to all wetlands ecosystems (such as primary productivity) or specific to a given site (for example, breeding habitat for an important avifauna species or population).

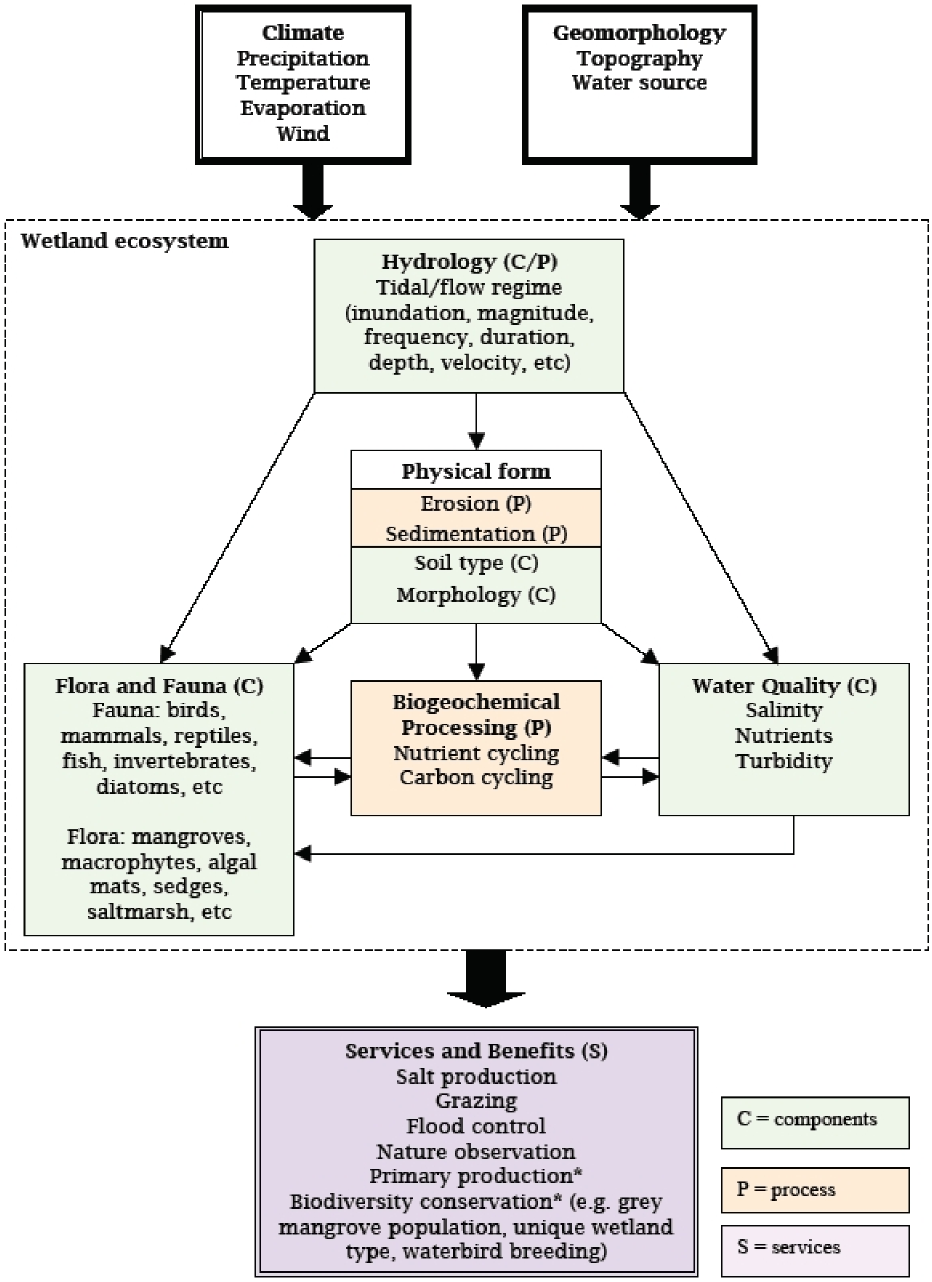
This section describes the critical components, processes and services/benefits that together make up the ecological character of the site. The method employed to identify critical components, processes and services/benefits is presented in Appendix A. Following the direction provided within the National ECD Framework (DEWHA 2008), the assignment of a given wetland component, process or service/benefit as critical was guided by the following considerations:

- the component, process or service/benefit is an important determinant of the unique character of the site, and/or
- the component, process or service/benefit is important for supporting one or more of the Ramsar Nomination Criteria under which the site was listed, and/or
- a change in a component, process or service/benefit is reasonably likely to occur over short or medium times scales (less than 100 years), and/or
- a change to the component, process or service/benefit will cause significant negative consequences.

Additionally, a second tier of ‘supporting’ components, processes and services/benefits have been identified. These ‘supporting’ components, processes and services/benefits, while important to wetland functioning, were in isolation not considered to directly address the criteria listed above.

For each of the critical components, processes and services/benefits (C, P, S/B), a brief description is provided for: (i) the rationale for inclusion as a critical; (ii) a description of the element and (iii) a description of patterns in variability over time. It should be noted that in nearly all cases, there was no actual baseline data-set describing the wetland indicator before or at the time of declaration of the site

in 1982. Therefore, in the following sections, both pre-listing and post-listing data have been used to describe patterns in variability in space or over time.



Note: Those marked with an * may be considered as components or processes as well as ecosystem services or benefits

Figure 3-1 Generic Conceptual Model Showing Interactions between Wetland Ecosystem Components, Processes and Services/Benefits (Source: DEWHA 2008)

3.2 Overview of Critical Components, Processes and Services/Benefits

A summary of the critical components, processes and services/benefits for the Corner Inlet Ramsar site as determined through the present study are shown in Table 3-1.

In summary, the following have been identified:

- two critical components and two supporting components
- one critical process and five supporting processes
- two critical services/benefits and two supporting services/benefits.

The justification for selection of each critical/supporting element and a more detailed discussion of each is described in Section 3.3 of this document.

The broad interaction of wetland services/benefits, processes and components at a whole-of-site level is shown in Figure 3-2. The figure shows that there are three broad processes identified (climate, geomorphology and regional-scale hydrodynamic and hydrological processes) that together have shaped the topography, marine and freshwater flow regime and other important aspects of the site. At the local habitat scale, there is a mix of physical and chemical processes as well as biological processes that control the wetland habitats and associated biota. The interaction of the wetland components with the wetland processes yields a range of wetland services/benefits (shown in the yellow box in Figure 3-2) that are characterised as supporting (ecosystem services) and cultural (relevant to providing a social or economic benefit to humans) using the terminology in the National ECD Framework.

Table 3-1 Summary of Critical Components, Processes and Services/Benefits

Critical Components	Critical Processes	Critical Services/Benefits
C1. Several key **wetland mega-habitat types** are present: • seagrass • intertidal sand or mud flats • mangroves • saltmarshes • permanent shallow marine water **C2.** Abundance and diversity of **waterbirds**	**P1. Waterbird breeding** is a key life history function in the context of maintaining the ecological character of the site, with important sites found on the sand barrier islands	**S1.** The site supports **nationally threatened fauna species** including: • orange-bellied parrot • growling grass frog • fairy tern • Australian grayling **S2.** The site supports **outstanding fish habitat values** that contribute to the health and sustainability of the bioregion
Supporting Components	**Supporting Processes**	**Supporting Services/Benefits**
Important **geomorphological features** that control habitat extent and types include: • sand barrier island and associated tidal delta system • the extensive tidal channel network • mudflats and sandflats. **Invertebrate megafauna** in seagrass beds and subtidal channels are important elements of biodiversity and control a range of ecosystem functions. The **diverse fish communities** underpin the biodiversity values of the site	**Climate**, particularly patterns in temperature and rainfall, control a range of physical processes and ecosystem functions Important **hydraulic and hydrological processes** that support the ecological character of the site includes**:** • Fluvial hydrology. Patterns of inundation and freshwater flows to wetland systems • Physical coastal processes. Hydrodynamic controls and marine inflows that affect habitats through tides, currents, wind, erosion and accretion. • Groundwater. For those wetlands influenced by groundwater interaction, the level of the groundwater table and groundwater quality. **Water quality** underpins aquatic ecosystem values within wetland habitats. The key water quality parameters for the site are salinity, turbidity, dissolved oxygen and nutrients Important **biological processes** include nutrient cycling and food webs.	The site supports **recreation and tourism values** (scenic values, boating, recreational fishing, camping, etc.) that have important flow-on economic effects for the region. The site provides a range of values important for **scientific research**, including a valuable reference site for future monitoring.

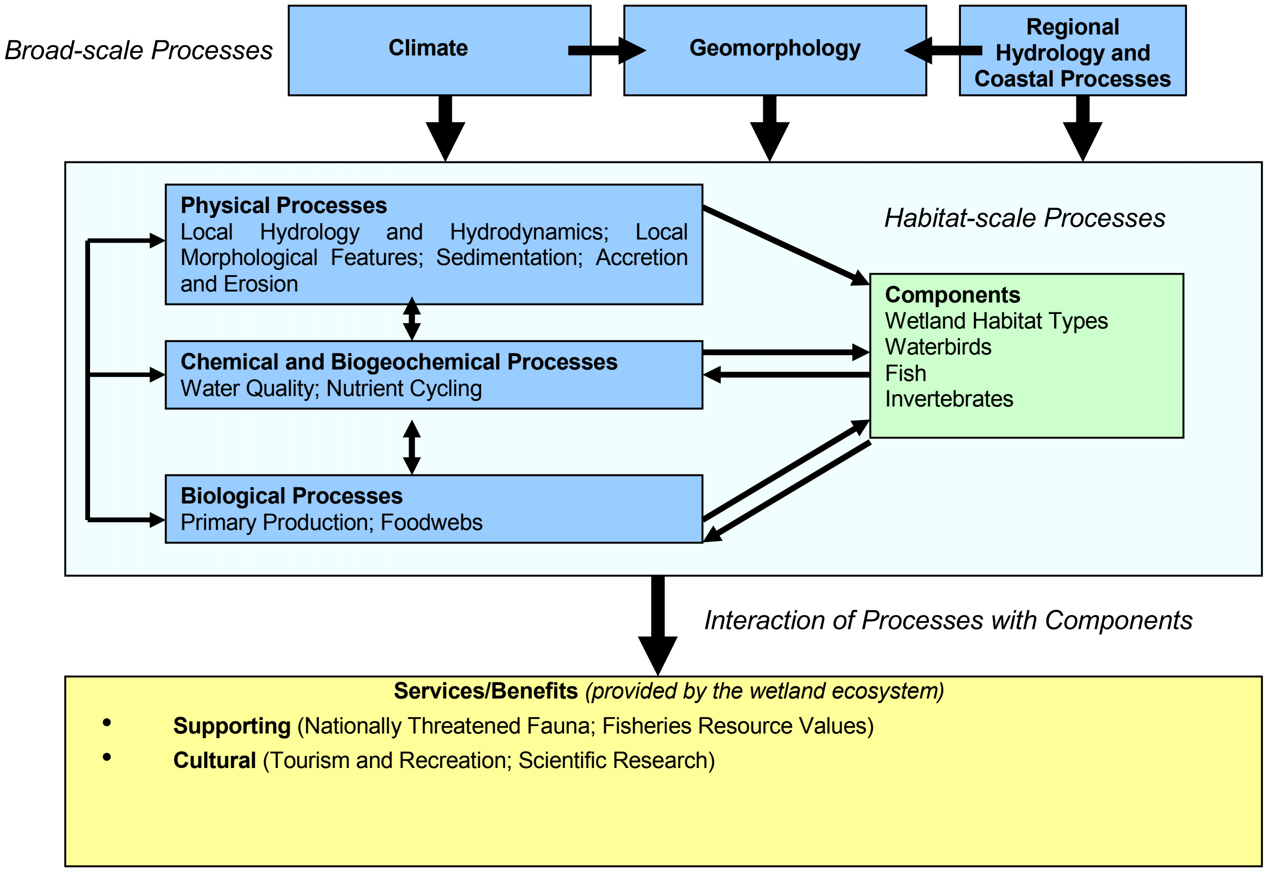


Figure 3-2 Conceptual Model Showing Interaction of Critical and Supporting Elements

3.3 Critical Components

As outlined in Section 2, a wide diversity of wetland types occurs within the site. These wetlands support a rich diversity of wildlife (from planktonic organisms to vertebrates), which together make up the ecosystem components of the wetland.

Critical ecosystem components are considered here to represent the critical habitats, key species and wildlife populations that underpin the critical services/benefits described in Section 3.7. Thus, they include broadly, the 13 confirmed natural wetland habitat types presented by the site as outlined in Section 2, the populations of wetland species of national/international conservation significance, and populations of those wildlife groups that underpin Ramsar listing namely, waterbirds and fish.

3.3.1 C1 - Marine and Estuarine Wetland Habitats

Reasons for Selection as 'Critical'

While the site supports a broad range of wetland habitat types, certain marine and estuarine habitats are considered to be particularly important in the context of maintaining fish, waterbird and other marine fauna assemblages. Furthermore, several of these wetland habitat types are considered to have high values in their own right, and are considered to be significant on a bioregional scale (see Criterion 1 – Section 2.2.2).

It is important to recognise that these habitat types do not represent discrete elements, but rather form a mosaic of habitat types that interact to maintain wetland functioning. Changes to functions in one habitat type are likely to have interactive and cumulative effects in other habitat types.

Description

As outlined in Section 2.1.2.2, the site supports a wide range of habitats, several of which are considered as critical components due to their roles in maintaining critical services discussed above. While all wetlands represent important components, the following are considered to be critical components in the context of the ecological character of the site including other critical components (fauna) and critical services/benefits:

Marine subtidal aquatic beds

Marine subtidal aquatic beds (analogous to Ramsar wetland type B) are characterised by seagrass meadows, although macroalgae (seaweed) also occurs through the site. Seagrass beds are considered critical components in the context of the following:

- *Posidonia* seagrass beds are the largest in the bioregion
- *Zostera* and *Heterozostera* beds are also significant in a bioregional context
- seagrass provides the basis of benthic food-webs at the site, particularly in the context of its role as a source of detritus for benthic invertebrates, and a source of epiphytic algae which represents a key food resource for commercially significant species (Nichols *et al*. 1985; Longmore 2007)
- seagrass, particularly *Posidonia* beds, provides important nursery habitat for stocks of fish and crustacean species of commercial and recreational fisheries value. Dense *Posodinia* and

Zostera-dominated seagrass beds represent structurally diverse habitats that provide important nursery habitat for luderick (Jenkins *et al*. 1997), flathead and snapper (Plummer et al. 2003). The larval stages of several commercial species, such as blue rock whiting (*Haletta semifasciata*), six-spine leatherjacket (*Meuschenia freycineti*) and rough leatherjacket (*Scobinichthys granulatus*), settle directly on deeper, subtidal *Heterozostera* beds (Jenkins *et al*. 1997)

- other species (such as flounder), while favouring 'unvegetated' habitats, also benefit from organic enrichment of sediments by seagrass debris, which can increase food production in 'unvegetated' habitats (Jenkins et al. 1993 cited in Jenkins et al. 1997)
- associated with the above, anecdotal reports by commercial fishers suggest that long-term fish catches in the site are determined by changes in seagrass extent. An apparent decline in *Posidonia* extent in 1974 reportedly resulted in a decline in fish catches, to such an extent that several fishers took up other business (Corner Inlet Fisheries Habitat Association 2009)
- seagrass provides regulatory services through stabilisation of coastal sediments
- seagrasses are responsible for a significant portion of critical processes that underpin the health of the site, for example, primary production, sediment stabilisation, nutrient, carbon and energy cycling.

Intertidal and shallow subtidal sand or mud flats

These environments are notable in their role in the provision of:

- habitat for microphytobenthos (benthic micro-algae), which is a key driver of foodwebs supporting commercially significant species (Nichols *et al*. 1985; Longmore 2007)
- habitat for macroinvertebrates, which provide prey resources for a range of fish and wader birds, as well as a key role in nutrient cycling in the estuary (see Section 3.6.4)
- protection of the shoreline from erosion.

Intertidal and fringing forested wetlands

This habitat type is characterised by mangroves, intertidal marshes (saltmarsh) and fringing teatree communities and freshwater marshes (dominated by *Melaleuca* and *Leptospermum*). These habitats form an important linkage between terrestrial and marine-based ecosystems. They are notable in the context of their role in the provision of habitat for juvenile fish and other marine organisms, as well as roosting sites for birds, and function in protecting the shoreline from erosion. Mangroves within the site are also of biogeographical importance, forming the most southern distribution of white mangroves in the world. Forest areas also provide important bird roost sites and feeding areas, as well as potential fisheries habitats.

Permanent shallow marine water

Like intertidal flats (without seagrass), microphytobenthos represent the dominant primary producers in this habitat type. There are no available data describing patterns in biomass of microphytobenthos over time and space (among depths, different sections of the site etc.). This habitat type is characterised by invertebrate activity (Ecos unpublished), which like tidal flats, provide important ecosystem functions in terms of nutrient cycling and maintenance of benthic foodwebs (see Section 3.6.4)

Patterns in Variability of Representative Wetland Types

Spatial and temporal variability in seagrasses

Patterns in 'natural' variability in the distribution and extent of seagrass meadows are reasonably well known from seagrass mapping studies (see Roob *et al*. 1998; Hindell et al. 2007).

Several studies describe seagrass extent prior to site listing (that is, pre 1982). Poore (1978) estimated that *Posidonia* meadows in 1965 had a total area of 11 900 hectares. Roob *et al*. (1998) mapped seagrass and reported on changes in seagrass beds in Corner Inlet from 1969 to 1998. Large-scale (1:20 000 to 1:25 000) historical aerial photographs were available for six sites (Duck Point, Doughboy Island, Barry Point, Snake Island, Port Albert and Manns Beach) but not all years analysed (1969, 1972, 1976, 1980, 1981, 1988, 1989, 1991 and 1998) were available for each site. There were notable data limitations (primarily related to image quality) which preclude a definitive assessment of seagrass changes, however it is apparent that:

- the key temporal pattern of seagrass change was one of continual fluctuations in the level of seagrass cover
- there was generally good coverage of seagrass in 1969, a decline in the 1970's, a period of regrowth and regeneration in the 1980's, and a return to good coverage in 1998
- however, patterns in temporal change (that is, increase or decrease) were not consistent across all sites, with distinct differences between Corner Inlet, the Snake Island area and the Nooramunga.

Note that Roob *et al*. (1998) provided only qualitative descriptions of historical seagrass changes, largely due to poor image quality of many of the aerial photographs (as well as absence of ground-truthing). For this reason, the only quantitative data available prior to Ramsar site listing is Poore's estimate as of 1965 (11 900 hectares), which is known to have changed since this time and is therefore not indicative of conditions at the time of listing. This represents a critical information gap.

Based on the most comprehensive available data available to date (Roob *et al*. 1998), 14 895 hectares of seagrass was mapped in 1998, with mono-specific *Posidonia* meadows having an area of approximately 3196 hectares, monospecific Zosteracea having an area of 10 999 hectares, and mixed *Posidonia/Zostera* and/or *Halophila* having a total area of approximately 696 hectares (Table 3-2). Roob *et al*.'s (1998) *Posidonia* cover estimate was therefore far lower than Poore's.

Table 3-2 Summary of Total Areas of Various Seagrass Communities Mapped at Corner Inlet and Nooramunga by Roob et al. (1998) (surveyed in 1998)

Seagrass species and density	Area (hectares)
Sparse *Zostera*	4179.3
Medium *Zostera*	1076.9
Dense *Zostera*	5743.0
Sparse *Posidonia*	109.3
Medium *Posidonia*	36.1
Dense *Posidonia*	3051.0
Sparse *Halophila*	5.1
Dense *Halophila*	15.9
Sparse Mixed *Zostera/Posidonia*	9.3562
Dense Mixed *Zostera/Posidonia*	173.0
Sparse Mixed *Zostera/Halophila*	455.4
Dense Mixed *Zostera/Halophila*	6.3
Sparse Mixed *Posidonia/Halophila*	30.3
Sparse Mixed *Zostera/Posidonia/Halophila*	1.2
Intertidal vegetation	3.7

Spatial extent of other habitat types

While there are some available data describing spatial patterns in the distribution and extent of mud flats, sand islands and mangroves, there is comparatively limited empirical data describing changes in these features at relevant (whole-of-site) spatial scales.

Figure 2-6 shows the present-day mapped extent of different vegetation communities (EVCs) within the site, which includes mangroves (2137 hectares) and saltmarsh (2613 hectares). These estimates are generally inconsistent with other mapping studies. For example, for mangroves, estimates include 1860 hectares (NLWRA 2001; see Table 3-3), 257 hectares (Australian Coastal Resource Atlas Online) and 3720 hectares (Bucher and Saenger 1989). All these studies were undertaken after Ramsar site declaration. For saltmarsh, NLWRA (2001) estimates that the area within Corner Inlet was 6550 hectares, which is far greater than the above EVC mapping estimates. It is likely that these differences were due to differences in mapping methodologies and study area extents.

NLWRA (2001) mapped the areas of mud flats, tidal sand banks and barrier/back barrier features in Corner Inlet (Table 3-3). Note that these data have limited spatial resolution and should therefore be considered as indicative only, and were also based on data collected well after Ramsar listing.

Table 3-3 Mapped Area of Different Habitat Features in Corner Inlet (Source: NLWRA 2001)

Feature	Area (hectares)
Barrier/Backbarrier	1071
Flood Ebb Delta	1081
Intertidal Flats	38 710
Mangrove	1859
Saltmarsh/Saltflat	6551
Tidal Sandbanks	689
Channel	16 349

Temporal patterns in extent of other habitat types

Denis (1994) provides estimates of temporal changes in mangroves at various stations in Corner Inlet between 1941 and 1987. The pattern of temporal change varied inconsistently among sites, with small changes noted at Millers Landing, losses recorded at Long Island, and increases recorded at Port Welshpool and Toora. Denis (1994) argued that most changes were associated with changes in climatic and coastal processes, as well as biological interactions with other vegetation types and existing mangroves. No studies have examined temporal changes in the extent of mangroves or saltmarsh at a whole of site scale, nor have any studies described changes in species composition in saltmarsh communities over time.

The sand barrier island system of Corner Inlet is known to be temporally dynamic, but no studies to date have quantified changes in distribution and extent over time. Similarly, there is little information describing changes in the extent of intertidal flats and shoals over time. These represent important information gaps in the context of this critical component.

3.3.2 C2 - Abundance and Diversity of Waterbirds

Reasons for Selection as 'Critical'

The importance of Corner Inlet as a site of national and international significance for migratory shorebirds has been widely described (Martindale 1982; Mansergh and Norris 1982; Watkins 1993; ANCA 1996; Bell 1998; Minton et al. 2002; DSE 2003; Clemens et al. 2007; and Bamford et al. 2008). The site is also significant for non-migratory shorebirds (Mansergh and Norris 1982; Watkins 1993; Minton 1997; Taylor and Minton 2006; Clemens et al. 2007; Ecos unpublished) and waterbirds generally (Norman 1982; Peter 1991; ANCA 1996; Bell 1998; Ecos unpublished). Selection of waterbirds as a critical component supports Ramsar nomination criteria 2, 4, 5 and 6.

Description

A total of 95 waterbird species have been recorded within the site (Martindale 1982; DSE 2009; Birds Australia 2009c; see Appendix C) which represents 93 per cent of the waterbird diversity recorded in Victoria (Barrett et al. 2003). The site's waterbird assemblage includes 24 migratory shorebird species, 13 resident shorebird species and 14 species of gulls and terns.

Migratory shorebirds species that are listed under international bilateral agreements, and are known to occur within the site, are shown in Table 3-4.

Table 3-4 Migratory Shorebirds within the Site that are Listed Under Bilateral Agreements

Scientific name	Common name	CAMBA	JAMBA	ROKAMBA
Actitis hypoleucos	common sandpiper	x	x	x
Ardea ibis	cattle egret	x	x	
Ardea modesta	eastern great egret	x	x	
Ardenna tenuirostris	short-tailed shearwater		x	x
Arenaria interpres	ruddy turnstone	x	x	x
Calidris acuminata	sharp-tailed sandpiper	x	x	x
Calidris alba	sanderling	x	x	
Calidris canutus	red knot	x	x	x
Calidris ferruginea	curlew sandpiper	x	x	x
Calidris melanotos	pectoral sandpiper		x	x
Calidris ruficollis	red-necked stint	x	x	x
Calidris tenuirostris	great knot	x	x	x
Charadrius leschenaultii	greater sand plover	x	x	x
Charadrius mongolus	lesser sand plover	x	x	x
Chlidonias leucopterus	white-winged black tern	x	x	x
Glarecola maldivarum	oriental pratincole	x	x	x
Gallinago hardwickii	Latham's snipe	x	x	x
Heteroscelus brevipes	grey-tailed tattler	x		x
Hydroprogne caspia	caspian tern	x	x	
Limosa lapponica	bar-tailed godwit	x	x	x
Limosa limosa	black-tailed godwit	x	x	x
Numenius madagascariensis	eastern curlew	x	x	x
Numenius phaeopus	whimbrel	x	x	x
Pluvialis fulva	Pacific golden plover	x	x	x
Pluvialis squatarola	grey plover	x	x	x
Sterna hirundo	common tern	x	x	x
Sternula albifrons	little tern	x	x	x
Sterna bengalensis	lesser crested tern	x		
Tringia glareola	wood sandpiper	x	x	x
Tringa nebularia	common greenshank	x	x	x
Tringa stagnatilis	marsh sandpiper	x	x	x
Xenus cinereus	terek sandpiper	x	x	x

Analyses of shorebird monitoring data by Clemens *et al*. (2007) indicate that the barrier islands (eastern part of the site) and the south-eastern sector of the site represent areas of high shorebird abundance. In addition, areas with the greatest diversity were similar to the areas with the greatest abundance, and south-eastern Corner Inlet has supported the most species (Clemens et al. 2007). Some areas such as Sandy Point (Figure 1-2) have relatively high abundance but low diversity, while other areas such as Camel Rocks reported relatively low abundance with high diversity (Clemens et al. 2007).

Species other than shorebirds also represent a large proportion of the overall waterbird assemblage (shorebirds and non-shorebirds). Non-shorebird species that are present in notable (potentially significant) abundance include black swan (*Cygnus atratus*), grey teal (*Anas gracilis*) and chestnut teal (*Anas castanea*) (Norman 1982; Peter 1991; Ecos unpublished; Norman and Chambers 2010).

Several factors contribute to the high abundances of shorebirds within the site, namely:

- the wide diversity of habitats in relatively close proximity
- the extensive areas of intertidal flats which represent the main feeding areas for shorebirds
- the relatively undisturbed nature of habitats
- low levels of human activity and associated disturbance.

Patterns in Variability

With some notable exceptions (see discussion on ducks below), data for waterbirds is not as comprehensive as that for migratory shorebirds, and is generally insufficient to confidently enumerate the size of that part of the waterbird assemblage. Notwitshading this, reviews of the available data indicate that both abundance and species richness of most non-migratory shorebirds have remained relatively stable in the long-term, but show great variability between years (Ecos unpublished, Norman and Chambers 2010).

Norman and Chambers (2010) analysed temporal patterns in the abundance of chestnut teal (*Anas castanea*), grey teal (*A. gracilis*), Pacific black duck (*A. superciliosa*) and Australian shelduck (*Tadorna tadornoides*) between 1977 and 2002 in western Corner Inlet. In summary they found:

- chestnut teal (mean count 753.6 ± 789.9 S.D., range 0 to 3201, n = 279) and grey teal (mean count 356.2 ± 464.9, range 0 to 2928, n = 928) were the most abundant duck species, and Pacific black duck (mean count 63.6 ± 128.8, range 0 to 1003) and Australian shelduck (mean count 3.4 ± 12.1, range 0 to 104) were the least abundant
- the two teal species and Pacific black duck were most numerous in summer and autumn, and shelduck reached peak abundance earlier
- Pacific black duck showed strong positive associations with stream flows, chestnut teal showed few correlations to flow and Australian shelduck showed no association with rainfall. Some lags between rainfall and duck abundance were noted, varying among species
- Long term temporal patterns in abundance appeared to be largely determined by breeding conditions elsewhere.

Approximately 25 percent of the waterbirds regularly occurring within the site are migratory shorebirds (24 species). These species utilise wetlands in the southern hemisphere during the austral summer, and while most return to the northern hemisphere in the austral winter, a small proportion may remain at the site. Populations of migratory species fluctuate over a range of time scales, subject to local factors and conditions external to the site (that is, conditions along migratory routes and/or breeding grounds).

For migratory shorebird species, there is insufficient data to establish a baseline at the time of listing, as most quantitative bird count data were collected after 1982. Therefore, in the context of

establishing a baseline to which LACs will apply, counts post listing were considered, particularly in the decade immediately after listing.

Figure 3-3 shows the maximum annual migratory shorebird counts and reporting rate (number of survey episodes and stations per year in which migratory shorebirds were reported) based on DSE Fauna Database Records for Corner Inlet (DSE 2009). The figure shows that for the period between 1986 and 1992, the maximum annual migratory shorebird count was typically (but not always) greater than 20 000 birds. Post–1995, the reported annual maximum migratory shorebird count was very low. The annual reporting rate was highly variable and did not show any consistent trends over time.

Table 3-5 shows the mean annual count for selected key waterbird species that have maximum annual counts that exceed the one per cent of the individuals within a population. Key trends are summarised for each species with the table. Refer also to Appendix D and Nomination Criteria 5 and 6 for discussion regarding trends in waterbird abundance over time. These data provide a reasonable baseline for developing limits of acceptable change (see Section 4).

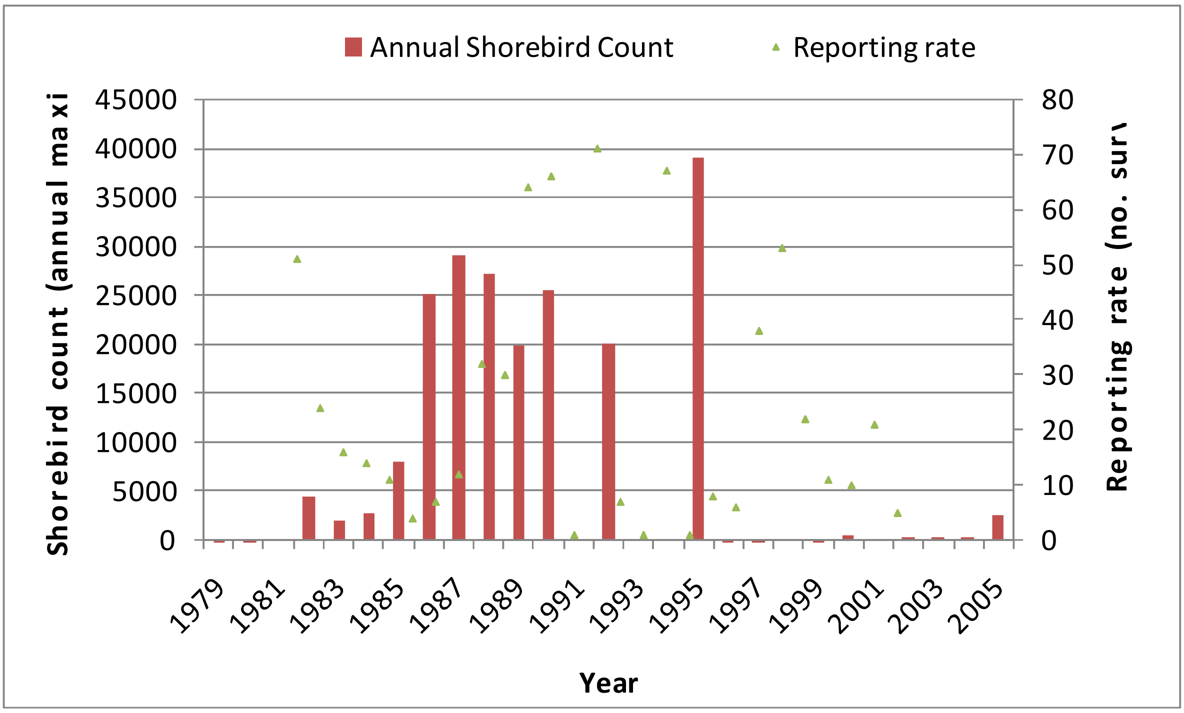


Figure 3-3 Maximum Annual Shorebird Counts and Reporting Rate (number of survey episodes and stations per year) based on DSE Fauna Database Records for Corner Inlet (DSE 2009)

Table 3-5 Patterns in Abundant Waterbird Species at Corner Inlet

Species	One per cent threshold	Average annual count
curlew sandpiper (*Calidris ferruginea*)	The current flyway one per cent threshold is 1800 birds (Bamford et al. 2008) This threshold has been exceeded regularly since 1982 (Ecos unpublished; Birds Australia 2009c). This species has been recorded in numbers equivalent to 2.2 per cent of current flyway population estimates (Ecos unpublished).	Long term mean annual count = 2588 birds (Birds Australia 2009c) 1987 to 1990, 1992 mean maximum annual bird count (DSE unpublished) = 886 ± 374.9 S.E. (DSE 2009)
bar tailed godwit (*Limosa lapponica*)	The current flyway one per cent threshold is 3250 (Bamford et al. 2008). This threshold has been exceeded regularly since 1982 (Ecos unpublished; Birds Australia 2009c), and on occasions, in numbers equivalent to 5.5 per cent of current flyway population estimates (Ecos unpublished).	Long term mean annual count = 9727 birds (Birds Australia 2009c) 1987 to 1992 mean maximum annual bird count (DSE unpublished) = 3694 ± 1678.5 S.E. (DSE 2009)
eastern curlew (*Numenius madagascariensis*)	The current flyway one per cent threshold is 400 (Bamford et al. 2008). This threshold has been exceeded regularly since 1982 (Ecos unpublished; Birds Australia 2009c), and on occasions, in numbers equivalent to 3.3 per cent of current flyway population estimates (Ecos unpublished).	Long term mean annual count = 1971 birds (Birds Australia 2009c) 1987 to 1990, 1992 mean maximum annual bird count (DSE unpublished) = 519 ± 126.6 S.E. (DSE 2009)
pied oystercatcher (*Haematopus ostralegus*)	The current flyway one per cent threshold is 110 (Wetlands International 2006). This threshold has been exceeded regularly since 1982 (data from Minton 1997; Taylor and Minton 2006; Birds Australia 2009c), and on occasions, in numbers equivalent to approximately eight per cent of current flyway population estimates (Ecos unpublished).	Long term mean annual count = 893 birds (Birds Australia 2009c) 1987 to 1990, 1992 mean maximum annual bird count (DSE unpublished) = 370 ± 130.3 S.E. (DSE 2009) Minton (1997) considers that the site may well support the largest breeding concentration in Australia (also supported by data in Taylor and Minton 2006). However, Taylor and Minton (2006) also suggest that predation by foxes may adversely affect breeding success of pied oyster catchers (see Section 5.1.10)
sooty oystercatcher (*Haematopus fuliginosus*)	The current flyway one per cent threshold for *Haematopus fuliginosus fuliginosus* (of southern	Long term mean annual count = 285 birds (Birds Australia 2009c)

Species	One per cent threshold	Average annual count
	Australia) is 40 (Wetlands International 2006). This threshold has been exceeded regularly since 1982 (Ecos unpublished; Birds Australia 2009c), and on occasions, in numbers equivalent to 4.3 per cent of current flyway population estimates (Ecos unpublished).	1987 to 1990, 1992 mean maximum annual bird count (DSE unpublished) = 31 ± 5.2 S.E. (DSE 2009)
double-banded plover (*Charadrius bicinctus*)	The current flyway one per cent threshold is 500 (Bamford et al. 2008). This threshold has been exceeded regularly since 1982 (see data in Birds Australia 2009c).	Long term mean annual count = 523 birds (Birds Australia 2009c) 1987 to 1990, 1992 mean maximum annual bird count (DSE unpublished) = 518 ± 126.6 S.E. (DSE 2009) Ecos (unpublished) data analysis indicates that numbers fluctuate between about 500 to 950 birds
fairy tern (*Sterna nereis nereis*)	The one per cent population threshold for *Sterna nereis nereis* (of south-eastern Australia) is 25 birds (Wetlands International 2006). This threshold has been exceeded regularly since 1982 (Ecos unpublished), and on occasions, in numbers equivalent to 3.3 per cent of current flyway population estimates (Ecos unpublished).	Insufficient data to determine trends and average number
Pacific gull (*Larus Pacificus*)	The one per cent population threshold for *Larus Pacificus Pacificus* (of Tasmania and Victoria) is 50 birds (Wetlands International 2006). This threshold has been exceeded regularly since 1982 (Ecos unpublished), and on occasions, in numbers equivalent to eight per cent of current flyway population estimates (Ecos unpublished).	Ecos (unpublished) notes that numbers have increased with counts of about 100 in 1982, to almost 400 in 1994, and having remained relatively constant since Long term average abundance (1965 to 2005) = 7 birds ± 2 S.E. (DSE 2009). For the period 1977 to 1979, maximum annual bird counts were 60, 100, 70 birds, and similar high variability recorded in 2003 to 2005 (172, 20, 23 birds)

3.4 Supporting Components

The supporting components outlined below are considered to be important or noteworthy in the context of maintaining the character of the site, but are not considered to represent a critical component in the context of the considerations outlined in Section 3.1 of this report.

3.4.1 Geomorphological Features

Reasons for Selection

Geomorphological features are important determinants of the configuration, extent and structure of both unvegetated (that is, tidal flats, sandy beaches etc.) and vegetated habitats within the site. Furthermore, the site supports a range of nationally significant geomorphological features that are considered important from a geological perspective.

Description

Geomorphological Setting

The catchment area of Corner Inlet Ramsar site is 2100 square kilometres and the water body compromising Corner Inlet has an area of approximately 600 square kilometres (CSIRO 2005). Corner Inlet is bound to the west and north by the South Gippsland coastline, in the south-east by a series of barrier islands and sandy spits lying end to end and separated by narrow entrances, and to the south by the hills of Wilsons Promontory (Casanelia 1999). The western half of Corner Inlet is a large open basin approximately 25 kilometres in diameter, which has a two kilometre opening between Wilsons Promontory and Snake Island. The eastern half of the site is located almost entirely within Nooramunga Marine and Coastal Park, and is comprised of numerous low lying islands and the outer barrier islands. There are five permanent entrances, which allow exchange of water with Bass Strait (CSIRO 2005).

Corner Inlet is a large submerged plain covered by subtidal and intertidal sand and mud flats, which are intersected by a network of radiating channels. Water depth in the channels is three to 10 metres deep in the northern and western areas of the site, and up to 40 metres deep near the centre and entrance of the site (Plummer et al. 2003; CSIRO 2005; Ecos unpublished). Flow velocities in the channels of Corner Inlet are quite high (greater than one metre per second), facilitating a large exchange of water, yet most of the area is shallow and drains and fills slowly.

A group of low, predominantly sandy islands that are an extension of the Ninety Mile Beach and Gippsland Lakes region occurs east of Corner Inlet between Barry Beach and McLoughlins Beach (DPI 2007b). There are five major islands (Snake, Little Snake, Sunday, Saint Margaret and Clonmel Islands) and over 20 smaller islands, which are comprised of late Pleistocene and Holocene marine sediments (DPI 2007b). Shorelines and tidal flats that border the islands are typically sandy, with the ocean beaches consisting of medium to coarse sand and shells, while finer sands and occasionally mud are the dominant materials of the intertidal areas (Ecos unpublished).

Sites of Geological and Geomorphological Significance

Sites of geological and/or geomorphological significance within Corner Inlet Ramsar site were mapped by the Victorian DPI (2007a, b and c) and described in the 1999 RIS (Casanelia 1999),

based on information in Rosengren et al. (1981) and Rosengren (1984; 1989). The dates of the original assessments by Rosengren and others suggest that the descriptions apply to the condition of the sites at the time of Ramsar listing in 1982.

Corner Inlet lacks sites of National Significance, but has numerous sites of State, Regional and Local Significance. At Nooramunga, two outer islands and the tidal entrances and tidal deltas have been assigned National Significance, and there are a number of sites of State, Regional and Local Significance. Significant sites at a national scale include (see Figure 1-2 and 1-3; Rosengren 1984; 1989):

- Snake Island
- Clonmel Island
- Shallow Inlet to Reeves Beach (Outer Barrier)
- Port Albert Entrance – Outer Barrier
- Kate Kearney Entrance – Tidal Entrances and Tidal Delta
- Shallow Inlet - Tidal Entrances and Tidal Delta
- New Entrance - Tidal Entrances and Tidal Delta.

Casanelia (1999) suggests that the chain of barrier islands are a westward extension of the Ninety Mile Beach and are of complex form and origin, providing an outstanding example of the processes involved in barrier island formation including the development of multiple beach ridges, lagoons and swamps, tidal creeks, tidal deltas, and tidal washovers. As well as providing localities for the monitoring of sediment dynamics associated with marine and aeolian processes, Ecos (unpublished) suggested that they are of critical importance in the analysis of the evolution of the entire coastal barrier system between Wilsons Promontory and Lakes Entrance (Casanelia 1999).

In the context of maintaining the ecological character of the site, the most important morphological features of the site are considered to be:

- The extensive sand barrier island and associated tidal delta system located on the eastern side of the site. The sand barrier island system partially encloses the site, and protects the site from wave attack due to oceanic swells and seas. This has allowed the development of the extensive network of shoals and channels, which provide habitat for a range of marine/estuarine flora and fauna, as well as shorebirds
- The extensive tidal channel network, which allows very high tidal exchange rates and tidal mixing within the site. The high rates of flushing are a key determinant of the physio-chemical properties of waters and sediments within the site, and the maintenance of relatively good water quality conditions
- Mudflats and sandflats (refer to critical components section for further information).

3.4.2 Invertebrate Megafauna

Reasons for Selection

Invertebrate megafauna are the large, conspicuous species commonly found in seagrass beds, mudflats and sandflats. These species all contribute to the maintenance of foodchains and

ecosystem functions that underpin the general biodiversity values of the site (underpinning services 1 and 2).

Description

The site supports diverse and abundant invertebrate megafauna assemblages. Surveys by O'Hara *et al*. (2002) noted that seagrass meadows of Corner Inlet effectively support a single benthic community. Representative species include:

- seastars (*Parvulatra exigua* and *Meridiastra calcar*), which are important detritivores that feed on plant and animal debris. Less common are the large eleven-armed seastar (*Coscinasterias muricata*) which preys on molluscs and the seven-armed Southern sand star (*Luidia australiae)*
- turban shells (*Thalotia conica* and *Astralium aureum*), which feed on epiphytes that grow on seagrass, and therefore are important in the maintenance of seagrass health
- crabs, including red swimmer crab (*Nectocarcinus integrifrons*) and the long-limbed decorator crab (*Naxia aurita*).

The deep channels that drain the seagrass beds support a different invertebrate megafauna community (O'Hara *et al*. 2002). Conspicuous species include:

- planktivorous brittle-star species (*Amphiura elandiformis* and *Ophiocentrus pilosa*), which form extensive colonies along the edge of the channels
- sponges and sea-squirt colonies form 'mini-reefs' at the base of channels (five to 20 metres depth). The sea-squirt *Pyura stolonifera* is a common species which can attach itself to dead oyster shells, and then form micro-habitats for other sedentary species such as sponges (*Dendrilla rosea*), encrusting ascidians, soft-corals, fragile lace-corals, large orange anemones, some red seaweeds and various hydroids, as well as a range of mobile species such as brittle stars, sea cucumbers and seastars.

3.4.3 Fish Species Richness

Reasons for Selection

This supporting component underpins Critical Service 2. Furthermore, fish communities also represent an important driver in maintaining foodwebs within Corner Inlet (see Section 3.6.4), and represent important biodiversity components in their own right.

Description

Approximately 171 fish species have been recorded at the site to date (Ecos unpublished). This represents a high proportion (just under a third) of the total number of marine fish species known to occur in southern temperate waters, although as discussed in Section 2.2.2 (Criterion 7), there is insufficient information to determine the level of diversity relative to other estuaries and embayments in the bioregion.

The high diversity of fish assemblages reflects in part the wide diversity and interconnectivity of habitats present (fresh to marine-estuarine waters) and the large size of the site. Furthermore, the key processes that ultimately control the diversity of habitats (as outlined in Section 3.3) are also likely to maintain fish biodiversity values.

As outlined in Ecos (unpublished), it is thought that marine ‘stragglers” (occasional visitors to the site) currently comprise just under half the total number of species previously recorded in the site, whereas estuarine – marine opportunists make up approximately one-third of the total number of species within the site.

There are no available data describing natural variability in fish species richness at smaller spatial scales, for example, within and among habitat types; stations within habitat types. The only long-term data describing fish assemblages within the site is commercial fish catch data (that is, catch per unit effort for selected species). These data are not suitable for assessing patterns in species richness. Systematic monitoring would be required to assess patterns in natural variability.

Fish populations within the site contribute to its ecological character but have been addressed as a critical service/benefit (refer Critical Service 2; see Section 3.7.2), focussing on those species and groups that are of commercial and recreational value. Overall, there are significant knowledge and information gaps about broader fish species abundance, distribution and diversity across the site.

3.5 Critical Processes

3.5.1 P1 - Waterbird Breeding

Reasons for Selection as ‘Critical’

Underpinning the abundance of waterbirds at Corner Inlet (see Critical Component 2; Section 3.3.2), the site supports habitat and conditions that are important to maintaining critical life cycle stages of a variety of wetland-dependent waterbird species (for example, breeding, overwintering, moulting), such that if interrupted or prevented from occurring, may threaten long-term conservation of those species. Of these life cycle functions, breeding is considered to be the most prominent and therefore critical.

Breeding is a critical life stage of species (as reflected in Criterion 4) that is essential in order to ensure the long-term persistence of waterbird populations.

Description and Patterns in Variability

Site values with respect to waterbird breeding habitat include the following (refer to Figure 1-2 and 1-3 for map of the locations outlined below):

- pied oystercatcher (*Haematopus longirostris*) - over 400 pairs comprising 402 pairs within Nooramunga Marine and Coastal Park (mainly islands, especially Sunday Island) and 44 pairs within Corner Inlet Marine and Coastal Park (mainly mainland coast) (Taylor and Minton 2006); 250 pairs recorded in 1996 considered an underestimate (Minton 1997). Considered to be a breeding (and non-breeding) site of national importance for this species (Taylor and Minton 2006)
- fairy tern (*Sterna nereis nereis*) - Clonmel Island (30 pairs); Boxbank Island (20 pairs); and Dream Island (up to 70 pairs) (Minton in Bell 1998; Ecos unpublished). Barrier islands in the Nooramunga area regularly supports 20 to 40 pairs of Fairy Tern, which is estimated to be 10 to 20 per cent of Victorian breeding population (Ecos unpublished)
- hooded plover (*Thinornis rubricollis*) - up to 20 pairs at sites including Dream Island, Box Bank, Clonmel and Snake Islands (C. Minton in Bell 1998; Ecos unpublished). A review by Clemens *et*

al. (2007) suggests that most of the ocean sandy beaches in the region offer good habitat that has been used for breeding by the hooded plover

- Caspian tern (*Sterna caspia*) - up to 55 pairs, one of the largest breeding colonies in Australia (Ecos unpublished), with up to 90 pairs at/on Clonmel Island at port Albert Entrance in late 1990s (Minton in Bell 1998; Ecos unpublished)
- crested tern (*Sterna bergii*) - approximately 400 pairs at McLoughlins Entrance and Dream Island in early 1990's with most breeding effort centred on Clonmel Island at Port Albert Entrance in late 1990s (Minton in Bell 1998; Ecos unpublished).

In terms of temporal patterns, the key breeding times of each species are well understood, however few studies have sought to examine temporal patterns and trends in waterbird breeding success within the site. This represents a key gap in the context of this critical process.

3.6 Supporting Processes

A broad range of ecosystem processes are occurring within Corner Inlet. Those ecosystem processes that are considered to most strongly influence the ecological character of the site have been described below.

Not all ecosystem processes will be relevant across all waterbodies/wetlands of the site, noting the diversity of habitat types and the natural variability of the site to key parameters such as freshwater flows, salinity and nutrient enrichment. Ecosystem processes can also be highly interlinked, for example, the relationship between increased rainfall, hydrological processes and the resultant runoff affecting water quality.

The following sections identify critical processes underpinning critical services/benefits within the site.

3.6.1 Regional Climate Patterns and Processes

Reasons for Selection

Key climatic processes that underpin the wetland values of the Corner Inlet Ramsar site include temperature, rainfall, and evaporation. These climatic processes influence the volume, timing and duration of water flows into the site from the major tributaries as well as water levels and inundation regimes within wetland environments.

Description

Based on Bureau of Meteorology data for Wilsons Promontory Lighthouse (1872 to 2009), the average maximum air temperature in summer is approximately 20 degrees Celsius and the minimum is approximately 14 degrees Celsius. The average maximum temperature in winter is approximately 12 degrees Celsius and the minimum average is approximately eight degrees Celsius (BOM 2009).

Rainfall in the Corner Inlet catchment varies slightly from east to west but significantly north to south. This is due to the presence of the Strzelecki and Hoddle Ranges to the north of the inlet, with much higher rainfalls occurring along the ranges (Ecos unpublished). Rainfall at Wilsons Promontory Lighthouse (Figure 3-4) varies between 46 and 122 millimetres per month (approximately 1049 millimetres annually), but higher average annual rainfalls occur along the mountain ranges situated north of the site (Wonyip station = 1250 millimetres annually). Set against the average annual rainfall, the observed daily rainfall across the catchment can be highly variable in response to weather patterns (southwest fronts, east coast lows) and the resulting stream hydrology is also highly variable (Ecos unpublished). It is expected that climate change will result in an increase in extreme events and altered rainfall and temperature patterns (see Section 5.1.8).

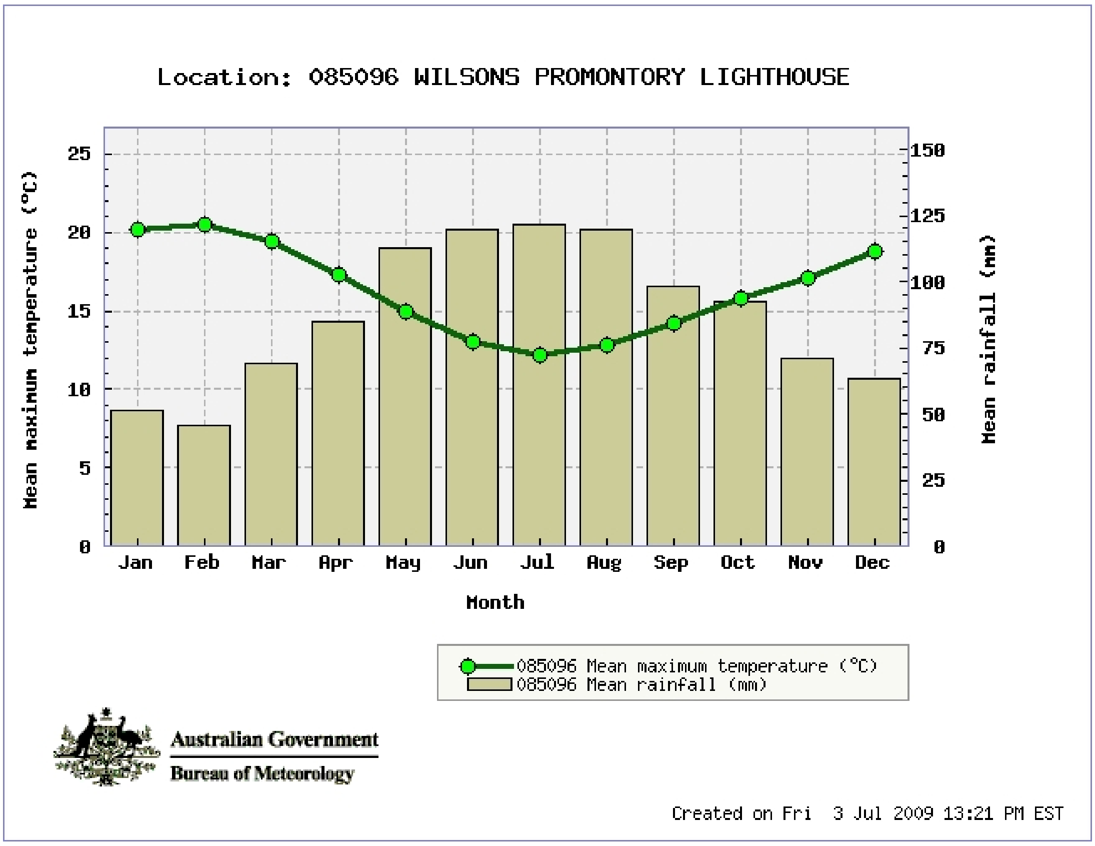


Figure 3-4 Mean Maximum Temperature and Mean Rainfall at Wilsons Promontory Lighthouse between 1872 and 2009 (source: BOM 2009)

As climate changes, the climate of Victoria is expected to become warmer, water availability will reduce and extreme storm events are likely to increase in frequency (State of Victoria 2008). In terms of water inflows and wetlands, a significant implication of climate change will be that while there will continue to be large flow events, the frequency of flooding, flows and duration of inundation is likely to

reduce. Further discussion about potential threats to the Ramsar site from climate change are discussed in Section 5.1.8 of this report.

3.6.2 Hydrodynamic Regime

Reasons for Selection

The Corner Inlet Ramsar site's hydrological regime can be separated into:

- surface freshwater inflows (fluvial hydrology)
- marine in-flows (coastal hydrodynamic processes)
- groundwater inflows and influences.

Each of these aspects of the hydrological regime are considered to be supporting processes that affect the ecological character of the site through their effect on water levels, inundation of soils and the distribution and condition of wetland vegetation communities and the wetland fauna that inhabit them.

Description

Fluvial Hydrology

The catchment to water ratio for Corner Inlet is approximately 4:1 with a catchment area of 2100 square kilometres and the Inlet area of about 600 square kilometres. This is comparable to Port Phillip Bay and Western Port (5:1) but much smaller than that of the Gippsland Lakes, which have a ratio of 50:1 (CSIRO 2005). The largest streams entering Corner Inlet are the Franklin, Agnes, Albert, Jack and Tarra Rivers, as well as Bruthen Creek (Figure 3-6).

Due to the relative shortness of these river systems and the small catchments they drain, significant rain events create large flows with higher concentrations of contaminants than during normal dry weather flows (CSIRO 2005). However, daily rainfall can be highly variable across the Corner Inlet catchment and the resulting stream flows are therefore also highly variable (WGCMA 2007). Generally, significant seasonal trends can be observed with higher flows during winter-spring (August to September) and lower flows in summer, but highly variable inter-annual flow is also apparent (WGCMA 2007).

Occurrence of high flow events is infrequent (Figure 3-5) and flows generally revert to their normal dry weather flow within a week. Furthermore, analysis of streamflow occurrence frequencies for several rivers discharging into Corner Inlet showed that flows can range between three to six orders of magnitude (one to 99 percentile flow). However, flows vary only within one order of magnitude for most of the time (15 to 85 percentile flow) indicating that rivers flow consistently for most of the time but may exhibit short events of very small or large flows (WGCMA 2007).

High flow events may lead to a complete flushing of the estuarine reaches of the rivers and make them completely fresh, although these events occur only for short periods (days). The resulting introduction of large volumes of sediment and nutrients may play an important role as lifecycle triggers for various species, for example, by facilitating fish migration by a flood that acts as a breeding trigger (Ecos unpublished).

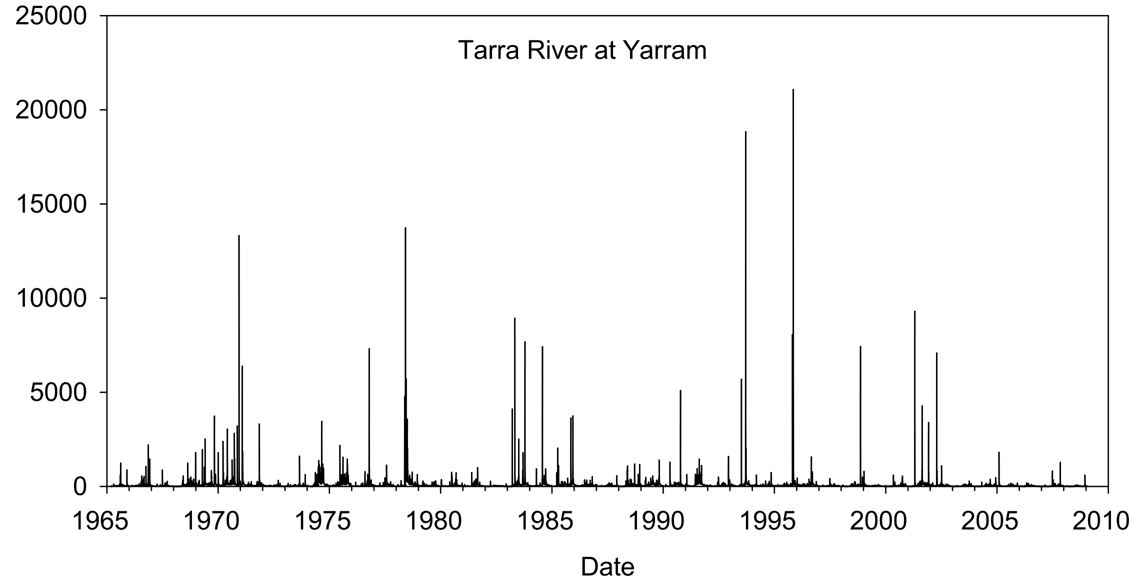


Figure 3-5 Average Daily Flow (Calculated) for Tarra River at Yarram from 1965 to 2009. Data Sourced from Victorian Water Resources Data Warehouse

Coastal Hydrodynamic Processes

A significant proportion of the Corner Inlet Ramsar area (approximately 630 square kilometres) comprises water and intertidal flats (540 square kilometres) with the remainder being barrier islands and fringing wetlands. Five permanent entrances allow exchange of water with Bass Strait (CSIRO 2005).

The extensive intertidal area within Corner Inlet (approximately 390 square kilometres) is dissected by a network of channels that drain and fill from the entrance in the east. The three main channels include the Franklin, Middle and Bennison channels, which are three to 10 metres deep and become shallower towards the western and northern areas of the Inlet. The main entrance channel is approximately 40 metres deep.

According to NLWRA (2001), Corner Inlet is a tide dominated estuary. Tides at Port Welshpool are classed as mixed with two high tides per day with a pronounced inequality between them (CSIRO 2005). Maximum tidal range can reach up to 2.5 metres during the equinoxes, while average daily tidal range is about 2.0 m (CSIRO 2005). Tidal variations are complicated by changes in wind speed and direction, high and low pressure systems, wave action and storm surges, which may lead to large variations in the width of the intertidal zone (Parks Victoria 2005).

While numerical modelling indicates that tidal currents can exceed 1.2 metres per second in the channels, tidal velocities on the tidal flats are generally quite low with less than 0.25 metres per second (WGCMA 2007). Tidal information for Corner Inlet indicates a slight amplification of the tidal signature as it propagates from Bass Strait into Corner Inlet. While the tidal range in Bass Strait is about 1.8 metres, the tidal range amplifies within Corner Inlet to about 2.0 metres, corresponding to approximately 10 per cent increase in tidal range (WGCMA 2007).

Based on modelling assessments by WGCMA (2007), it is predicted that more than 40 per cent of Corner Inlet is exposed during a typical low spring tide (–1.0 metres AHD at Port Welshpool),

corresponding to an area of approximately 220 square kilometres. However, owing to the relatively flat slope of the intertidal flats and due to frictional effects, there is insufficient time for the water to drain completely off the tidal flats prior to the next incoming tide. This means that not all of the tidal flats are exposed during low tide.

The reasonably large tidal range in Bass Strait and the extensive shallow areas in Corner Inlet mean that more than 60 per cent of the inlet volume is exchanged over an average tidal cycle (WGCMA 2007). While the majority of the water within the system is likely to be exchanged within only a few tidal cycles within Corner Inlet, the extensive network of channels and islands in Nooramunga leads to longer residence times of approximately one week (WGCMA 2007). Accordingly, impacts from runoff from the catchment are likely not as severe as might be observed for other less well flushed inlets.

Groundwater

The Seacombe Groundwater Management Area (GMA) extending from near Welshpool to Bairnsdale partly covers the Corner Inlet catchment. Seacombe GMA's primary groundwater extractions are for urban/industrial uses including domestic, industrial, mining, power and commercial uses. Rural extractions include stock activities and irrigation of agricultural areas (CSIRO 2005).

Groundwater may be discharged across the sea floor to the coastal ocean. This submarine groundwater discharge is primarily driven by hydraulic gradient (gravity) due to the difference in water level between the groundwater table and seawater level (Burnett *et al*. 2006). Hindell *et al*. (2007) suggested that submarine groundwater discharge may also be of significance for Corner Inlet. The authors noted high concentrations of ammonia and nitrate/nitrite in Corner Inlet at Yanakie and concluded that local contaminated groundwater inflows were the underlying cause for the exceptionally high nutrient concentrations rather than riverine discharges.

Water Technology (2008) undertook follow-up investigations to assess Hindell et al.*'s* (2007) hypothesis that groundwater was a key source of localised nutrient contamination. Water Technology (2008) found that only a minor percentage of flow was in the form of groundwater recharge in comparison to stream flow. With the exception of ammonia, all water quality parameters measured had lower concentrations in groundwater than the natural surface water course (Golden Creek). On this basis, groundwater was considered by Water Technology (2008) to represent a relatively minor contaminant source.

3.6.3 Water Quality

Reasons for Selection

Water quality is a key driver of aquatic ecosystem health within Corner Inlet. In particular, the generally low levels of turbidity and nutrients are required to maintain the health of seagrass meadows (and associated biodiversity and fisheries values) within the site. The high degree of tidal flushing strongly influences water quality within the site (see Section 3.6.2).

Description

Catchment Loads to Corner Inlet

The main rivers discharging into Corner Inlet are relatively short and drain small catchments, which leads to a rapid response to significant rain events and ensuing high concentrations of nutrients and sediment loads (CSIRO 2005). The important impact of rainfall events on water quality is generally reflected in higher total and reactive phosphorus concentrations and increased turbidity levels in catchment streams during years with above average rainfalls, such as occurred in 2001 (CSIRO 2005, NCI 2007).

Of the major streams in the catchment, the Tarra River (refer Figure 3-6) is normally the largest contributor for loads entering Corner Inlet. However, other rivers such as the Franklin, Agnes, Albert and Jack River can produce greater loads when flood events have been isolated to their catchment (CSIRO 2005). While the Agnes River contributed more nutrients than the Franklin River, the Franklin was a higher contributor of suspended sediment (South Gippsland Water 2002). Deep Creek supplied a significantly higher proportion of reactive (biologically available) phosphorus to Corner Inlet than the other rivers.

Overall, the main streams entering Corner Inlet exhibited moderate to good water quality, while many of the smaller streams were characterised by poor water quality (South Gippsland Water 2002). However, the actual impact of these smaller streams on water quality in Corner Inlet is largely unknown as no flow data exists and loads cannot be adequately estimated. Similarly, the impact of urban stormwater drains is largely unknown because of the lack of information on water quality and quantity (CSIRO 2005).

The impact of wastewater treatment plants (WWTP) (see Figure 3-6 for locations) on water quality in Corner Inlet has been assessed by South Gippsland Water (2002). Figure 3-7 presents annual discharge volumes and loads of suspended solids and nutrients for major streams and wastewater treatment plants discharging into Corner Inlet. Discharge volumes for the wastewater treatment plants were much lower than for the rivers and typically contributed only around one per cent of the total annual discharge. Correspondingly, annual loads of suspended solids and total nitrogen from the WWTP's were minor compared to the respective river loads. However, total phosphorus loads from the WWTP's were sometimes as high as those from the major streams (refer Figure 3-7). Loads of reactive phosphorus (directly available for plant growth) from the WWTP's were of similar magnitude or higher than those contributed by the major streams in 2000 and 2001 (South Gippsland Water 2002).

Figure 3-6 Corner Inlet Ramsar Site (red outline) with Locations of Waterwatch Sampling Sites (red stars) and Outfall Locations for Foster, Toora and Port Welshpool Wastewater Treatment Plants (black squares)

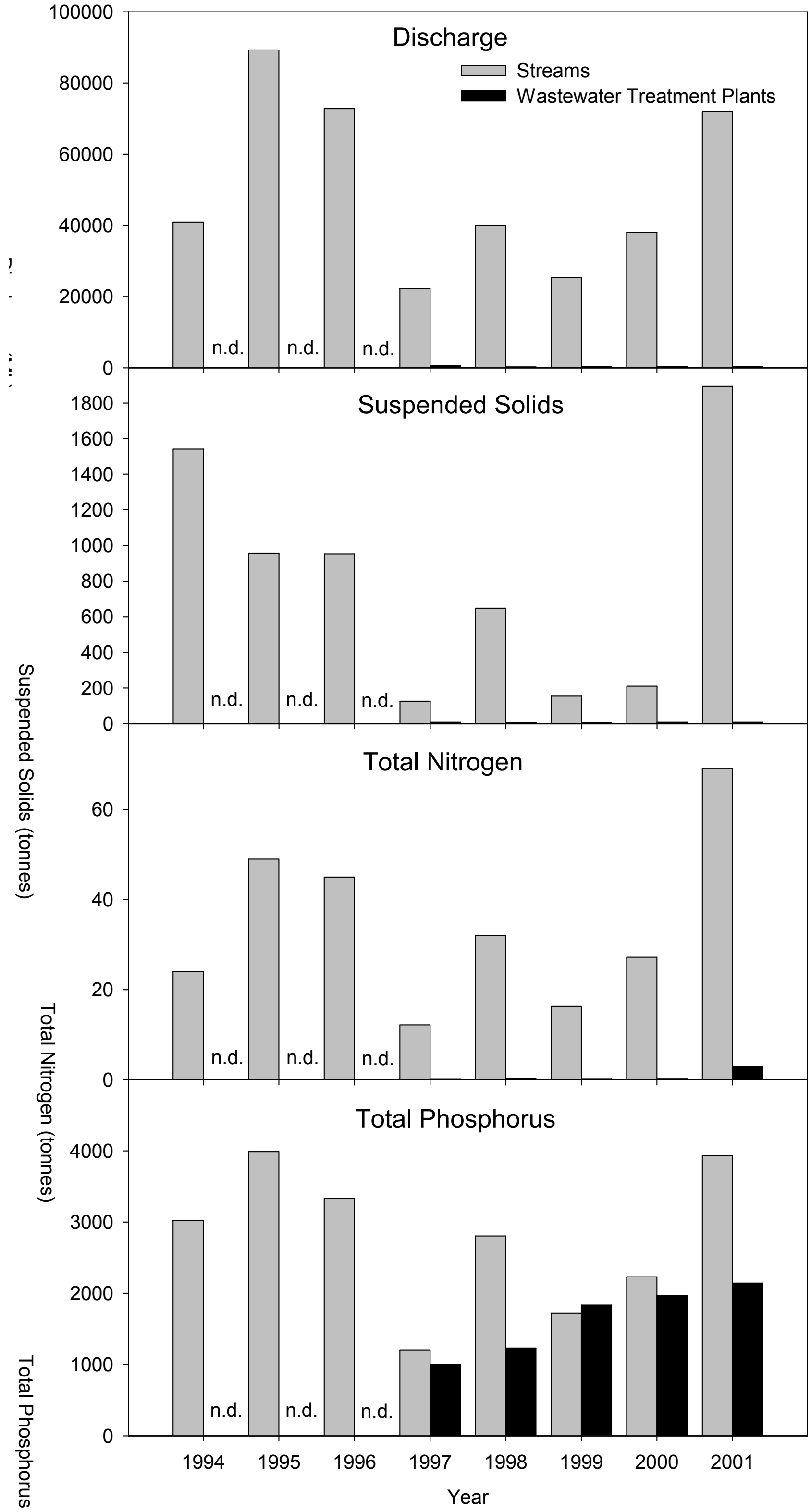


Figure 3-7 Discharge and Summed Annual Loads of Suspended Solids, TN and TP for Major Streams Discharging into Corner Inlet (Franklin River, Agnes River, Deep Creek) and Wastewater Treatment Plants (Toora, Foster, Port Welshpool). No Data Exists for the WWTP between 1994 and 1996. Annual Loads Based on Calculations in South Gippsland Water (2002)

Ambient Water Quality in Corner Inlet

Water quality data are not available from sites within the Corner Inlet Ramsar boundary from the time of listing (1982). The Waterwatch Victoria volunteer monitoring program has closed this information gap since 2001 with regular sampling of water quality data from sites along the boundaries of the Corner Inlet Ramsar wetlands (refer Figure 3-6). Accordingly, the recent Waterwatch data represents a current description of Corner Inlet and inferences whether the water quality in Corner Inlet has deteriorated or improved since the time of listing cannot be made.

Table 3-6 presents the Waterwatch water quality data for ten sites within the Ramsar boundary and comparison with ANZECC/ARMCANZ (2000) guideline values. It should be noted that the purpose of this comparison to guideline values is to determine whether there are any key contaminants of concern that could have an effect on ecosystem health. Due to the lack of data from around the time of listing, it is uncertain whether either the guideline values or monitoring data reflect water quality conditions at the time of listing.

Reactive phosphorus concentrations exceeded the guideline values for all stations. It should be noted, however, that the values for six of the sites were at the lowest limit of measurement resolution rendered possible by Waterwatch analysis methods. Notable exceedances of the guideline trigger limits include sampling sites ESC010 and BCK020, which exceed trigger limits for reactive phosphorus 20 to 48 fold, total phosphorus six to 10 fold and turbidity by about 3.5 fold (Table 3-6). These two sites are located close to the outfalls of the Foster and Toora WWTP's, which were shown to discharge significant loads of phosphorus into Corner Inlet (South Gippsland Water 2002). Water quality parameters generally met the guidelines at site EPW010, which is located close to Port Welshpool WWTP. South Gippsland Water (2002) noted that phosphorus loads for this WWTP were typically 10 times lower than for the Foster and Toora WWTP's. They also observed that phosphorus loads contributed by Deep Creek were significantly higher than for the other rivers, which is reflected in elevated reactive and total phosphorus concentrations at site EFR010 located close to the mouth of Deep Creek (refer Figure 3-6 and Figure 3-6).

Hindell *et al*. (2007) recorded water quality data from six sites within Corner Inlet as part of an investigation into seagrass health between March 2005 and August 2006. Salinity within Corner Inlet was generally oceanic but could exceed oceanic levels during summer due to evaporation. Dissolved oxygen levels were well in excess of saturation during summer, indicating significant oxygen production through algae and seagrass photosynthesis. A significant overnight oxygen sag was hypothesised due to respiration of algae and seagrass. Hindell et al. (2007) noted elevated dissolved inorganic nitrogen concentrations (ammonium and nitrate/nitrite) but found that reactive phosphorus (phosphate) concentrations were typically quite low. The authors proposed that the source of the elevated nitrogen concentrations was both river discharge as well as groundwater influx.

Table 3-6 Waterwatch data of stations within the Ramsar site (refer to Figure 3-6). The data were calculated to give the 80th Percentile (20th and 80th Percentiles for pH) and Compared against the ANZECC/ARMCANZ (2000) for Southeast Australian Estuaries where applicable*

Location	Station	Data period	Water Temp (°C)	EC (µS/cm)	pH	Reactive P (mg/L)	Total P (mg/L)	Turbidity (NTU)
	ANZECC Estuarine				20th–80th per centile 7.0–8.5			Default 0.5–10
	SEPP WoV Estuarine					75th percentile ≤ 0.005	75th percentile ≤ 0.030	
NW Corner Inlet – Near-shore	BCK020	2004, 2006–2008, n=74	17.1	42 320	7.00– 7.55	0.240	0.318	34.1
	EAG010	2001–2009, n=299	19.1	56 800	7.83–8.15	0.010	0.030	7.0
	EAL010	2002–2008, n=238	18.0	55 900	7.56–8.05	0.020	0.050	16.6
	EFR010	2001–2009, n=243	22.1	54 900	7.66–8.04	0.029	0.056	12.4
	ESC010	2001–2003, n=32	18.0	52 700	7.34–7.86	0.100	0.195	35.2
Main Entrance	EEN010	2001–2009, n=269	18.0	55 724	7.88–8.14	0.010	0.020	2.4
Port Welshpool	EPW010	2001-2009, n=274	19.0	56 200	7.84–8.13	0.010	0.020	2.9
Port Albert	ETB010	2001–2006, n=201	21.0	57 784	7.76–8.03	0.010	0.020	6.7
	ETR010	2008–2009, n=13	21.1	55 540	8.12–8.28	0.007	0.028	7.2
McLoughlins	MCL010	2001–2002, n=51	20.0	61 536	7.91–8.30	0.010	0.060	6.8

* The 75th percentile has been calculated for reactive and total phosphorus to be compared against the SEPP Waters of Victoria guideline. Orange and red shading indicate exceedance of guideline values up to a factor of 2 or more than a factor of 2, respectively.

3.6.4 Nutrient Cycling and Foodwebs

Reasons for Selection

Biological processes describe any process occurring within, or by, an organism, and can operate at the genetic, cellular, individual, population, community or ecosystem levels. There is a vast range of biological processes that, together with physical (abiotic) processes described above, are important to the maintenance of wetland ecosystem functioning. Of particular note in the context of the biological processes that maintain the ecological character of the site are nutrient cycling and foodwebs.

Description

Marine and Estuarine Nutrient Cycling

As vegetative and animal matter begins to senesce and die, microbes invade the tissues and transform the organic material into more bio-available forms of carbon and other nutrients. While microalgae, marshes and seagrasses are mainly responsible for primary productivity within estuarine and marine waters of the site, microbial breakdown is a key pathway for plant material entering the food-web in these ecosystems (Alongi 1990). This is especially true for marine and freshwater macrophytes (seagrass, mangroves, saltmarsh, freshwater marshes), which with few notable exceptions (for example, by some invertebrates fish and birds) are generally not directly grazed, but instead enter food-webs following microbial conversion of organic matter (Day *et al*. 1989).

Nutrient cycling processes are controlled by tidal exchange (flushing and dilution of nutrients), and the relative influence of different nutrient sources and sinks. Due to the relatively large tidal range in Bass Strait, over 60 per cent of the Corner Inlet volume is exchanged over an average tidal cycle (see Section 3.6.2). Although high nutrient concentrations were noted close to wastewater treatment plant outfalls, the rapid dilution through high flushing rates means that impacts are likely localised (CSIRO 2005; see Section 3.6.3).

Corner Inlet is characterised by its extensive areas of intertidal sand- and mudflats (approximately 390 square kilometres) as well as large areas covered by seagrass (approximately 150 square kilometres) (NLWRA 2001). Due to their wide extent, these habitats potentially play a very important role for nutrient cycling within Corner Inlet.

Productivity and Foodwebs

The main primary producers within the site include phytoplankton, benthic microalgae (microphytobenthos) and seagrass. Saltmarsh and mangroves, while having high productivity rates, are not likely to represent dominant primary producers at a whole of site scale due to their limited spatial coverage. The relative contribution of each of these components to total primary productivity will vary from place to place and across a range of spatial (and possibly temporal) scales.

Case studies elsewhere demonstrate that seagrass, mangroves and saltmarshes represent particularly productive communities (on a 'productivity per unit area' basis). When taking into account the large total area of phytoplankton habitat (open water), phytoplankton may represent a major proportion of total primary productivity of the wetland.

Grazing of phytoplankton by zooplankton is likely to represent an important link in the chain of nutrient flux and energy flow in the coastal and estuarine waters of the site. Furthermore, the planktonic phase forms part of the life-cycle of most benthic and marine demersal fauna (meroplankton), including most species of direct fisheries significance. Little is known about the relationships between nutrient levels, phytoplankton dynamics and zooplankton composition, grazing and production within the wetland.

The direct consumption of macrophytes by grazers also represents a pathway for energy flow through the ecosystem. Macrophytes generally form a direct food source for only a limited number of species, including sea urchins, some amphipods, gastropod snails, some fish species (for example, garfish, luderick and leatherjackets), together with black swan, ducks and geese (Day *et al*. 1989; Colwell 2010). From an energy flow perspective, perhaps the most important linkage between macrophytes and higher trophic levels is through the decomposition of dead plant material by bacteria and fungi (see discussion on nutrient cycling above). This is likely to be particularly the case in detritus-based foodwebs that characterise saltmarsh, seagrass and mangrove wetland habitats.

Recent studies at Corner Inlet using stable isotope analysis indicate that the nutrition of three fish species of recreational and commercial importance (King George whiting, southern sea garfish and yelloweye mullet) was mainly obtained from foodwebs derived from seagrass and seagrass-associated epiphytes (micro-algae). Mangroves and saltmarsh did not contribute significantly to foodwebs supporting these species. While these fish do not generally graze on seagrass and epiphytes, the organisms that form their prey rely on these plants for nutrition (Longmore 2007). Stable isotope analysis of fish in Port Phillip Bay also indicated that seagrass underpin the foodwebs supporting several piscivorous fish species (Hindell 2008). These results indicate that seagrass is important to the maintenance of foodwebs supporting commercially significant species within the site.

The diet of waterbird species differs between species, and also within species, depending on food availability (Colwell 2010). While many waterbirds feed on freshwater and estuarine/marine benthic macroinvertebrates on intertidal flats, there are also a number of herbivores (species that feed directly on submerged aquatic macrophytes, such as black swan) and piscivores (species that feed on fish, such as cormorants and pelicans). No studies to date have examined the relative contribution of different primary producers to foodwebs supporting bird assemblages within the site.

3.7 Critical Services/Benefits

3.7.1 S1 – Presence of Threatened Species

Reasons for Selection as 'Critical'

Biological diversity, or biodiversity, is the variety of all life forms, the genes they contain and the ecosystem processes of which they form a part. The term biodiversity can therefore incorporate most of the critical and supporting components outlined in the previous sections. However, in the context of how the Ramsar site provides a critical role in maintaining global biodiversity, the site supports critical habitat for globally and nationally threatened wetland-dependent species.

Key services provided by the site in regards to threatened fauna complies with Ramsar Nomination criteria 2 in that the site supports nationally threatened fauna including:

- orange-bellied parrot (*Neophema chrysogaster*) – Critically Endangered under the EPBC Act and Endangered under IUCN Red List (IUCN 2010)
- growling grass frog (*Litoria raniformis*) - Vulnerable under the EPBC Act and Endangered under IUCN Red List (IUCN 2010)
- fairy tern (*Sterna nereis nereis*) - Vulnerable under the IUCN Red List (IUCN 2010)
- Australian grayling (*Prototroctes maraena*) - this species is listed as Vulnerable under the EPBC Act and Near Threatened under the IUCN Red List (IUCN 2010).

Ramsar Nomination criteria 4 is also relevant in that the site supports habitat for critical stages in the life cycles of these nationally threatened fauna.

Description

<u>Orange-bellied parrot</u>

Neophema chrysogaster is listed as critically endangered under the EPBC Act and IUCN Red List (IUCN 2010). The current total wild population of orange-bellied parrots is unlikely to exceed 150 individuals (OBPRT 2006). The orange-bellied parrot is endemic to south-eastern Australia and migrates from breeding grounds within coastal south-western Tasmania to non-breeding grounds within coastal areas of southern Australia (about east from the Murray River mouth to South Gippsland) (Higgins 1999; OBPRT 2006). Birds generally arrive on the mainland during March/April and depart September/November (OBPRT 2006; Birds Australia 2009b).

In Victoria, orange-bellied parrots are found mostly within three kilometres of the coast where they forage within coastal saltmarsh vegetation associated with sheltered coastal areas such as bays, estuaries and lagoons (Emison et al. 1987; Birds Australia 2009b). Within these habitats, known key food plants include beaded glasswort (*Sarcocornia quinqueflora*), shrubby glasswort (*Sclerostegia arbuscula*), sea-blite (*Suaeda australis*) and other low herbaceous plants (Higgins 1999; BA 2009b). Current data indicates that a significant proportion of the known orange-bellied parrot population congregates at three sites in Victoria (around Port Phillip Bay and the Bellarine Peninsula) (Birds Australia 2009b).

In the Gippsland area, there are sporadic records at Jack Smith Lake, the fringes of Corner Inlet and several islands within, Andersons Inlet, and from the Powlett River mouth (DEWHA 2009b; Birds Australia 2009b). There are seven records for the Ramsar site (1983–1988; DSE 2003 and 2009), the most recent being 2004 (Ecos unpublished). Records were associated with the Port Albert area and Mangrove Root, Barry, Long and Mangrove Islands in western Corner Inlet.

The main current threat to the orange-bellied parrot is the loss and fragmentation of its non-breeding saltmarsh habitat due to: drainage of wetlands for grazing; alteration and destruction of saltmarsh for industrial and urban development; grazing of native vegetation; vegetation clearance for agricultural purposes; changes to land use practices; and recreational activities (Garnett and Crowley 2000; OBPRT 2006).

Growling grass frog

Litoria raniformis is found mostly amongst emergent vegetation (for example, bullrush *Typha* spp., sedges, and reeds, for example, *Phragmites* sp. and *Eleocharis* spp.), in or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds and farm dams (DEWHA 2009a). Approximately 1405 hectares of this vegetation type is present within the site on Snake Island (refer Section 2.1.2), although the exact proportion of this that is used by growling grass frog is not known. This species is dependent upon permanent freshwater lagoons for breeding where shallow still or slow moving water (up to approximately 1.5 metres) supports a generally complex vegetation structure of emergent or submergent vegetation (for example, Heard et al. 2004; Clemann and Gillespie 2004; Hamer and Organ 2006). The following are regarded as threats to the growling grass frog: habitat loss and fragmentation, habitat degradation, altered flooding regimes, predation by introduced fish (especially G*ambusia holbrooki*), chemical pollutions of water bodies (herbicides, insecticides, biocides), salinisation, and disease (chytrid fungus) (NSW DEC 2005a, DEWHA 2009a).

Fairy tern

Fairy tern (*Sterna nereis nereis*) is listed as vulnerable under the IUCN Red List (IUCN 2010). This small tern mainly occupies sheltered coastlines (rarely found out of sight of land), favouring estuaries, embayments, inlets, and along ocean beaches and near-shore environments (Hill et al. 1988; Higgins and Davies 1996). Fairy terns are colonial nesters and prefer to nest on near-shore islands, small islands in archipelagos, and on open sandy beaches inside estuaries. Breeding habitat within the Ramsar site includes Clonmel, Boxbank and Dream Islands (Figure 1-2), and barrier islands in the Nooramunga area (Minton in Bell 1998; Ecos unpublished).

In the context of all of these species, the dominant process required for the maintenance of suitable habitat conditions are natural patterns of freshwater inundation to freshwater wetlands, natural patterns of tidal inundation and freshwater flows to intertidal and supralittoral wetland systems; and natural vegetation patterns, extent, health, and habitat interconnectivity.

Australian grayling

The Australian grayling (*Prototroctes maraena*) is considered almost certain to occur in the Ramsar site. Confirmed records for this species exist for all major river basins that drain directly into the site (Agnes, Albert, Franklin and Tarra Rivers; Backhouse et al. 2008). This species spends most of its life-cycle in freshwaters (McDowall 1996). Australian grayling spawns in freshwaters, and their larvae are subsequently transported into estuarine and marine waters (which are represented in the Ramsar site) by river flows. Given the apparent obligatory oceanic habitat requirement of juveniles, it is almost certain that this species relies on the Ramsar site to complete its life-cycle.

Patterns in Variability

There are presently too few data describing patterns in the abundance of any of these species. In summary, available data show:

- orange-bellied parrot - there are seven records for the site (Birds Australia = one record in 2004; DSE 2003 and 2009 = six records between 1983–1988). Records were associated with

the Port Albert area (Mangrove Root Island, Barry Island, Long and Mangrove Islands). There are too few data to determine patterns in the abundance of this species within the Ramsar site

- growling grass frog – there are 39 records for the site (two individuals in 1977 and 37 individuals in 1995, based on DSE 2009 data). There are insufficient data to determine patterns in the abundance of this species within the Ramsar site

- fairy tern – Figure 4-2 shows the maximum annual count of fairy terns recorded at the site based on DSE Fauna Database records. Unfortunately there are few data available for the site at the time of site listing, therefore baseline conditions needs to be considered in the context of data collected post-listing. These data show that the maximum count in the period 1983 to 1994 was generally greater than 10 birds, with a peak in 1994. Since 1994 the counts were generally less than 10 birds, except in 2003 when 60 birds were recorded. The Birds Australia database has only a few records of this species at the site, and only one record contained count data (eight individuals)

- Australian grayling – there are no data describing the occurrence and abundance of this species within the site. South Gippsland Water monitors fish abundance at stations located throughout the Tarra and Agnes River catchments, however none of the stations are located within the Ramsar site. This represents an important information gap in the context of this critical service.

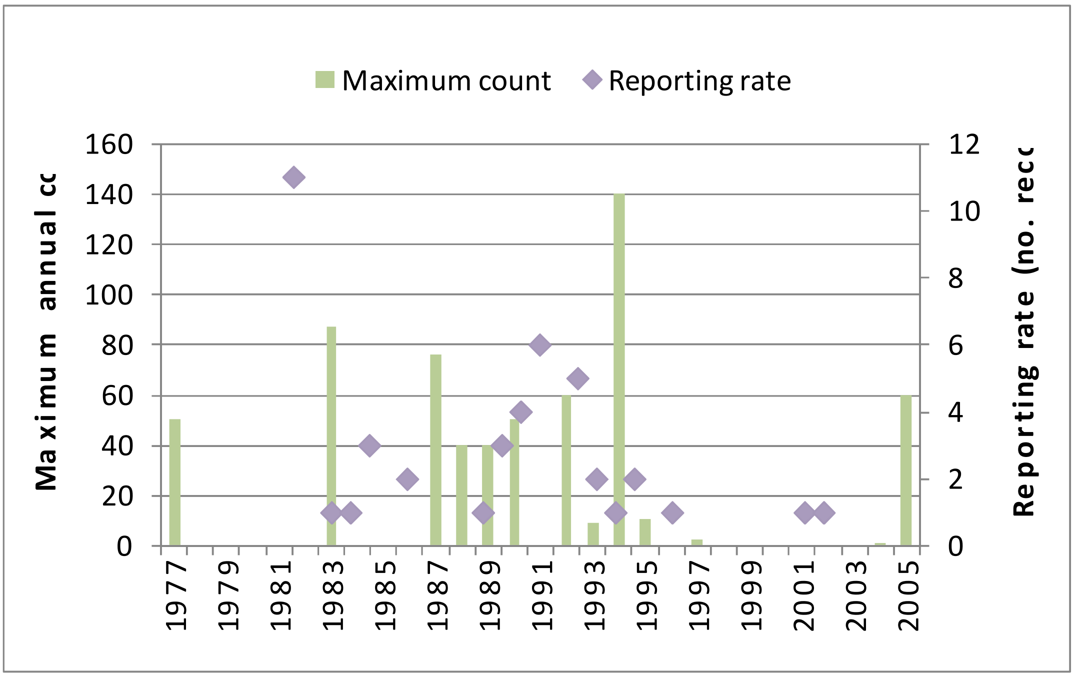


Figure 3-8 Maximum Annual Count and Reporting Rate (Number of Episodes and Stations) for Fairy Tern Abundance (Total Records in each Year) at Corner Inlet Ramsar Site (Data source: DSE fauna database)

3.7.2 S2 – Fisheries Resource Values

Reasons for Selection as 'Critical'

As discussed in the context of the justification for meeting criterion 8 of the Convention, the site provides important habitats, feeding areas, recruitment areas, dispersal and migratory pathways, and spawning sites for numerous fish species of direct and indirect fisheries significance. These fish have important fisheries resource values both within and external to the site.

This service/benefit is based on fisheries habitat and fish abundance, and excludes fishing activities. It was selected on the basis of being an important determinant of the site's unique character and the importance of fisheries values with respect to support of other services/benefits including recreation and tourism (supporting service).

Description

The Corner Inlet commercial fishery is based mostly on King George whiting (*Sillaginodes punctatus*), Australian salmon (*Arripis* spp.), greenback flounder (*Rhombosolea tapirina*), southern garfish (*Hyporhamphus melanochir)*, yellow eye mullet (*Aldrichetta forsteri*), silver trevally (*Pseudocaranx dentex*), flatheads (several species) and school shark (*Galeorhinus galeus*) (DPI 2007c; 2010). According to habitat/life-history classifications of Ecos (unpublished), these fish are either estuarine dependent, marine estuarine opportunists or marine straggler species. The fishery also includes southern calamari, which is considered a "marine straggler" invertebrate species (Ecos unpublished).

Table 3-7 shows that important fisheries species commonly found within the Ramsar site are not found exclusively in any one habitat type during any part of their life-cycle. Rather, these species have relatively plastic habitat requirements, and are typically found in a variety of habitat types. In general terms, most of the species listed in the table below spend their juvenile stages in shallow protected waters, particularly around seagrass and mangroves, whereas most species tend to spawn in coastal and marine waters. Adults of most species tend to utilise a variety of habitats.

There are exceptions to these general patterns. Corner Inlet is recognised as an important pupping area for school shark (AFMA 2009). Shallow sheltered bays, estuaries and littoral areas such as mangrove lined creeks are of particular importance in this regard (Olsen 1954; Walker *et al*. 2005). Furthermore dusky flathead (*Platycephalus fuscus*) and river garfish (*Hyporhamphus regularis*) spawn in estuaries near seagrass and/or shoals, whereas black bream (*Acanthopagrus butcheri*) is thought to spawn in upper estuaries near the fresh and brackish water interface (Ramm 1986).

Patterns in Variability

Relative abundance data can be broadly determined based on commercial fish catch data (see long term trends in Figure 3-9) and catch-per unit effort data (Table 3-8). Data are available for a small number of years prior to site listing (four years), which is insufficient for developing an appropriate 'pre-listing' baseline incorporating the range of inter-annual variability. For this reason, baseline values are defined as the 11 year period leading up to and immediately following site declaration (1978/79 to 1988/89). Note that these commercial catch data have a number of limitations, including a strong bias towards adults, are not based on systematic standardised catch methods and have

limited spatial resolution. There are also no suitable fisheries independent catch data to validate trends in commercial catch data.

These data show that commercial catch varies greatly over time, partly in response to changes in fishing effort. Changes in commercial catch are discussed further in Section 5.2.1 in the context of whether there is any evidence of changes in ecological character.

Table 3-7 Key Fisheries Species present in the Corner Inlet Ramsar site, and their Primary Habitats at Different Stages of their Life-cycle (Data: Kailoa et al. 1993)

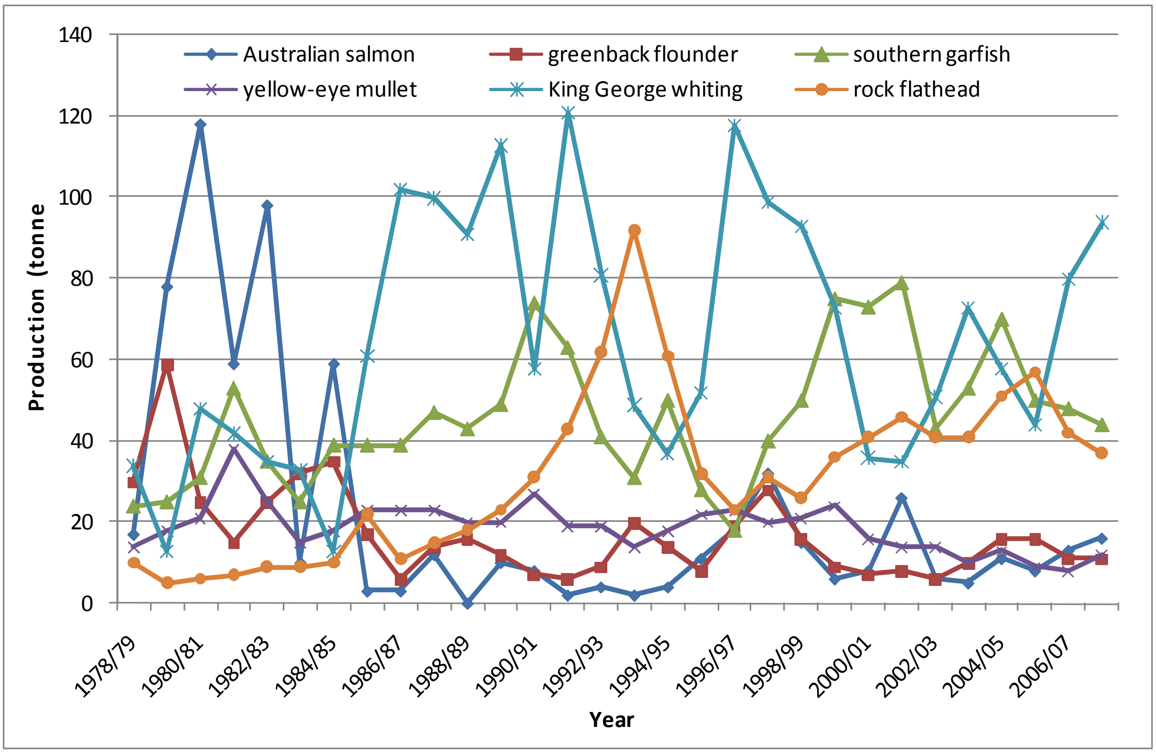
Species	Estuary/Freshwater					Coastal/Oceanic			
	Mangroves*	Seagrass*	Shoals*	Channels and Mud basin*	Fresh/ brackish creeks and wetlands*	Nearshore sand/ pelagic	Offshore sand/ pelagic	Seawall*	Coastal Reefs
Australian salmon	Juv.	Juv.	Juv.	Ad.		Ad.	Ad.	Ad.	Ad., Spw.
Australian anchovy						Ad.	Spw.		
dusky flathead	Juv., Ad.	Spw., Juv., Ad.	Spw., Juv., Ad.,	Ad., Juv.	Juv., Ad.**	Spw.			
greenback flounder	?	Juv., Ad	Juv., Ad.	Juv., Ad.	Juv.	Sp., Ad.	Sp., Ad.		
river garfish	Juv., Ad	Juv., Ad., Spw.	Juv., Ad		Juv., Ad				
school shark	Juv.	Juv.	Juv.	Juv.			Ad.		
King George whiting	Juv.	Juv.	Juv.	Juv.		Ad.	Ad., Spw.	Ad.	Ad.
silver trevally		Juv.	Juv.	Juv., Ad.		Ad.		Ad.	Ad., Spw.
snapper	Juv.	Juv.	Juv.	Juv.			Spw.	Juv., Ad.	Juv., Ad.
tailor		Juv., Ad.	Juv., Ad.	Juv., Ad.		Spw., Juv., Ad.			
black bream	Juv., Ad.	Juv., Ad.	Juv., Ad.		Spw., Juv., Ad.**	Ad.		Ad.	Ad.
mulloway	Ad.	Juv., Ad	Juv. Ad	Juv., Ad.	Juv.,Ad.**	Ad. Spw.		Juv., Ad.	Juv., Ad.
luderick	Juv. Ad.	Juv. Ad.	Ad.	Ad.	Juv., Ad**	Ad. Spw.	Ad.	Ad.	Ad.
sea mullet	Juv. Ad.	Juv.	Juv.	Juv., Ad.	Juv.	Spw.	Spw.		
yellow-eye mullet	Juv. Ad.	Juv.	Juv.	Juv., Ad.	Juv.	Spw., Ad.			
southern calamari		Spw., Juv.	Juv., Ad.	Juv.,Ad		Ad.			Spw.
estuary perch		Juv.		Juv. Ad.	Juv, Ad.	Spw (estuary mouth			
king prawn	Juv.	Juv.	Juv.	Juv.		Ad.	Ad., Spw.		
school prawn		Juv.	Juv., Ad.	Juv., Ad.			Spw.		

Note: Juv. = Juvenile, Ad. = Adult, Spw. = Spawning; * denotes habitat type found in the Ramsar site; ** often in association with large woody debris; blue shading = habitats not represented in the site

Table 3-8 Catch Per Unit Effort (Commercial Production in Tonnes Caught Divided by Number of Boats) for Corner Inlet (20th, 50th and 80th Percentile Values) around the time of listing (1978/79 to 1988/89) and post 1989

Species	1978/79 to 1988/89				1989/90 to 2008/09
	n	25th	50th	75th	50th
Australian salmon	11	379	1047	3799.3	404.6
bream, black	8	18.9	28.5	41.1	58.9
bream, yellowfin	1		621.4		545.3
calamari, southern	8	96.8	235	490.8	802.3
flathead, rock	11	316.3	411.7	579.7	2051.8
flathead, sand	11	347.3	415.7	434.1	1450
flounder	11	514.4	332.2	1165	491.7
garfish, southern sea	11	1452.3	1573.5	1672	2415
mullet, sea	11	68.0	108.2	125.9	128.8
mullet, yellow-eye	11	739.7	809.1	903.5	817.4
shark, gummy	11	167.4	261.5	415.9	411.9
whiting, King George	11	1347.1	1490	2988	2813.4

Note: no data where less than five fishers. Values are kilogram production per boat



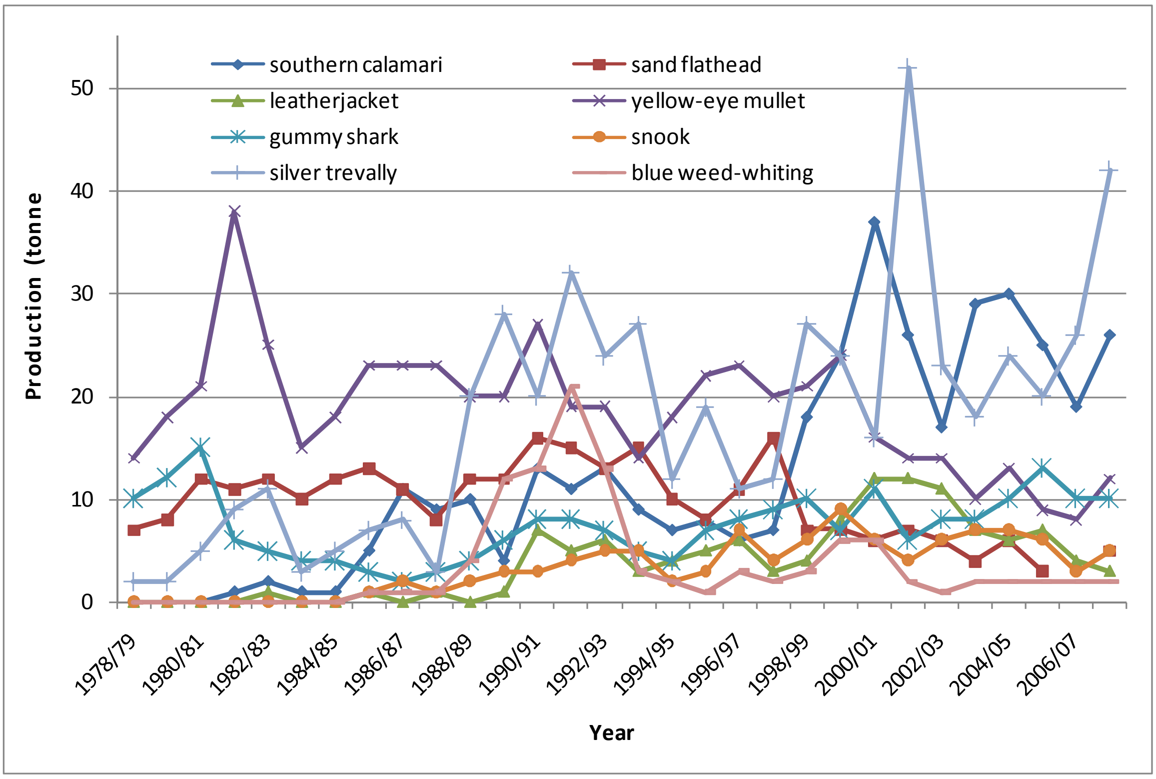


Figure 3-9 Long-term Trends in Commercial Fisheries Catch Data between 1978–2008 (Source: DPI 2008)

3.8 Supporting Services/Benefits

The supporting services/benefits outlined below are considered to be important or noteworthy in the context of maintaining the character of the site, but are not considered to represent critical services/benefits. In this context:

- The supporting services/benefits are not, in isolation, thought to fundamentally underpin the listing criteria. However, supporting services/benefits may, in combination with other elements, underpin Nomination Criteria
- Some supporting services/benefits are already partially covered by other critical components or processes.

3.8.1 Recreation and Tourism Values

Reasons for Selection

This supporting service recognises the importance of the site as a recreational and tourism resource. While not intrinsically key determinants of the ecological character of the site, tourism and recreation are among the most important uses of the Corner Inlet, and have a major impact on employment and the economic wealth of the region.

Description

Tourism is a vital industry for Victoria's regional economy, worth $3.4 billion annually and responsible for an estimated 61 000 jobs (Minister for Tourism and Major Events 2007). In the Gippsland Region alone, since 1999, the Victorian Government has allocated over $4.6 million in direct tourism support (Minister for Tourism and Main Events 2007). The Gippsland region receives approximately seven per cent of all tourist visits to Victoria (Parks Victoria 2005).

Based on broad scale regional data, 84 per cent of overnight visitors to Gippsland were from intrastate, followed by 12 per cent from interstate and three per cent from the international market (Tourism Victoria 2007).

There are several important factors underpinning this service:

- The perceived 'naturalness' of the site. To a large extent, the degree of naturalness perceived by visitors will depend on the existing low levels of development in the surrounding areas, as well as aesthetic considerations
- The diversity of landscape and seascape types. Parks Victoria (2005) suggests that the notable landscape and seascape values include:
  - a spectacular backdrop of granite and peaks within Wilsons Promontory National Park
  - extensive intertidal flats exposed at low tide
  - granite and Benisons Islands
  - low marshy shorelines
  - sandy beaches set between granite headlands
  - a dramatic change in seascape as the tide rises and falls

- Recreational fish economic values. Recreational fishing represents an important activity within the site. Approximately 43 per cent of Victorian recreational fishing that took place in 2000/2001 occurred in bays, inlets and estuaries such as Corner Inlet (FV 2007). Recreational fisheries are an important aspect of the Corner Inlet region, contributing significantly to regional economy and tourism (Ecos unpublished). Recreational fishing supports the tourism and recreational industries in the region that surrounds the Ramsar site, which has a major impact on the regional economy
- The status of fish stocks. Recreational catches are similar in quantity to commercial catches but are, in large part, reliant upon commercial bait fishing (Hundloe *et al*. 2006). Within the Ramsar site, there is recreational line fishing for King George whiting (*Sillaginodes punctatus*), sand flathead (*Platycephalus arenarius*), yank flathead (*Platycephalus speculator*), and snapper (*Pagrus auratus*) (CSIRO 2005). Recreational fishing catch/effort data for a six month period during 1983 and 1984 indicated that the recreational catch of King George whiting from Corner Inlet/Nooramunga was at least as large, and probably larger, than the total commercial catch of this species (MacDonald 1997). DPI (2007d) has prepared a Draft Fisheries Management Plan for the recreational fishing sector and seeks to identify and manage key fish habitats in the West Gippsland region. Existing management arrangements for the commercial sectors will remain unchanged by this plan. The plan covers the estuarine reaches of the rivers and streams flowing into Corner Inlet but not the inlet itself
- Accessibility, availability and types of recreational facilities and tourism infrastructure. Key considerations here include:
    - Tourism infrastructure offered by local coastal towns in the region. Coastal towns in the Corner Inlet region (particularly Port Albert, Port Welshpool, Yanakie, Tidal River, Sandy Point and Walkerville) are subject to large seasonal population fluctuations usually in summer which are directly related to tourist influx into the region's motels, hotels and caravan parks for holidays as well as holiday homes.
    - Commercial tour operations. A number of licensed operators offer boating and sea kayaking tours within Nooramunga and Corner Inlet Marine and Coastal Parks and Wilsons Promontory National Park.
    - Camping and recreational facilities. Bush camping is allowed on the sand barrier islands within Nooramunga Marine and Coastal Park, but not on the granite islands. There are also numerous picnic and other visitor areas, boating facilities and toilet blocks throughout the site (DSE 2003).

There are no available data on changes in the local scale recreation and tourism values of Corner Inlet over time. Tourism figures from 2007 showed positive results for the region with an increase of 3.6 per cent in international overnight visitors and an increase of 6.4 per cent in domestic visitor nights spent in the region compared to the same time in the previous year (Minister for Tourism and Main Events 2007). There was also a 3.8 per cent increase in domestic day trip visitors over the same period.

3.8.2 Scientific Research

Reasons for Selection

The site has a number of values that make this a supporting service, most notably:

- Identification of the functions and ecological values of relatively undisturbed wetland ecosystems. In contrast to other large embayments within Victoria, Corner Inlet is in relatively good condition. This makes the inlet a good reference site for ecological research. Recent research on the trophic linkages between autotrophs and species of fisheries significance is a key example in this regard (for example, Klumpp and Nichols 1983)
- Monitoring population trends in key flora (for example, seagrass) and fauna (that is, bird) species. This research is not only important for identifying trends in ecosystem condition, but also provides an opportunity for local communities and natural historians to become involved in monitoring.

Description

The site does not contain any scientific research stations or environmental educational facilities. However, a wide range of research organisations use the site for scientific research programs including:

- Arthur Rylah Institute for Environmental Research (ARI), the research arm of the Department of Sustainability and Environment (DSE), which is based in Melbourne
- Marine and Freshwater Resources Institute (MAFRI) - Victoria Department of Primary Industries, based in Queenscliff
- CSIRO Marine and Atmospheric Research, based in Hobart.

Other universities and colleges use Corner Inlet for research and education, including University of Melbourne and Victoria University.

Numerous research programs and projects have been undertaken with respect to the Inlet's habitats and important species that are documented in Section 7, References. In terms of recent research activities, the following are of note (see DNRE 2002):

- The use of the site as a long term monitoring site of Chestnut Teal numbers by ARI.
- Snake Island is used annually as a field site to study floristic composition and fire ecology by Melbourne University.
- Research by MAFRI into the role of seagrass and algae on fisheries production.
- Mapping of seagrass extent and distribution in Corner Inlet by ARI.
- Collaborative saltmarsh research coordinated by Victoria University.
- Catchment load modelling undertaken by University of Melbourne.
- Community attitude assessments of environmental values, coordinated by Waterwatch and West Gippsland CMA.

Condition indicators such as water quality are monitored by State government departments. Other monitoring activities include extensive work by volunteers such as:

- Reef Watch community-based ecosystem health monitoring
- Seagrass Watch community-based seagrass monitoring
- Waterwatch water quality monitoring
- Wader bird observations collected by the Victorian Wader Study Group (VWSG).

Through the Coastal Catchments Initiative, the Australian Government has also invested a significant amount of research funding in the Corner Inlet area. Projects completed include an Ecological Monitoring Plan, development of Models and a Decision Support System, and geomorphologic and sediment studies.

3.9 Conceptual Model

The interaction of processes and components are shown in conceptual models for the site as shown in Figure 3-9. The model simplifies many of the complex ecological attributes and processes occurring at the site, and provides a summary of the key attributes of the Corner Inlet that most strongly determine their ecological character. The model is based on the five wetland types used in this study to categorise the key components of the ecological character of Corner Inlet; namely:

- seagrass beds
- intertidal sand or mud flats
- mangroves
- saltmarshes
- permanent shallow marine water.

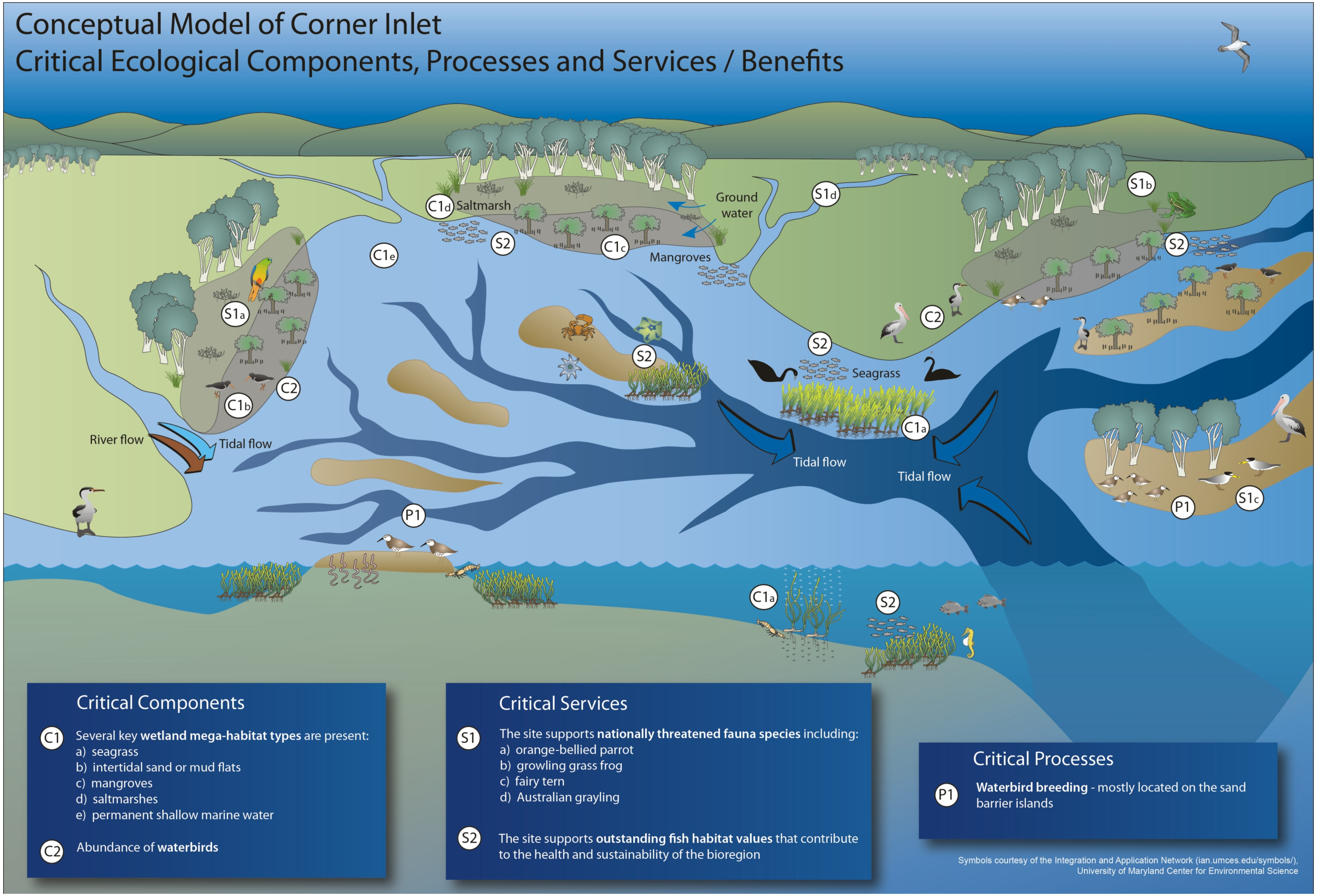


Figure 3-10 Conceptual Model of Components, Processes and Services/Benefits at Corner Inlet

4 LIMITS OF ACCEPTABLE CHANGE

4.1 Background and Interpretation

A key requirement of the ECD is to define the limits of acceptable change (LACs) for the critical components, processes and services/benefits of the wetland. 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' (DEWHA 2008). The limits of acceptable change may equal the natural variability or may be set at some other value. Where possible, limits of acceptable change should be based on quantitative information from relevant monitoring programmes, scientific papers, technical reports, or other publications and information about the wetland or input from wetland scientists and experts. In most cases, however, the datasets are not ideal but enough information is available to set limits of acceptable change based on expert judgment and to review and revise the limits over time with improved data and understanding.

Exceeding or not meeting a LAC does not necessarily indicate that there has been a change in ecological character. While the best available information has been used to prepare this Ecological Character Description and define LACs for the site, in many cases only limited information and data is available for these purposes. The LACs in Table 4-1 may not accurately represent the variability of the critical components, processes services and benefits under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland

Exceedence of a LAC may indicate a potential change to the ecological character of the Ramsar site. In most cases this will need to be determined through monitoring of the extent and condition of key wetland parameters (refer Section 6.2 regarding monitoring needs) and may require several sampling episodes in order to determine that the change is not part of broader natural variability of the system (for example LACs based on a per cent reduction in the use of the site by waterbirds based on successive counts of waterbirds over a specified time period).

It should also be noted that there may be a range of processes occurring outside of the site that could affect the exceedance of a particular LAC, for example, the populations of migratory species that use the site. As such, in the future evaluation of LACs it is important to determine if the underlying reason for the exceedance of an LAC is attributable to natural variability, related to anthropogenic impacts at or near the site (for example, catchment related processes) or alternatively a result of anthropogenic impacts off the site (for example, lack of available breeding habitat for migratory birds in the northern hemisphere).

4.2 Derivation of Limits of Acceptable Change

In developing LACs as part of this ECD, a number of approaches were applied, using existing data sets and information as well as national, state and local guidelines. In this context, LACs identified in the study generally fall into one of two categories:

- **Based on natural variability or probability.** As outlined in the National ECD Framework, it is most preferable for LACs to be based on the known natural variability (over time) of a parameter. The LAC can then be set at appropriate levels at or exceeding the upper and lower bounds of that natural variability profile. However, in most cases such data are unavailable or incomplete. As

such, LACs as part of the current study have also been based on a statistical measure of baseline data for a particular parameter. These LACs can be derived for both process/stressors (for example, water quality) and condition indicator based parameters (for example, maximum depth range at which seagrass can grow). For those parameters that exhibit a high degree of natural variability (for instance, water quality parameters such as salinity), LACs derived using this method can help to define more meaningful long term shifts in ecological character such as for example, where the long term (10 year) median for a particular parameter moves from the 50th percentile to the 10th percentile.

- **Broad ecosystem state and function.** This type of LACs is based on a broad change in an ecosystem from one state to another or on the basis of the wetland continuing to provide a particular function (such as provision of breeding habitat). An example of this type of LAC is a change in a particular wetland from a freshwater system to a brackish water system. This type of LAC has the advantages of encompassing a variety of indicators, and specifically addresses an ecosystem 'end-point' that can be directly linked to critical components (and/or services). This type of LAC is particularly relevant where there is a lack of data and information to support a more quantitative LAC about ecological response or threshold.

Wherever possible, the LACs derived as part of the current study have been based on existing benchmarks, data and guideline values used in other programs or documents that have the key aim of protecting environmental values of relevance to this ECD. In this context, indicators and LACs set out in other ECD studies (prepared by BMT WBM and other authors) have also been reviewed for their applicability to the Corner Inlet ECD.

4.3 Characterising Baseline Information

In characterising the baseline information used in deriving LACs, the following typology has been used:

Level A – This LAC has been developed from data and/or information (such as bird count data, fisheries catch data or similar) that has been reviewed by the authors and deemed to be sufficient for setting an LAC. This type of LAC is typically derived from long-term monitoring data.

Level B – This type of LAC is derived from empirical data, but is unlikely to describe the range of natural variability in time. This can include two sub-types:

- repeated measurements but over a limited temporal context
- single measurement (no temporal context) of the extent of a particular habitat type, abundance of a species or diversity of an assemblage.

Level C – This type of LAC is not based on empirical data describing patterns in natural variability. This can include two sub-types:

- Based on a published or other acceptable source of information, such as personal communication with relevant scientists and researchers, or is taken from referenced studies as part of management plans, journal articles or similar documents

- Where there are no or limited data sets and a lack of published information about the parameter, and the LAC has been derived based on the best professional judgement of the authors.

In most cases, the LACs in the current ECD have been subjectively derived (level C) based on the best scientific judgement of the authors. This is due to:

- a largely incomplete data set for key parameters such as waterbird usage, fish usage and environment condition (both geographically and temporally) since listing
- the general lack of scientific knowledge about the response of particular species and habitats to multiple stressors (for instance a combination of water flows, salinity and habitat availability).

4.4 Summary of Limits of Acceptable Change

Table 4-1 lists the LAC indicators relevant to each critical component, process and service/benefit. For each LAC indicator, the following information is provided:

(i) The primary critical component, process or service benefit relevant to the LAC.

(ii) The relevant timescale at which the LAC should be assessed. This recognises that different LACs are relevant to different timescales. For example, multiple cyanbacteria blooms over multiple years could result in a change to character within a relatively short time frame (measured in years), whereas changes in wetland vegetation are typically considered over longer timeframes (decadal scale). Three timescale categories are used: short-term (within five years), medium term (between five and 10 years) or the long-term (greater than 10 years).

(iii) The LAC value. The LAC value is typically expressed as the degree of change relative to a baseline value. The adopted baseline values are typically described in the relevant critical component, processes and services/benefits sections of this report, or in the case of some of the habitat type indicators, the wetland types described in Section 0.

(iv) The spatial and temporal scale at which measurements must be undertaken to assess the LAC. This column provides guidance on how the LAC should be applied.

(v) Data quality rating for baseline data. This is based on the baseline data quality categories described in Section 4.3.

(vi) Any other (secondary) critical components, processes or service/benefits that are also addressed by the LAC indicator.

As a general rule, short-term LACs listed in Table 4-1 will need to be reviewed to determine their potential applicability in subsequent periods.

Table 4-1 Limits of Acceptable Change for each Critical Service – Corner Inlet Ramsar Site

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[4]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
Critical Components						

C1	Seagrass extent	Long Term	• Total mapped extent of dense *Posidonia* will not decline by greater than 10 per cent of the baseline value outlined by Roob et al. (1998) at a whole of site scale (baseline = 3050 hectares; LAC = mapped area less than 2745 hectares) on any occasion. (Note: the small degree of allowable change recognises that this seagrass species is a critical habitat resource and generally shows low natural variability)
			• Total mapped extent of the dense and medium density Zosteraceae will not decline by greater than 25 per cent of the baseline values outlined by Roob et al. (1998) at a whole of site scale on two sampling occasions within any decade.
			  ◦ Dense *Zostera* - Baseline = 5743 hectares (LAC = mapped area less than 4307 hectares)
			  ◦ Medium *Zostera* - Baseline = 1077 hectares (LAC = mapped area less than 807 hectares)
			(Note: the moderate degree of allowable change recognises that these seagrass species generally show moderate degrees of natural variability)
				Sampling to occur at least twice within the decade under consideration.
				
				Note that the seagrass assessment by Hindell (2008) did not produce mapping but did use similar sampling sites to Roob *et al*.
					Level B - Recent quantitative data describes seagrass condition at various sites but over a limited timeframe. It is thought that the Roob *et al*. (1998) study under-estimated the total available seagrass habitat (J. Stevenson, Parks Victoria, pers. comm. February 2011), hence a 10 per cent change from this baseline value would represent a larger actual change from the true baseline.
					Note: Prior to declaration, *Posidonia* covered approximately 44 per cent (119 square kilometres) of the site (Poore 1978). Morgan (1986) estimated that *Posidonia* meadows covered 119 square kilometres in 1965, 35 per cent of the site in 1976 and 90 to 95 square kilometres in 1983–84. There is significant uncertainty regarding these mapping data and it is not recommended that empirical LACs are based on these data.
						S2

	Mangrove forest extent	Long term	• Based on EVC mapping, it is estimated that mangroves presently cover an area of 2137 hectares within the site (see Section 3.3.1). A 10 per cent reduction in the total mapped mangrove area, observed on two sampling occasions within any decade, is an unacceptable change. (LAC – mapped area less than 1924 hectares). (Note: the small degree of allowable change recognises that mangroves are a critical habitat resource and generally shows low natural variability)	Sampling to occur at least twice within the decade under consideration.	Level B - No available data to determine changes in extent over time. It is unlikely that this has changed markedly since Ramsar listing. Note that there are uncertainties regarding the quality of existing mapping, and therefore the baseline value should be	S2

[4] Short Term – measured in years; Medium Term – five to 10 year intervals; Long term – 10+ year intervals.

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[4]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
					considered as indicative only.	
	Saltmarsh extent	Long term	• Based on EVC mapping, it is estimated that intertidal saltmarsh presently covers an area of 6500 hectares within the site (see Section 3.3.1). A 10 per cent reduction in the total mapped saltmarsh area, observed on two sampling occasions within any decade, is an unacceptable change (LAC – mapped area less than 5850 hectares). (Note: the small degree of allowable change recognises that saltmarsh is a critical habitat resource and generally show low natural variability)	Sampling to occur at least twice within the decade under consideration.	Level B - No available data to determine changes in extent over time. It is unlikely that this has changed markedly since Ramsar listing. The note regarding data quality for mangroves applies also to saltmarsh.	S2
	Shallow subtidal waters	Long term	• A greater than 20 per cent reduction in the extent of subtidal channel (areas mapped by NLWRA = 16 349 hectares), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 13 079 hectares). (Note: the moderate degree of allowable change recognises that shallow subtidal waters represent a critical habitat resource, generally show low natural variability, but data reliability is low)	Sampling to occur at least twice within the decade under consideration.	Level B - NLWRA mapping data describes wetland extent. This is coarse scale mapping and should be considered as indicative only. Note: there is a need to develop a condition-based LAC for this critical component. While some water quality data exists, this is presently insufficient to derive a LAC (i.e. whether a change in water quality represents a true change in ecological character of the wetland)	S2
	Inlet waters (intertidal flats)	Long term	• A greater than 20 per cent reduction in the extent of permanent saline wetland – intertidal flats (areas mapped by DSE = 40 479 hectares, see Figure 3-1), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 36 431 hectares). (Note: the moderate degree of allowable change recognises that intertidal flats represent a critical habitat resource and generally show low natural variability. A loss of intertidal flat would also result in changes in seagrass)	Sampling to occur at least twice within the decade under consideration.	Level B - VMCS mapping data describes wetland extent. This is coarse scale mapping and should be considered as indicative only. Note: there is a need to develop a condition-based LAC for this critical component. While some water quality data exists, this is presently insufficient to derive a LAC (i.e. whether a change in water quality represents a true change in ecological character of the wetland)	S2
C2	Abundance and of waterbirds	Short term (All species)	• Mean annual abundance of migratory bird species - Birds Australia (2009c) notes that there is a maximum annual abundance of migratory species of 42 811 birds, with a mean annual abundance of migratory species being 31 487 birds (deriving from 28 years of data collection to September 2008). The annual abundance of migratory shorebirds will	At least four annual surveys (summer counts) within the decade under consideration.	Level A	P2

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[4]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
			not decline by 50 per cent of the long-term annual mean value (that is, must not fall below 15 743 individuals) in three consecutive years. (Note: the large degree of allowable change recognises that these species can show high levels of natural variability, and that limitations of existing baseline data)			
		Short term (individual species)	• Mean annual abundance of migratory species that meet the one per cent criterion will not be less than 50 per cent of the long-term annual mean value in five years of any ten year period. These values are follows: o curlew sandpiper – baseline = 2588 birds, LAC = 1294 birds o bar tailed godwit – baseline = 9727 birds, LAC = 4863 birds o eastern curlew – baseline = 1971 birds, LAC = 985 birds o pied oystercatcher – baseline = 893 birds, LAC = 446 birds o sooty oystercatcher – baseline = 285 birds, LAC = 142 birds o double-banded plover– baseline = 523 birds, LAC = 261 birds There are insufficient baseline data to determine long-term average abundance of fairy tern and Pacific gull. (Note: the large degree of allowable change recognises that these species can show high levels of natural variability, and that limitations of existing baseline data)	At least five annual surveys (summer counts) within the decade under consideration.	Level A	P2
Critical Processes						
P1	Waterbird breeding	Short Term	A greater than 50 per cent decrease in nest production at two or more monitoring stations (based on two sampling episodes over a five year period) within any of the following locations and species: • Clomel Island - fairy tern, hooded plover, Caspian tern, crested tern • Dream Island - fairy tern, hooded plover, crested tern • Snake Island and Little Snake Island - pied oystercatcher	Recommended baseline monitoring program should comprise a minimum two annual sampling periods separated by at least one year (and within a five year period).	Level C - The use of the site by these species is well documented. However, there are no empirical data describing breeding rates. Baseline data will need to be collected to assess this LAC.	C2
Critical Services/Benefits						
S1	Threatened Species	N/A	For orange-bellied parrot and growling grass frog, an unacceptable change will have occurred should the site no longer support these species.	Based on multiple targeted surveys at appropriate levels of spatial and temporal	Level C – Most site records are based on opportunistic surveys	P1, C3

Number	Indicator for Critical Component / Process/Service for the LAC	Relevant timescale[4]	Limit(s) of Acceptable Change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
				replication (at least four annual surveys in preferred habitats) over a 10 year period.		
		Short Term	For Australian grayling, an unacceptable change will have occurred should all of the drainages that drain into Corner Inlet no longer support this species.	Based on four annual surveys in a 10 year period at multiple sites located in all major catchments.	Level C - This species has been recorded in the major drainages that drain into the site. There are no data describing the population status of this species in the site. Abundance data are available for drainages that discharge into the site (Ecowise 2007; O'Connor *et al*. 2009). O'Connor *et al*. (2009) notes that collection of this species is difficult and requires targeted survey techniques. Few targeted empirical surveys have been undertaken in the site's drainages to date.	P1, C1, C2
S2	Fish abundance (using fish catch of key species as a surrogate)	Medium term	An unacceptable change will have occurred if the long term (greater than five years) median catch falls below the 20th percentile historical baseline values in standardised abundance or catch-per unit effort of five or more commercially significant species (relative to baseline) due to altered habitat conditions within the site. The 25th percentile pre-listing baseline commercial catch per unit effort values for the site are as follows (units are tonnes per annum per number of boats – see Table 3-8): Australian salmon 379 rock flathead 316 southern sand flathead 373 greenback flounder 514 southern garfish 1452 yelloweye mullet 740 gummy shark 167 King George whiting 1347	Annual fish catch measured over a greater than five year period.	Level A – Commercial fish catch data. Note that there are presently no fisheries-independent baseline data (collected using empirical, systematic methods) describing patterns in the distribution and abundance of key species. Therefore, the limits of acceptable change should be treated with caution, noting socio-economic factors should be taken into account when assessing catch data underpinning this LAC.	S2

5 CHANGES TO ECOLOGICAL CHARACTER AND THREATS

5.1 Overview of Threats

Given the size and diversity of wetland habitats present, the threats to the values of the Ramsar site vary greatly across multiple spatial and temporal scales and in terms of their potential severity. Some of these threats are discussed in the above section in relation to changes to ecological character and a range of threats have also been identified for each of the critical services/benefits.

Broad scale threats to the ecological character of the site are summarised in Table 5-1 and discussed below. The expected timing, likelihood and consequence have been estimated for each threat, and the risk of each threat has then been identified based on a simple risk matrix as follows:

		Consequence		
		Minor	**Moderate**	**Major**
Likelihood	**High**	Medium	High	High
	Medium	Low	Medium	High
	Low	Low	Low	Medium

Note that these threat types and the risk scores are largely consistent with independent risk assessments for the site undertaken by Carey et al. (2007).

5.1.1 Recreational Activities

Boating is the most popular recreational activity in Corner Inlet (Parks Victoria 2005). A range of boating-related threats, especially to seagrass beds, are apparent for Corner Inlet (Parks Victoria 2005), including:

- navigation across shallow seagrass beds at, or on either side, of low tide, resulting in direct physical damage
- discharges of sewage, oil or litter
- bow wash, especially from boats exceeding about five knots
- anchoring in sensitive seagrass areas (see also Walker *et al*. 1989).

This is particularly an issue with *Posidonia* given its slow growth and recolonisation rates following disturbance (Meehan and West 2000). However, pioneer species such as *Zostera muelleri* and *Heterozostera tasmanica* have a faster growth rate and adaptations that allow rapid recolonisation following disturbance, making them less at risk from disturbance than *P. australis* (West and Larkum 1983).

Table 5-1 Summary of Key Threats to the Ecological Character of the Corner Inlet Ramsar Site

Threat	Potential impacts to wetlands	Timing	Likelihood	Consequence	Risk
Recreational activities	Direct and indirect effects to habitats due to recreational activities (boat wash, anchor damage to seagrass, water quality impacts) Development impacts for tourism infrastructure developments	Short to long-term	Medium	Moderate	Medium
Natural resource utilisation	Grazing impacts to vegetation Changes to fish stocks due to recreational and commercial fishing Modifications to habitats due to fishing practices	Short to medium term	Low to Medium	Moderate	Low to medium
Modified flow regimes	Altered environmental process linked to river flows, including spawning and migrations of fish	Short to long-term	Medium	Major	High
Pollutant (sediment and nutrients) inputs affecting water quality*	Loss of seagrass and associated impairment of ecological functions Increase in algae Changes in biological assemblages	Short to long term	Medium to High (depending on location and degree of flushing)	Moderate to major	Medium to high
Future infrastructure development	Removal of vegetation and habitats Changes to water quality and hydrodynamics Interruption of surface water/groundwater flow paths	Medium to long term	Low to medium	Moderate to major	Medium to high
Acid sulphate soils	Water quality degradation and associated fish kills, or impairment to ecosystem functions	Medium term	Low	Moderate to major	Low to medium
Oil spill/marine incident	Injury/fatality of marine species and communities	Short to long term	Low to medium	Major	Medium to high
Habitat loss resulting from seawalls* and urban development	Loss of habitat Pollutants in stormwater runoff and sewage Weeds and pest fauna	Medium to long term	Medium	Moderate to major	Medium to high
Climate change	Reduction of freshwater species Reduction of suitable fauna habitat Greater fire risk Increase in disturbance due to storm surge	Long term	Medium to high	Major	High
Weeds*	Reduced regeneration of native flora	Medium term	Medium	Moderate	Medium
Exotic pest fauna*	Disturbance of birds and other fauna, resulting in impairment to ecological functions (such as bird breeding and feeding) Predation of native fauna Modification of marine fauna assemblages due to competition	Short to Medium term	Low to Medium	Moderate	Low to medium

(*) identified as a key hazard for the site by Carey et al. (2007)

Large tourism developments would have the potential to place additional pressures on the marine environment of Corner Inlet. Given the anticipated increase in population growth both locally and in Victoria generally, there will be commensurate pressures on tourist facilities and environmental resources of the site.

5.1.2 Natural Resource Utilisation

Grazing of vegetation and trampling of wetland habitat by native and non-native species as well as resource utilisation in terms of small scale commercial and larger scale recreational fishing effort that occurs in the wetland are identified as ongoing threats. The large sand islands (for example, Big Snake Island) are grazed by cattle, and vegetation communities are expected to be affected by ongoing grazing pressures.

Recreational angling and commercial net fishing are also likely to represent key ongoing threats to fish stocks, although there are no available data to determine impacts. Bait digging for worms and callianassid shrimps (ghost nippers) also represents a locally important fishery, however the impacts on values and habitat resources due to collection activities are also unknown.

O'Hara et al. (2002) suggests that fishing using weighted seine nets in *Posidonia* beds at Corner Inlet can also lead to damage to seagrass habitats. At one site examined by O'Hara et al. (2002), the senescent ends of the seagrass leaves and associated epiphytes had apparently been thinned and/or removed by seining. O'Hara et al. (2002) also found lower crab and gastropod abundances in areas subject to seining. O'Hara et al. (2002) remarked that seining techniques in Corner Inlet have changed in comparatively recent times. For most of last century, wooden boats and hand-hauled nets restricted seining to the shallow banks. The introduction of powered boats and boat-drawn nets in the 1980's opened up deeper (for example, *Posidonia*) seagrass beds and channels to seining operations.

Corner Inlet commercial fishers have developed an Environmental Management Plan (2004) which aims to manage some of the impacting processes associated with fishing activities. This includes, among other actions, measures to reduce seagrass damage including using specially designed nets that do not 'rip' the grass, not anchoring in beds, as well as not anchoring in seagrass meadows. The EMP recognises the role of land-based activities leading to damage and degradation of fisheries habitats, most notably increased pollutant loads and its effect on seagrass.

5.1.3 Modified Flow Regimes

The present Sustainable Diversion Limit (SDL) prevents diversions in summer, and allows winter diversions up to the river-specific SDL. In the absence of a more detailed, locally-specific investigation, the present SDL-based rules are the most appropriate limit of acceptable change for stream flows in Corner Inlet catchments. Adoption of these SDL-based rules should theoretically minimise the threat of water extraction on the ecological character of the site.

From a groundwater resource perspective, information from the Australian Natural Resources Atlas website indicates that the Seacombe GMA is currently overdeveloped, as total water consumption exceeds the sustainable yield by more than two-fold. Falling groundwater levels near Yarram (Latrobe Aquifer) have been of concern to farmers in recent times, especially during periods of drought (CSIRO 2005). Dewatering activities associated with the offshore extraction of oil and gas

has been identified as an underlying influence for the declining groundwater levels in the region (Hatton *et al*. 2004).

5.1.4 Pollutant Inputs

The main threats to the Corner Inlet Ramsar wetlands in terms of water quality are increased inputs of sediments and nutrients (Ecos unpublished; BL&A 2008; CSIRO 2005; Water Technology 2008). Increased sediment loads lead to increased water column turbidity resulting in lower light levels reaching benthic microalgae living on the sediment surface and seagrass meadows. Although light requirements vary between individual seagrass species, the minimum light requirements are much higher for seagrasses (two to 37 per cent of surface irradiance) than for macroalgae and phytoplankton (one to three per cent) (Lee *et al*. 2007). Therefore, potential impacts associated with decreased light levels may be most detrimental to the seagrass in Corner Inlet. Because seagrasses are important for stabilising the sediment (O'Hara et al. 2002), a decrease in seagrass coverage in Corner Inlet may lead to a negative feedback loop leading to more sediment resuspension and, hence, higher turbidity. Furthermore, the important role of seagrass as a nutrient sink (Connell and Walker 2001) may be impaired by loss of seagrasses. Increased sediment loads may also affect distribution and vegetation patterns of mangroves and saltmarshes by providing new substrate or smothering of mangrove pneumatophores and herbaceous saltmarsh plants (Ecos unpublished).

The main issues associated with increased nutrient input involve an increase in phytoplankton biomass, which may also include toxic blue-green algae such as *Nodularia spumigena*, as is frequently observed in nearby Gippsland Lakes (Stephens *et al*. 2004). The main impacts associated with increased nutrients may include (Ecos unpublished):

- shifts among periphyton, phytoplankton and macrophytes as dominant primary producers (that is, switches across stable states)
- shifts in phytoplankton populations to domination by bloom-forming species that may be toxic or inedible by fish and zooplankton
- decrease in seagrass coverage in favour of an increase in algal mats and biomass of benthic macroalgae
- increase in epiphyte density on seagrasses shading out the seagrass host
- increases in blooms of gelatinous zooplankton
- changes in macrophyte species composition and biomass
- decreases in water transparency and light availability to benthic primary producers
- increase in taste and odour issues
- increased incidence of fish kills
- changes in fish populations to taxa more tolerant of poor water quality
- reductions in amount or quality of harvestable fish or shellfish
- decreased aesthetic and amenity values.

An increase in nutrients could result in excessive growth of algae, leading to potentially deleterious changes including outcompeting of seagrasses, changes to physico-chemical sediment processes

and a reduction in the abundance of benthic infauna that act as prey for fishes and birds (Raffaelli *et al*. 1998).

Corner Inlet (including the Nooramunga area) receives input of nutrients and sediments from several major streams (Franklin, Agnes, Albert and Tarra Rivers, Deep and Stockyard Creeks) and numerous smaller streams. Furthermore, three wastewater treatment plants discharge into Corner Inlet (South Gippsland Water 2002) as well as about 30 stormwater and agricultural drains (Parks Victoria 2005). Raw sewage may be discharged into Corner Inlet from septic systems in Port Welshpool during flooding periods and from boats not equipped with suitable toilets (Parks Victoria 2005). Another potential input of nutrients to Corner Inlet is the discharge of nutrient rich groundwater (Hindell *et al*. 2007).

Since catchment loads are mainly controlled by the prevailing hydrologic conditions, loads are generally higher during wetter periods than drier periods (Water Technology 2008). Catchment and receiving water modelling indicates that dryland agriculture contributes the greatest nutrient loads to Corner Inlet due to the extensive area of this land use in the catchment (Water Technology 2008). Production forests produced the highest sediment and high oxidised nitrogen loads, despite covering a small area of the catchment (22 per cent of the total catchment). Discharges from sewage treatment plants produced high loads of nutrients (particularly phosphorus), but represented a relatively contribution of total pollutant loads to Corner Inlet.

It is important to note that while pollutant loads from the catchment are relatively high, the extensive tidal channel network promotes tidal exchange and flushing within the inlet (see Section 3.6.2). This tidal flushing regime reduces the risk of broad-scale water quality degradation, although as discussed previously, some areas within north and western Corner Inlet appear to be under water quality stress. In particular, die-off of *Posidonia* and possibly the occurrence of blooms of filamentous algae “slub” are consistent with the effects of nutrient enrichment (CSIRO 2005), which has also been reported to occur prior to site listing (Roob *et al*. 1998). Modelling by Water Technology (2008) confirms that under current conditions, the western streams, Foster WWTP, Franklin River, Angnes River and Albert River were producing loads significant enough to influence nearby seagrass beds.

5.1.5 Urban Encroachment and Habitat Modification

There is limited urban development within the site, although the land use change and future development could affect the character of the site. Direct impacts of future urban development include direct vegetation destruction, altered hydraulic regimes due to dredging, reclamation or seawall construction, and habitat fragmentation and associated loss of ecological functions.

Ecos (unpublished) suggests that developments such as canal estates, proposed for places such as Port Albert and Port Welshpool, as well as intensification of urban development currently being experienced in these towns and Foster, Manns Beach, Roberstons Beach and McLoughlins Beach, could result in direct loss of vegetation and habitat value. Furthermore, future developments could increase pollutant loads associated with increased stormwater runoff and increased sewage effluent releases.

Seawalls represent a key agent leading to fragmentation and isolation of littoral habitats from adjacent marine waters (Carey et al. 2007). While habitat isolation due to the presence of existing seawalls are thought to represent an existing threat to breeding success of gummy shark

(*Galeorhinus galeus*) and green-back flounder (*Rhombosolea tapirina*), it is thought that the threat level has stabilised in time, and that tighter planning controls would reduce the likelihood of new seawalls being constructed (Carey et al. 2007). There have also been proposals for removing seawalls, which would reduce the threat level.

5.1.6 Acid Sulfate Soils

Corner Inlet contains soil types classified as acid sulfate prone, most notably tidal flats and recent marine sediments (CSIRO 2005). Examples include soils around Black Swamp Yanakie, Old Hat Road Foster, Toora foreshore and Port Albert.

Acid sulfate soils, which were initially formed under marine conditions, contain iron sulfide layers that when disturbed, may be oxidised resulting in the formation of sulfuric acid. The mobilisation of sulphuric acid can have a range of adverse environmental impacts including (CSIRO 2005):

- acidic run-off reduces the water quality in surrounding waterways
- toxicity to fish, crustaceans and other water species
- reduction in biodiversity of surrounding wetlands
- corrosion of buildings and other infrastructure
- reduced agricultural productivity.

Activities likely to disturb the iron sulfide layer include excavations for urban development, construction of foreshore facilities, and drainage of coastal swamps. CSIRO (2005) did not identify any reports of significant acidic runoff within and adjacent to Corner Inlet, although it was noted that occasional low pH levels may be a consequence of acid sulfate soils.

5.1.7 Oil Spills and Other Incidents

Parks Victoria (2005) noted that there was potential for “devastating effects” of oil spills on the ecological, social and economic values of Corner Inlet. Proposals to develop industrial estates, port facilities and marinas at locations such as Barry Beach, Port Welshpool and Port Albert are likely to increase the risk of spills of oils or other toxicants (Ecos unpublished).

5.1.8 Climate Change

As outlined in GCB (2006), a sea level rise of seven to 55 centimetres is predicted across Western Port, as well as Western and Eastern coastal regions of Gippsland (0.8 to 8.0 centimetres per decade) by 2070. The Gippsland coastal dune systems are erosion prone, and a number of climate change processes could lead to further erosion including increases in sea level, more severe storm surges and high wave actions.

There are two main considerations with respect to identifying potential impacts of sea level rise on Corner Inlet Ramsar site:

- increased erosion. Sea level rise could lead to coastal retreat where sandy beaches are present. Retreat magnitudes vary according to the local beach profile, which is typically in the range 1:50 to 1:100. Consequently, a retreat of between 25 to 50 metres would be expected were sea levels

to rise by 0.5 metres. Such a retreat could impact on the size of some islands in the Nooramunga precinct in particular

- changes in distribution and extent of habitats due to altered water levels. A long-term change in sea level is likely to lead to migration in the positions of the various intertidal vegetation communities as well as in the positions of individual species within each community. A consequence of landward migration of mangroves and saltmarshes in response to sea level rise is "coastal squeeze". In Corner Inlet this may result in the loss of mangrove and saltmarsh vegetation arising from the restriction of landward movement and long term survivability caused by levee banks, seawalls, embankments, public infrastructure such as roads and steeper topographical slopes and gradients (Ecos unpublished)
- impacts to coastal habitats and communities associated with an increase in frequency of storm surges. Changes to the frequency of storm surge events could affect the rate at which coastal habitats and species recover from disturbance, and possibly the distribution and extent of habitats and structure of coastal flora and fauna communities.

While attention to date in terms of climate change in the region has focussed on sea level rise and coastal inundation, other potential climate change impacts are also relevant for the Ramsar site. Particular issues include:

- increased extreme rainfall events associated with climate change given the dominant contribution to extreme water levels and water chemistry is due to elevated stream flow
- lower freshwater inputs
- increased drought and higher temperature between major rainfall events leading to increased evaporation, which could expose and oxidise acid sulphate soils and exacerbate salinity in the shallow marsh environments.

The extent and magnitude of these threats can only be qualitatively described as part of the current study but are significant issues that could affect future ecological values and usage of the site by wetland flora and fauna.

5.1.9 Weeds

Weeds have the potential to cause a number of adverse ecological impacts, including displacement of native flora species and reduced habitat suitability for fauna species. A total of 93 introduced plant species are known to occur within the Ramsar site, many of which pose a serious threat to the site (DSE 2003).

The most notable weed threatening the Ramsar site is spartina (Ecos unpublished). The common name spartina refers to *Spartina angelica* as well as the hybrid *Spartina* x *townsendii*, which are declared noxious pests under Victorian legislation. Spartina is a perennial aquatic grass that invades mudflats and sandy shores on sheltered coastal bays and estuaries (Blood 2001). Spartina is reported to have been widespread in the Ramsar site, but a control program has been successful in reducing infestations (Parks Victoria 2005). Continued management of spartina is essential due to the threats it places on wetland ecosystems, including prevention of mangrove germination, reduced availability of mudflats for waterbird feeding and changes to mangrove tidal inundation regimes (either waterlogging or prevention of inundation, dependent on the scenario).

Intertidal feeding habitat degradation resulting from the spread of spartina is considered to be a significant threat to waterbirds, especially shorebirds. Spartina can form dense swards and can increase sedimentation rates which in turn can negatively affect the growth of mangroves and saltmarshes and the availability of intertidal areas as foraging habitat for waterbirds. This is particularly relevant to migratory shorebirds of the site as it can lead to the loss of foraging habitat because birds are unable to access prey when spartina becomes thick on mudflats (see Melville 1997 and Stralberg et al. 2004). Clemens et al. (2007) notes that Franklin Island was historically used on average by high numbers of shorebirds before a spartina invasion appeared to make the area unsuitable. Interestingly, shorebirds did not return to Franklin Island after spartina was controlled.

Sea spurge (*Euphorbia paralias)* is another notable threat within the Ramsar site. This species invades coastal areas and has the potential to alter dune morphology (Belbin 1999). It is known to occur on a number of islands and beaches within Corner Inlet, where it has the potential to result in breeding failure of Hooded Plover due to forcing this bird species to nest in the storm tide zones (DSE 2003).

The green macroalga *Codium fragile* ssp *tomentosoides* is another weed species of concern. This species was first discovered in Corner Inlet in March 1995 (Trowbridge 1999). *Codium fragile* ssp *tomentosoides* was introduced to south-east Australia in the mid 1990s, presumably via New Zealand (Ecos unpublished). Ecos (unpublished) suggests that it is *"…a pest of cultivated shellfish beds and a serious ecological and economic pest on the north-west Atlantic coast as well as along the shores of southern England and western Ireland".*

Codium fragile ssp. *tomentosoides* has reportedly formed dense populations in Corner Inlet and other locations in Victoria. It is possible that this species could out-compete native marine plants for space and nutrients. On the basis of its known temperature and salinity tolerances, Trowbridge (1999) predicted that *Codium fragile* ssp. *tomentosoides* had the potential to spread to wave-protected bays, lagoons and estuaries from New South Wales to Western Australia.

5.1.10 Feral Pests

Terrestrial

A variety of introduced fauna species are known to occur within the site (Martindale 1982; DSE 2003; Ecos unpublished). These include black rat (*Rattus rattus*), house mouse (*Mus musculus*), common starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), common blackbird (*Turdus merula*), rabbit (*Oryctolagus cuniculus*), red fox (*Vulpes vulpes*), cat (*Felis catus*) and domestic dog (*Canis lupus*). The majority of these introduced taxa have been widely acknowledged as implicit in the degradation of habitat values for both native fauna biodiversity and threatened species.

Of the introduced species recorded on the site, comparatively higher threats to fauna habitat values are linked to the presence of foxes and cats, though also dogs. Threats include disturbance to birds on their feeding grounds, roost and breeding sites, and predation of birds, their chicks and eggs. Such threats to waterbirds, and particularly shorebirds, have been widely acknowledged (for example, Davidson and Rothwell 1993; Environment Australia 1999; Harding and Wilson 2007).

Foxes are known to occur within areas used by shorebirds for feeding, roosting and breeding (for example, Dream, Snake and Little Snake Islands; Clemens et al. 2007). Foxes are known to predate

on birds, their chicks and eggs, and are implicated in local declines of threatened shorebirds including Hooded Plover (Weston 2000 and 2003; Clemens et al. 2007) and pied oystercatcher (Minton 1997; Taylor and Minton 2006; Clemens et al. 2007).

Taylor and Minton (2006) contend that the poor usage of pied oystercatchers within what appears to be suitable nesting habitats on both Snake Island (the largest island within the site) and Little Snake Island, is largely influenced by the presence of foxes (compared with high numbers of oystercatchers recorded on Sunday Island – the only island within the site considered to be free of foxes and other introduced predators such as cats). Pied oystercatchers have been observed to have very low breeding success on islands where introduced foxes have eaten eggs and chicks (Clemens et al. 2007). Note that the bird count data presented in Section 3.3.2 are not of sufficient temporal resolution to detect long term changes in pied oystercatcher abundance in these areas.

Clemens et al. (2007) noted the high potential for threats to shorebirds along beaches and coinciding with human activity - accidental human induced mortality or breeding failure in these areas occurs primarily to well camouflaged eggs or chicks that are killed when they are accidentally stepped on or run over by vehicles. Clemens et al. (2007) also highlighted that domestic dogs, especially when not on a leash can step on or eat eggs and chicks. Thompson (1992) found that the presence of dogs (and humans) can impact on feeding and roosting shorebirds more than 200 metres away.

Invasive Marine Animals

Ecos (unpublished) identified three key invasive marine pest animal species as potential threats in Corner Inlet Ramsar site:

- Northern Pacific seastar (*Asterias amurensis*) - This invasive starfish occurs in mud, sand or rocky habitats, but typically in areas protected from direct wave action. It is a voracious predator and will eat almost any animal it can capture. It is considered a serious pest in Australia because of its impact on native marine ecosystems and marine industries such as shellfish farming (DSE 2007). This species has been recorded at Port Phillip Bay and represents an invasion risk to Corner Inlet. Ongoing survey work is required to detect and remove any infestations of this species within Corner Inlet
- European shore crab (*Carcinus maenas*) – This species has been present at Corner Inlet since the late 19th century (Parks Victoria 2005). It is an extremely tolerant and hardy species, and is found in both the intertidal and shallow subtidal zones of bays and estuaries rather than exposed, rocky or sandy open coasts. *C. maenas* is a voracious predator with a broad diet and has been implicated in the decline of native shellfish populations, some of commercial importance. In the northwest Atlantic it consumes a wide variety of native species, outcompeting most for food and habitat. Based on its invasion history around the world, the impacts that it may have had when it first reached Australia are likely to have been substantial. Similarly, its effects in Corner Inlet are unknown but are likely to have been significant. In Tasmania, *C. maenas* has been present for about 15 years and is a major cause of mortality in native crab and mollusc populations (NIMPIS 2002). Survey work is required to map the extent of their invasion and its impact on the environment
- Mediterranean fanworm (*Sabella spallanzanii*) – this species has become established along the south eastern and south western Australian coastline including Port Phillip Bay. *S. spallanzanii* inhabits shallow subtidal areas between one and 30 metres depth, preferring harbours and

embayments sheltered from direct wave action. It colonises both hard and soft substrata, often anchored to hard surfaces within the soft sediments. *S. spallanzanii* presents a potential invasion risk to Corner Inlet since it is established in similar habitats in other areas elsewhere along the Victorian Coast. Survey work is required to ascertain if there has been an infestation of the species in Corner Inlet.

5.2 Changes to Ecological Character

The National ECD Framework requires ECD studies to assess the extent to which the ecological character of the wetland has changed, with a specific point of reference or baseline from the date of designation into the Ramsar List of Wetlands of International Importance.

Following a review of scientific literature and planning documents relevant to the Corner Inlet Ramsar site, together with information contained within Ecos (unpublished), the study team engaged the Steering Committee members about their preliminary views regarding potential changes to ecological character that have occurred since listing of the site. In particular, the study team sought advice about impacts to those aspects of the site nominated as critical services/benefits and underlying components and processes as outlined in the previous sections of this report.

The literature review and experts have not identified any significant or overarching changes in ecological character of the site since 1982, but recognise that a number of long term threats are having an incremental and cumulative effect on ecological character and require further investigation (refer Section 6.1.1). Likewise, no views were expressed in the information sources reviewed or from the committee members to merit consideration that the ecological character of the site had significantly diminished with respect to the critical services/benefits, components and processes outlined in this study (that is, no LACs are known to have been breached, refer Section 6.1.2).

5.2.1 Key Trends

With regards to threats that are having an incremental and cumulative effect on ecological character, key issues in the context of perceived impacts and potential changes to ecological character of the Ramsar site are discussed as follows:

Localised Die-off of Seagrass Communities

In response to anecdotal reports from commercial fishers of recent seagrass loss, Hindell et al. (2007) examined seagrass at six locations in Corner Inlet since 1998. Analysis of aerial photographs showed that there had been a substantial loss of seagrass in the greater north-western region of Corner Inlet. Specifically, four sites showed considerable loss of seagrass, one site showed an increase in area and one site exhibited no change. Dense seagrass beds, mostly comprised of *P. australis*, were observed to have declined in extent, whereas there was an increase in the distribution of sparse seagrass. Ecos (unpublished) concluded that the reasons for the loss of seagrass were not entirely clear, but were most likely due to high turbidity.

Given the importance of seagrass in supporting the nutrition of animals living in Corner Inlet (demonstrated for fish by Hindell *et al*. 2007), it would be reasonable to suggest that the loss could have lead to changes in fish and prawn recruitment success and possibly productivity. Based on anecdotal reports by Corner Inlet Fisheries Habitat Association (2009), previous losses in *Posidonia*

meadows in 1974 reportedly resulted in major declines in fish catches, to the extent that some commercial fishers could no longer operate. Therefore, there would likely be serious ramifications for the sustainability of estuarine and marine fauna in the inlet should the recently observed seagrass loss continue.

Further investigations are required to determine whether the recent loss of *Posidonia* beds in north and western Corner Inlet could be considered to represent a change to ecological character.

Use and Quality of Habitat for Migratory Waterbirds

Ecos (unpublished) analysis indicates that both migratory species richness and species abundance have remained stable since 1982 (see also section 3.3.2). Two notable exceptions to this are the curlew sandpiper and sharp-tailed sandpiper, though declines in abundance of both species may reflect overall declines across their range resulting from population impacts within other parts of the flyway and on breeding grounds (see Wilson 2001; Gosbell and Clemens 2006) rather than as a consequence of habitat change within the site *per se* (Ecos unpublished). For curlew sandpiper, there are positive signs within the last few seasons of a recovery (VWSG 2008; Ecos unpublished).

It is also possible that orange-bellied parrot has declined, as it has suffered loss at other sites in the region (Orange-bellied Parrot Recovery Team 2006). However, work on this species at Corner Inlet has only just begun and initial observations suggest that good quality habitat exists (C. Tzaros, Birds Australia pers. comm. in Ecos unpublished). The lack of reports may be due more to the small observer effort, especially given the remoteness of sites and it is still possible Corner Inlet represents a stronghold. This is a key data gap on a critically endangered species for which there are several recent records within the Ramsar site.

It is important to note that any changes in bird abundance are likely to be the result of multiple stressors both off and on-site. Off-site impacts that may contribute to decline are the quality and availability of habitat in other nations along the Australasian Flyway as well as the condition of Australia's inland wetland habitats (refer recent article on declines in waterbird presence as part of a long term survey by Nebel *et al*. 2008). On-site impacts may include habitat loss and modification, and increases in frequency of disturbance are also likely contributing factors.

Loss of Mangroves and Saltmarsh

Farmers undertook extensive clearing and draining of lowland coastal fringe habitats around the inlet in the first half of the twentieth century, resulting in loss and fragmentation of intertidal habitats (Glowrey 2009). Denis (1994) examined more contemporary changes within the site, finding that changes in mangrove coverage varied from 1941 to 1987. Some areas such as Millers Landing exhibited minor change, while other areas such as Long Island experienced loss of mangroves, and areas such as Port Welshpool and Toora experienced mangrove expansion. Based on EVC mapping, it is estimated that mangrove extent has declined by approximately 235 hectares within the site between 1750 and 2005, and that saltmarsh extent has declined by approximately 282 hectares within the site between 1750 and 2005, representing a loss of approximately 10 per cent for each of these habitat types. The extent of change that may have occurred since time of listing is unknown, and therefore it is uncertain whether a change in ecological character has been experienced. Baseline studies are required to assess mangrove distribution and monitor future changes in extent.

Water Quality in North West Corner Inlet

There are limited water quality data from the time of listing (1982), although more recent data are available. The Waterwatch program and other awareness campaigns by the CMA, EPA and others, along with improvements to sewerage systems, have improved catchment management practices since 1982 (Ecos unpublished). However, Ecos (unpublished) notes that ongoing development, recreational and commercial pressure on the waterways in the catchment could potentially have offset some of these catchment management improvements.

In the absence of long-term monitoring data it is not possible to determine whether there has been a change in water quality since listing. The most notable line of evidence to suggest that there has been contemporary, long-term change in water quality outside the range of natural variability is the reported loss of *Posidonia* seagrass beds in northwest Corner Inlet in recent times (see discussion above). As *Posidonia* can take decades to recover from disturbance, the loss in seagrass is expected to be symptomatic of contemporary water quality change (that is, nutrients and turbidity) that is outside the range of natural variation. There is a clear need to collect additional water quality data to assess trends over time and space, and potential linkages to anthropogenic disturbances (see Sections 6.1 and 6.2).

Commercial Fish Catches

The commercial catch data presented in Figure 3-9 and Table 3-9 show the following trends:

- There was a decline in catch of two key species over time: Australian salmon (*Arripis* spp.) and yellow-eye mullet (*Aldrichetta forsteri*). In the years leading up to site declaration (1978–83), Australian salmon tended to dominate catches, but declined markedly in 1985–86, and is now ranked ninth in terms of total catch. Similarly, yellow-eye mullet, which represented the third to fourth most abundant species in 1980 to 1983, is presented ranked eighth in terms of total catch. Yellow-eye mullet catches prior to 1999-2000 were with only three exceptions (1978–79, 1983–84, 1993–94) greater than 17 tonnes, but in the eight years since this time, catch ranged from eight to 16 tonnes. Green-back flounder (*Rhombosolea tapirina*) catches also appear to have declined over time, with the twentieth percentile pre-1982 catch less than the median post-1982 catch
- Southern garfish (*Hyporhamphus melanochir*) and King George whiting (*Sillaginodes punctatus*) were ranked second and third respectively in terms of catch in 1978–83, but now dominate catches. These two species had a total catch that was within the range or greater than the post-Ramsar listing catch
- The catch of most other species was generally higher in post 1982 than pre–1982. This was particularly the case for southern calamari (*Sepioteuthis australis*) and rock flathead (*Platycephalus laevigatus*).

The differences in catch over time could relate to either changes in fishing effort, or changes in actual abundance of these species. In Table 3-8, catch per unit effort was calculated to determine possible influence of effort of catch. Notwithstanding the limitations of effort-based data, these results again indicate that there was a decline in Australian salmon and flounder catches. However, median yellow-eye mullet catches was similar before and after site listing, indicating that changes in catches were effort driven.

There is no empirical evidence to suggest that Australian salmon stocks in Australia are diminishing, although the fishery is considered to be fully exploited (NSW Industry and Development 2010). Australian salmon is a wide ranging species that does not rely on habitats that are in decline (for example, seagrass), and elsewhere stocks are thought to be secure. At the other three locations where this species is harvested in Victoria, catches show either no clear trend (for example, Port Phillip Bay), an increase (Gippsland Lakes) and decline (Western Port Bay) (DPI 2008). The main commercial use of this species is as bait for Rock Lobster fishery, which itself has been subject to significant regulatory changes post–2001. The change in catch of Australian salmon may be in response to these changes in fisheries regulations, or changes in other market sectors.

In the context of school sharks (*Galeorhinus galeus*), there is very little available information on their population status within the site. As discussed in Section 5.1.5, it is thought that building of seawalls in the 1920s resulted in isolation and fragmentation of pupping habitat, to the extent that shark numbers in Corner Inlet have markedly declined. All Victorian coastal waters are closed to targeted shark fishing (AFMA 2009), however any sharks incidentally captured are sold to market. Figure 3-9 shows that shark catches within the site have been variable over time, but show no clear trend between 1978 and 2008.

5.2.2 Comparison to Limits of Acceptable Change

Table 5-2 provides a summary of changes in ecological character, as described by LACs, since nomination. Comment is also provided on trends in LAC pre-listing in order to determine whether changes are a consequence of longer-term or contemporary impacting processes. Changes are subjectively ranked as likely or unlikely based on professional opinion or in some instances empirical data.

Table 5-2 Comparison of LACs to Observed Trends Post-Ramsar Listing

Critical C/P/S	Limits of acceptable change	Pre–1982 trend	Post–1982 trend
C1	**Inlet waters** • A greater than 20 percent reduction in the extent of permanent saline wetland – intertidal flats (areas mapped by DSE = 40 479 hectares), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 36 431 hectares). • A greater than 20 percent reduction in the extent of subtidal channel (areas mapped by NLWRA = 16 349 hectares), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 13 079 hectares).	No data to quantify changes No large scale works (for example, training wall construction, dredging, sand extraction) have been undertaken that would cause a major change to extent.	Ecological Character Change unlikely. See pre–1982.
	Seagrass • Total mapped extent of dense *Posidonia* will not decline by greater than 10 percent of the baseline value outlined by Roob *et al*. (1997) at a whole of site scale (baseline = 3050 hectares;	Major declines in *Posidonia* have been recorded over time, most notably the 1930s and 1974.	Unknown. Reduction in *Posidonia* density/cover recorded in north west Corner Inlet between 1998 and 2007. However, no data available on changes in overall extent.

Critical C/P/S	Limits of acceptable change	Pre–1982 trend	Post–1982 trend

	LAC = mapped area less than 2745 hectares) on any occasion.
	• Total mapped extent of the dense and medium density Zosteraceae will not decline by greater than 25 percent of the baseline values outlined by Roob *et al*. (1998) at a whole of site scale on two sampling occasions within any decade.
	  • Dense *Zostera* - Baseline = 5743 hectares (LAC = mapped area less than 4307 hectares)
	  • Medium *Zostera* - Baseline = 1077 hectares (LAC = mapped area less than 807 hectares)		

	Mangroves • Based on EVC mapping, it is estimated that mangroves presently cover an area of 2137 hectares within the site. A 10 percent reduction in the total mapped mangrove area, observed on two sampling occasions within any decade, is an unacceptable change. (LAC – mapped area less than 1924 hectares).	EVC mapping indicates approximately 10 percent loss in mangroves/ saltmarsh since 1750.	Unknown. Post–1982 trend not quantified
	Saltmarsh • Based on EVC mapping, it is estimated that intertidal marshes presently cover an area of 6500 hectares within the site. A 10 percent reduction in the total mapped saltmarsh area, observed on two sampling occasions within any decade, is an unacceptable change (LAC – mapped area less than 149 hectares).		
C2	• Mean annual abundance of migratory bird species - Birds Australia (2009c) note that a maximum annual abundance of migratory species of 42 811 birds, with a mean annual abundance of migratory species being 31 487 birds. The annual abundance of migratory shorebirds will not decline by 50 per cent of the long-term annual mean value (that is, must not fall below 15 743 individuals) in three consecutive years.	Limited data	Ecological Character Change unlikely. While some species have declined (see below), there is no evidence to suggest that the overall average total count has declined by 50 per cent in three consecutive years.
	• Mean annual abundance of species that meet the one per cent criterion will not be less than 50 per cent of the long-term annual mean value in five years of any ten year period. These values are follows: o curlew sandpiper – baseline =	See component above	Unknown. Most bird numbers have remained stable since 1982, although declines are evident for curlew sandpiper and sharp-tailed sandpiper. The trend for this latter species, however, has altered, with increases in their numbers being recorded since 2002 (Ecos

Critical C/P/S	Limits of acceptable change	Pre–1982 trend	Post–1982 trend
	2588 birds, LAC = 1294 birds o bar tailed godwit – baseline = 9727 birds, LAC = 4863 birds o eastern curlew – baseline = 1971 birds, LAC = 985 birds o pied oystercatcher – baseline = 893 birds, LAC = 446 birds o sooty oystercatcher – baseline = 285 birds, LAC = 142 birds o double-banded plover– baseline = 523 birds, LAC = 261 birds		unpublished). The decline in curlew sandpiper numbers reflects an overall decline across their range (including south-eastern Australia) and therefore, is unlikely to be a consequence of a change in habitat at Corner Inlet. It is possible that it is being adversely affected by flyway condition or breeding success in its breeding habitats of north-eastern Siberia and Alaska.
P1	• A greater than 50 percent reduction in nesting activity at key nesting sites for fairy tern, hooded plover, Caspian tern, crested tern is an unacceptable change	No available data	Unknown
S1	• An unacceptable change would have occurred if either growling grass frog, orange-bellied parrot or Australian grayling no longer supported	All species are threatened, primarily due to long term habitat loss and degradation throughout their range.	Ecological Character Change unlikely due to site specific threats.
S2.	• Median abundance of key fisheries species will not fall below the 20th percentile baseline value over a five year period.	Like other estuaries, abundance of most fish species is likely to have declined in response to habitat loss and degradation, fishing and altered flow regimes (both within and external to site).	Ecological Character Change unlikely. Some declines in catch per unit effort of Australian salmon and green-back flounder (see Table 3.9), although the LAC value was not exceeded. There is no evidence that stocks of these species are in decline.

6 INFORMATION GAPS, MONITORING AND EDUCATION

6.1 Information Gaps

The ECD preparation process promotes the identification of information or knowledge gaps about the Ramsar site that are principally derived through interrogation of the nominated ecosystem services/benefits, components and processes and associated understanding of natural variability and limits of acceptable change.

In general, data and information gaps have been identified in this ECD in three broad areas:

- in relation to the natural variability and LACs for critical wetland habitats and species (as outlined in Sections 4 and 5.2, particularly for those attributes/controls where there are no data
- in relation to lack of information and data to support a more detailed assessment of ecological character change at a whole of site and individual waterbody/wetland scale (refer Section 5.1)
- in the context of the discussion of each of the critical services/benefits in the detailed ecological character description section (refer Section 3.3).

In analysing the information gaps identified in these three sections of the ECD, the following thematic information gaps are identified as priority areas for future investment:

- Baseline water quality characteristics within representative habitats throughout the site. In particular, inclusion of nitrogen species in routine monitoring and additional monitoring of wastewater treatment plants are seen as priorities (Water Technology 2008). This is considered to represent the most critical information gap in terms of identifying potential future impacts to most critical components and services/benefits
- Further investigation into the high nutrient concentrations in the Yanakie region
- Additional research and monitoring expenditure to establish an ecological character baseline for the key waterbodies/wetland habitats, with a priority on habitats such as seagrass and fringing littoral vegetation, which support important flora and fauna species, habitats and life-history functions (for example, breeding sites, roosting sites, spawning sites, etc.) that are at most risk of future ecological change
- Comprehensive seagrass mapping was undertaken by Roob et al. (1998) for the site and used for comparative purposes as part of more recent condition assessments (as documented by Hindell 2008). However, the primary purpose of this has been to assess the impact and recovery of seagrass (in terms of extent and density) from algal blooms in the lakes as opposed to repeating Roob et al.*'s* broad-scale resource mapping exercise (Hindell 2008)
- In terms of wetland flora, mapping layers for both the Victorian Wetland Classification System (VWCS) and Ecological Vegetation Classes (EVC) were made available to the study team. However, as previously mentioned, the classification systems on which these mapping layers are based do not have direct equivalents to Ramsar wetland types. As such, it is difficult to quantify the distribution and extent of Ramsar wetland types within the site. Furthermore, there is limited specific information on the condition of individual wetlands and/or areas within the site.

- The need for better information and data sets about the presence and natural history of critical wetland species and their habitat; and more systematic surveys of important avifauna and fish species and populations. Surveys should focus on quantifying patterns in the abundance of waterbirds, as well identifying important areas and site usage by threatened wetland-dependent fauna species that are known (that is, growling grass frog, Australian grayling, orange-bellied parrot) or highly likely (for example, Australasian bittern) to occur in the site
- Better information and understanding about the natural variability of critical wetland fauna populations and key attributes and controls on those populations (including whether or not any non-avian fauna species meet the one per cent population requirement in Ramsar nomination criterion 9)
- More specific assessment of the vulnerability of the site to the impacts of climate change and adaptation options that could be explored to reduce the impacts
- The Nooramunga barrier islands and sandy dune systems are highly susceptible to erosion and impacts associated with climate change related increases to sea level and increased wave energy. There is currently no data describing sediment movements and long-term shoreline changes to identify climate change impacts
- Recorded information on waterbird counts were undertaken at only a few sites, or only for a short period of time, or were collected in a manner that is not directly comparable across different years or sites, or had gaps where monitoring/counting was not undertaken at all (refer data review in Appendix C). The population of waterbirds in Corner Inlet has been relatively low since 1982, with the variations that can be observed over this time strongly correlated with rainfall. Curlew sandpiper have shown a decline over time, however the reason for this is not known and requires further investigation
- LACs are difficult to assess for fish because of their high variability in abundances and recruitment. Furthermore, there are no systematic data available to assess trends over time. This is an important gap in the context of assessing (i) potential future changes to Australian grayling; and (ii) trends in commercially significant species.

6.2 Monitoring Needs

The Corner Inlet Ramsar Site Ecological Monitoring Program Brett Lane and Associates (2008) provided an overview of 34 existing and historical monitoring activities within the Corner Inlet Ramsar site, the majority based around water quality and waterbirds. There were significant gaps identified in the monitoring programs currently underway.

In the context of the site's status as a Ramsar site and in the context of the current ECD study, the primary monitoring needs relate to the need to assess the suitability of limits of acceptable change (versus natural variability) and to assess more definitively if changes to ecological character have occurred or are being approached. Principally, this monitoring should relate to:

- Broad-scale observation/monitoring of wetland habitat extent at representative wetland types within the site (noting that a logical precursor to this would be to establish a better correlation between Victorian wetland mapping and the Ramsar wetland type classification system).
- Habitat condition monitoring which should occur both as:

    - long term analysis of vegetation community structure including identified trends in vegetation patterns in the freshwater fringing wetlands (particularly on the barrier islands); estuarine fringing wetlands (mangroves and saltmarsh); and seagrass meadows (focussing on *Posidonia*, but also other more transient species)
    - monitoring underlying wetland ecosystem processes such as hydrological process (both surface and groundwater), water quality and surrogate biological indicators for these processes

- More targeted surveys of the threatened flora and fauna species (perhaps on a five year or ten year basis) to assess presence/absence or population changes of noteworthy species or communities identified in the critical components. Specifically this should target presence and usage of the site (at various spatial scales) by growling grass frog, orange-bellied parrot and Australian grayling (see Critical Service/Benefit 1)
- More regular counts of all waterbirds in accordance with the monitoring regime envisioned by the LAC (refer Critical Component 2)
- More regular counts of breeding waterbirds at identified breeding colony sites (refer location and description of sites in the discussion of critical Process 1)
- Continued and more intensive survey and monitoring of recreationally and commercially important fish stocks including key nursery area and spawning sites (refer Critical Service/Benefit 2).

Brett Lane and Associates (2008) provides a comprehensive monitoring plan to address many of these information gaps.

6.3 Communication, Education, Participation and Awareness Messages

Under the Ramsar Convention a Program of Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. At the Conference of Contracting Parties in Korea in 2008, a resolution was made to continue the CEPA program in its third iteration for the next two triennia (2009 – 2015).

The vision of the Ramsar Convention's CEPA Program is: "People taking action for the wise use of wetlands." To achieve this vision, three guiding principles have been developed:

- The CEPA Program offers tools to help people understand the values of wetlands so that they are motivated to become advocates for wetland conservation and wise use and may act to become involved in relevant policy formulation, planning and management
- The CEPA Program fosters the production of effective CEPA tools and expertise to engage major stakeholders' participation in the wise use of wetlands and to convey appropriate messages in order to promote the wise use principle throughout society
- The Ramsar Convention believes that CEPA should form a central part of implementing the Convention by each Contracting Party. Investment in CEPA will increase the number of informed advocates, actors and networks involved in wetland issues and build an informed decision-making and public constituency.

The Ramsar Convention encourages that communication, education, participation and awareness are used effectively at all levels, from local to international, to promote the value of wetlands.

A comprehensive CEPA program for an individual Ramsar site is beyond the scope of an ECD, but key communication messages and CEPA actions, such as a community education program, can be used as a component of a management plan.

One of the ten objectives of the strategic management plan for the Corner Inlet Ramsar site, Objective 8, is to 'promote community awareness and understanding and provide opportunities for involvement in management' (DSE 2003). The management objective is supported by four site management strategies in the management plan.

Key CEPA messages for the Ramsar site arising from this ECD, which should be promoted through this objective and associated actions, include:

- The site is a wetland of international importance based on the critical and supporting components, processes and services/benefits (C/P/S) that it provides, as described in this ECD
- The critical and supporting components, processes and services/benefits include the range of natural values under which the site has been listed as a Ramsar site as well as important social and scientific/research values
- The site provides habitat for threatened species and communities at the State, National and International level
- Most of the site is managed for conservation purposes. Most existing and future major threats are due to activities within the site's catchments located outside the site.
- Given the current and future threats, the site requires improved ecological understanding for proper management and more detailed monitoring of changes to ecological character
- The site is managed following a joint management approach that engages landowners, land managers and site users in a manner that aims to maintain its ecological condition.

Key stakeholders responsible for the communication of this central message include managers and site users, regulators, advisors and funders, and the broader community, as shown in Table 6-1.

Table 6-1 Stakeholder Groups of the Relevance to the Corner Inlet Ramsar Site

Stakeholder Group	Stakeholders
Managers and Users	West Gippsland CMA Parks Victoria South Gippsland Shire (including relevant Committees of Management) Wellington Shire (including relevant Committees of Management) Department of Sustainability and Environment Gippsland Ports Department of Primary Industries South Gippsland Water Authority Gippsland Coastal Board Landholders Corner Inlet Fisheries Association
Regulators	Environment Protection Authority DSEWPAC (EPBC) Department of Sustainability and Environment Department of Primary Industries (Fisheries)
Advisors and Funders	Australian Government – DAFF and DSEWPAC Consultants and Contractors Universities and Researchers: CSIRO University of Melbourne Monash University
Broader Community	Landholders Environment Victoria Birds Australia - Victoria Commercial Fishing Industry General Public

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8 GLOSSARY

Acceptable change, means the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. Acceptable variation is that variation that will sustain the service, component or process to which it refers.

Aquatic/marine fauna, the context of this report relates to fauna species that spend all or the majority of their life cycle in or underwater. As such this grouping primarily relates to fish, marine reptiles, aquatic mammals such as dugong and cetaceans, and aquatic/marine invertebrates.

Ecological character, defined under Resolution IX.1 Annex A: 2005 of the Ramsar Convention as, the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

Epiphytes, means algae, larger in size than periphyton, that grows on seagrass leaves.

IMCRA bioregion, refers to the Interim Marine and Coastal Regionalisation for Australia (Mesoscale) to the 200 meter isobath and derived from biological and physical data, (for example, coastal geomorphology, tidal attributes, oceanography, bathymetry and intertidal invertebrates).

Microphytobenthos, means the surface biofilms of photosynthetic micro-algae and bacteria.

National ECD Framework, refers to the document entitled, 'National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands – Module 2 of the National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia' (DEWHA 2008) and its successive documents as endorsed by the Natural Resource Management (NRM) Ministerial Council.

Periphyton, means thin biofilms of microbes growing on seagrass leaves.

Ramsar Nomination Criteria, refers to the nine criteria for the listing of a site as internationally significant under the provisions of the Ramsar Convention. Also referred throughout the report as the nomination criteria for the site.

Resident species, in the context of waterbirds, are species that remain permanently in Australia but undertake localised migrations often in response to seasonal or climatic events.

Sedimentation, means the process of deposition of sediment of any size. This is often colloquially referred to as siltation, but this term implies that only silt-sized material is deposited.

Shorebirds, as used in this report, refers to both resident and migratory species which are ecologically dependent upon wetlands from the following families: Scolopacidae; Burhinidae; Haematopodidae; Recurvirostridae; Charadriidae; and Glareolidae. Shorebirds form a sub-set of the waterbird grouping.

Values, means the perceived benefits to society, either direct or indirect that result from wetland functions. These values include human welfare, environmental quality and wildlife support.

Waterbirds, as used in this report, refers to those species which are ecologically dependent upon wetlands from the following families: Anseranatidae, Anatidae, Podicipedidae, Anhingidae, Phalacrocoracidae, Pelecanidae, Ardeidae, Threskiornithidae, Ciconiidae, Gruidae, Rallidae, Scolopacidae, Rostratulidae, Jacanidae, Burhinidae, Haematopodidae, Recurvirostridae, Charadriidae, Glareolidae, Laridae and Sternidae (after Kingsford and Norman 2002; Wetlands International 2006). Only those species of gulls (Laridae) and terns (Sternidae) which make extensive use of shallow, inshore waters or inland wetlands are included. Whilst at least some other species of other families traditionally regarded as “seabirds” (that is, Spheniscidae, Phaethontidae, Sulidae, Fregatidae, Stercorariidae and Alcidae) also make use of shallow, inshore waters (and thus could be therefore be considered as waterbirds), these have not been included in the waterbird group (following precedent within Wetlands International 2006).

Wetlands, is used in this report in the context of the definition under the Ramsar Convention which includes, 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 six metres.

Wetland-dependent terrestrial fauna, in the context of this report relates to fauna species that occur within or otherwise are dependent on wetland habitats but do not spend the majority of their life cycle underwater (for example, non-aquatic species). As such this grouping primarily relates to birds, amphibians such as frogs, non-aquatic mammals such as water mouse, non-aquatic reptiles and terrestrial invertebrates.

Wetland flora, in the context of this report relates to flora species that are characterised as wetland or wetland-dependent species or populations.

Wetland ecosystem components, as defined in the National ECD Framework, are the physical, chemical and biological parts or features of a wetland.

Wetland ecosystem processes, as defined in the National ECD Framework, are the dynamic forces within the ecosystem between organisms, populations and the non-living environment. Interactions can be physical, chemical or biological.

Wetland ecosystem benefits or services (includes the term ecosystem services), as defined in the National ECD Framework, are the benefits that people receive from wetland ecosystems. In general, benefits and services are based on or underpinned by wetland components and processes and can be direct (for example, food for humans or livestock) or indirect (for example, wetland provides habitat for biota which contribute to biodiversity).

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APPENDIX A: DETAILED METHODOLOGY

This ECD report has been prepared by a consultant study team led by BMT WBM Pty Ltd under contract with the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). This has occurred with input from a Project Steering Committee made up of officials from DSEWPaC, the Victorian Department of Sustainability and the Environment (DSE), Parks Victoria (Parks Victoria), the Gippsland Coastal Board (GCB), the Department of Defence (DoD) and the West Gippsland Catchment Management Authority (WGCMA).

This report updates and replaces an unpublished draft ECD document for the site prepared by the Ecos Consortium (Ecos unpublished). However, the draft Ecos document was regarded as an important source of technical information about the site and where appropriate, figures, data analysis and conclusions drawn from the draft Ecos document have been referenced in this ECD report.

A1 Steering Committee

A Steering Committee was created as part of the study and was chaired independently. The organisations represented on the Steering Committee were as follows:

Department or Organisation
Independent Chair
Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)
Department of Sustainability and Environment (DSE)
Parks Victoria
Department of Defence
Gippsland Coastal Board
West Gippsland Catchment Management Authority

A2 Methodology – Information Collation and Review Stage

The first step in ECD preparation as outlined in the National ECD Framework is to identify the wetland services/benefits, wetland components and wetland processes present in the Ramsar site. These key terms are defined in Section 3 of the Report and the Glossary. This was initiated by undertaking a process of information collation and literature review.

As part of the information collation phase, literature and existing data relevant to the study area (site boundary and surrounds) were collated and reviewed. Relevant existing information was sourced from the following:

- published scientific papers
- database records (EPBC, DSE, etc.)
- quantitative data (Birds Australia, Victorian EPA, etc.)
- mapping products supplied by the DSE and Parks Victoria (vegetation and wetland mapping)

- management plans, strategies and other policy documents
- grey literature from internet searches and other sources of data.

Each article of information was collated to a cursory level sufficient to determine its relevance to the study. The collected information was then reviewed to prioritise and identify information of direct relevance to the ECD.

As part of the information collation phase, key information sources to be used in the study were presented to the project Steering Committee and gaps were identified on the basis of these reviews. In some cases, additional information was supplied directly by Steering Committee representatives.

A3 Selection of Critical Components, Processes and Services/Benefits

A wide range of ecosystem components, processes and services/benefits were seen as being represented within the Ramsar site. Following the method within the National ECD Framework, the assignment of a given wetland component, process or service/benefit as critical was determined with reference to the following criteria:

- The component, process or service/benefit is an important determinant of the uniqueness of the site, or is widely accepted as representing a particularly outstanding example of an environmental value supported by the site.
- The component, process or service/benefit is important for supporting one or more of the Ramsar Nomination Criteria under which the site was listed.
- A change in a component, process or service/benefit is reasonably likely to occur over short or medium times scales (less than 100 years).
- A change to the component, process or service/benefit would result in a fundamental change in ecological values of the site.

The views of the Steering Committee were also considered in the assignment of critical elements. Justification for inclusion of critical and supporting components, processes or services/benefits is provided in the body of this report.

In selecting key species/groups that underpin critical components, the following methods were considered:

Flora Species

In nominating particular wetland flora species or communities for consideration under the critical components, the following considerations were applied:

- Species should generally occur in aquatic environments (for example, macrophytes) or are otherwise considered to be wetland-associated species or communities.
- Species or communities should be listed as threatened (that is, vulnerable or endangered) at the national (threatened under EPBC Act) and/or international (IUCN) level or are considered to be particularly noteworthy or critical from a regional biodiversity perspective (refer to Nomination

Criterion 3). This includes species or communities that are perceived by the authors to be iconic to the site, or are designated as threatened under Victorian legislation (endangered or vulnerable at a State/Territory scale).

Fauna Species

In nominating particular fauna species/groups for consideration under the critical components, the following considerations were applied:

1. Species should generally occur in aquatic or marine environments or are otherwise considered to be wetland-dependent terrestrial species (refer Glossary for definitions of these terms and Appendix C for list of species).
2. Species should be either:
    - designated as threatened (for example, endangered or vulnerable) at a national scale (under the EPBC Act) or international scale (under IUCN Red List)
    - particularly noteworthy or critical from a regional biodiversity perspective. This includes species that are perceived by the authors to be iconic to the site, or are designated as threatened under Victorian legislation (endangered or vulnerable at a State/Territory scale).
3. Given the boundaries of the Ramsar site are largely confined to near-shore areas or internal waters, emphasis has been placed on inclusion of those species that use the site as core habitat, have significant population numbers and spend a large proportion of their life cycle within the site boundaries. This excludes vagrant species of conservation significance such as whales, sharks and migratory seabirds that may only occur in the Ramsar site infrequently but for which species records within the site exist.

A4 Derivation of Limits of Acceptable Change

Limits of Acceptable Change were derived using a staged approach as follows:

- determine values of the site. These represent the critical components and/or services/benefits
- identify critical processes underpinning site values
- describe patterns in natural variability in critical components, processes and services/benefits indicators
- define the relative magnitude of acceptable change. The relative magnitude of acceptable change was determined on the basis of (i) an assessment of criticality of the site to the maintenance of species populations or habitats, based on known or likely patterns in geographic distribution, abundance and criticality of the site to maintaining the survival of a species; (ii) patterns (short-term and long-term) in natural variability; and (iii) a qualitative assessment of the vulnerability of changes outside bounds of natural variability
- derive specific limits of acceptable change. The broad relative magnitude of acceptable change definitions was used to describe specific limits of acceptable change.

The specific values of the site was determined on the basis of (i) known or likely patterns in the distribution and abundance of species and habitats that comprise the critical components, processes and services/ benefits of the site, and (ii) expert opinion and or empirical data describing the criticality of the site to maintaining the survival of a species. Three levels of criticality were derived based on these factors (Least, Moderate and Highest Concern), as described in Table A-1 below.

Table A-1 Categories Describing Importance of the Site to Maintaining Habitats and Species that Underpin the Critical Services/Benefits and Components

Distribution and criticality to populations	Abundant	Uncommon
Widespread globally and nationally, life-history functions supported in many areas elsewhere (species).	1a	2b
High diversity feature (habitat and community descriptor).	1b	2c
Habitat specialist with disjunct and very limited number of populations globally and nationally (species).	3a	3d
May be widespread nationally or regionally but is a critical breeding, staging or feeding site that is critical to survival of population (habitat and species).	3b	3e
Limited to bioregion but found in numerous basins, and is not known to be critical to survival of a species (habitat and species).	2a	3f
Limited to bioregion, found in a small number of basins and has limited distribution in the site (species).	3c	3g

Where least concern = 1 (green), of concern = 2 (yellow), most concern = 3 (orange)

The relative magnitude of acceptable change was then determined based on:

- The categories describing site values/importance described in Table A-1 above.
- Whether species/habitats that underpin the critical components or services/benefits are known or likely to be highly sensitive/intolerant to changes in environmental conditions.
- Known/likely patterns in natural temporal variability of indicators in the short-term (based on inter-annual cycles or episodic disturbance) and long-term (based on processes operating over time scales measured in decades).
- A high level qualitative assessment of the consequences associated with changes in parameters outside natural variability was undertaken. Five consequence categories were derived, and are based in part on general risk categories developed by the SCFA – FRDC Project Team (2001) for the Risk Assessment Process for Wild Capture Fisheries (Version 3.2) (refer Table A-2).
- Consideration of patterns in natural variability, site values/importance and the consequence ratings for assessing sensitivity to change were used to derive three relative magnitudes of acceptable change categories: (i) no change; (ii) small change; (iii) moderate to large change. These are shown in Table A-3.

Table A-2 Defining Impact Magnitude

Category	Habitat affected/modified	Key species	Ecosystem functioning
Major	greater than 60 per cent habitat	Mortality likely local extinction.	Total ecosystem collapse.
High	30 to 60 per cent	Mortality may affect recruitment and capacity to increase.	Measurable impact to functions, and some functions are missing/ declining/ increasing outside historical range and/or facilitate new species to appear.
Moderate	five to 30 per cent	Mortality within some spp. Levels of impact at the maximum acceptable level.	Measurable changes to ecosystem components but no loss of functions (no loss of components).
Minor	less than five per cent	Affected but no impact on local population status (for example, stress or behavioural change to individuals).	Keystone species not affected, minor changes in relative abundance.
Negligible	less than one per cent	No impact.	Possible changes, but inside natural variation.

Table A-3 Magnitude of Acceptable Change Categories for LAC Indicators

Impact Significance	Level 3 species or habitat	Level 2 species or its habitat		Level 1 species or its habitat			
		Short-term, localised	Long-term or multiple areas	Short-term, localised	Short-term, multiple areas	Long-term, localised	Long-term, multiple areas
Major	No change	No change	No change	No change	No change	No change	No change
High	No change	No change	No change	Moderate change	No change	No change	No change
Moderate	No change	Small change	No change	Moderate change	Small change	Small change	No change
Minor	No change	Moderate change	Small change	Moderate change	Moderate change	Moderate change	Small change

APPENDIX B: NLWRA (2001) DATABASE RESULTS FOR ESTUARIES IN THE IMCRA BIOREGION

STATE	ESTUARYNAME	DLAT	DLONG	CONDITION	CLASSIFICATION	BARRIER_BACKBARRIER	CENTRAL_BASIN	FLUVIAL_BAYHEAD_DELTA	FLOOD_EBB_DELTA	INTERTIDAL_FLATS	MANGROVE	SALTMARSH_SALTFLAT	TIDAL_SANDBANKS	CHANNEL
VIC	CORNER INLET	-38.781	146.484	largely unmodified	tide dominated	10.71301			10.81198	387.10413	18.59332	65.51435	6.89234	163.49541
VIC	WESTERN PORT BAY	-38.429	145.216	modified	tide dominated			4.13857	3.46703	90.57019	15.36289	29.65951	3.69584	577.74547
VIC	ANDERSON INLET	-38.65	145.721	modified	wave dominated	0.4693		0.83757	2.71268	13.25415	0.96114	5.58578	0.21311	7.7043
VIC	SHALLOW INLET	-38.871	146.184	largely unmodified	wave dominated	2.99533			0.42845	7.04799		11.67968	0.11473	2.98393
VIC	JACK SMITH LAKE	-38.497	147.04	near pristine	wave dominated		1.27068	0.14518	0.91885	6.17077		5.17006		0.53759
VIC	MALLACOOTA INLET	-37.569	149.763	near pristine	wave dominated	0.86063	19.76209	1.87327	0.95698	3.86887		1.00609	0.06924	5.77364
NSW	CLYDE RIVER/BATEMANS BAY	-35.747	150.255	largely unmodified	tide dominated			5.20938	1.24143	3.68788	0.90927	1.35359	0.02039	45.55038
NSW	JERVIS BAY	-35.107	150.787	largely unmodified	tide dominated	0.17871		1.0786	0.07506	3.28999	1.87997	3.5002	0.13338	120.71644
VIC	BARWON RIVER	-38.286	144.501	modified	wave dominated	0.3792	8.33747	0.48088	0.43088	1.91563	0.22153	11.98214		2.02118
VIC	SYDENHAM INLET	-37.781	149.017	largely unmodified	wave dominated	0.54957	9.91461	0.67093	0.1674	1.44033		7.11582		0.94002
VIC	LAKE TYERS	-37.859	148.088	largely unmodified	wave dominated	0.30295	7.49772	0.44372	0.83073	1.29182		1.58591		2.04442
VIC	SNOWY RIVER	-37.805	148.557	modified	wave dominated	0.99424	5.03053	0.38535	0.31979	1.2373		6.04228		3.87305
NSW	SAINT GEORGES BASIN	-35.184	150.594	modified	wave dominated	16.06281	34.54946	3.75395	0.56961	1.22626	0.09454	0.93989	0.27947	2.65214
NSW	LAKE BROU	-36.137	150.124	largely unmodified	wave dominated	0.50971	1.74297	1.76547	0.531	0.95947		0.00604		0.27808
NSW	CULLENDULLA CREEK	-35.703	150.209	largely unmodified	tide dominated				0.20505	0.9198	0.1182	0.24258		0.19495
NSW	SHOALHAVEN/CROOKHAVEN RIVER	-34.9	150.763	extensively modified	river dominated	3.00039	1.43382	101.68148	4.4895	0.84879	3.21867	2.62498		19.69845
NSW	MORUYA RIVER	-35.905	150.151	modified	wave dominated		0.3791	2.37487	1.70689	0.79536	0.08839	0.35583	0.73518	2.15223
NSW	DURRAS LAKE	-35.639	150.305	near pristine	wave dominated	0.18495	2.29098	0.38839	0.24	0.78469		0.36093		0.36584
VIC	GLENELG RIVER	-38.061	140.984	modified	wave dominated	0.05892	0.40564		0.15887	0.74842		0.66133		0.66276
NSW	TUROSS LAKE	-36.067	150.132	modified	wave dominated	0.53911	5.62781	17.69419	1.74876	0.55731	0.27517	0.93264	0.89186	5.34083
NSW	BEGA RIVER	-36.706	149.984	modified	wave dominated	1.79346	0.37899	1.29864	0.34935	0.5358	0.04052	0.02586	0.12513	2.73705
NSW	PAMBULA LAKE	-36.948	149.916	largely unmodified	wave dominated		1.50871	4.97362	0.66084	0.52338	0.26755			1.35659
NSW	TABOURIE LAKE	-35.438	150.411	modified	wave dominated	1.32074	0.71653	0.31927	0.28981	0.47685		0.40452		0.53255
NSW	WAGONGA INLET	-36.214	150.132	modified	wave dominated	0.13062	4.17188	1.22045	1.54613	0.42762	0.06338	0.01459		0.53121
VIC	HOPKINS RIVER	-38.399	142.509	modified	river dominated	0.04896	0.25273		0.03891	0.4208		0.30376		1.32503
VIC	TAMBOON INLET	-37.779	149.148	largely unmodified	wave dominated	0.30325	5.74239	0.40109	0.01528	0.38371		1.66415	0.08147	0.97658
VIC	WINGAN INLET	-37.749	149.513	near pristine	wave dominated	0.06507		0.11934	0.28279	0.37995		0.73667		0.71609
NSW	SWAN LAKE	-35.201	150.561	largely unmodified	wave dominated	1.67602	4.12464		0.9245	0.37213		0.08629		0.18055
NSW	TWOFOLD BAY / EDEN	-37.078	149.947	modified	tide dominated	1.24387	0.53852	4.17022	1.33063	0.35338	0.02259	0.30641	0.2425	34.45343
NSW	LAKE CONJOLA	-35.269	150.508	modified	wave dominated	1.85494	4.64153	0.61758	0.77924	0.33817	0.31331	0.03405		0.80382
VIC	MOYNE RIVER	-38.384	142.242	modified	wave dominated		0.8029	0.26745	0.02379	0.31764		0.50733	0.01364	0.27154
NSW	WOLLUMBOOLA LAKE	-34.94	150.776	largely unmodified	wave dominated	2.6167	4.93458	0.76852	0.55523	0.31638	0.04439			0.21167
NSW	MERIMBULA LAKE	-36.896	149.922	modified	wave dominated	2.99472	2.26939	0.56467	2.02111	0.30402				0.4263
NSW	NARRAWALLEE INLET	-35.302	150.475	largely unmodified	wave dominated	0.58307			0.20642	0.2777	0.24737	0.71278		0.40903
NSW	BERMAGUI RIVER	-36.425	150.065	modified	wave dominated	0.20377	0.19928	0.97496	0.39799	0.27543	0.43458	0.3467		0.63618
NSW	COILA LAKE	-36.048	150.139	modified	wave dominated	1.50359	6.1651	0.70075	0.38347	0.27522		0.05586		0.10125
NSW	MINNAMURRA RIVER	-34.628	150.861	modified	river dominated	0.40948			0.09312	0.27489	0.93543	0.52907		0.3727
NSW	MEROO LAKE	-35.484	150.391	near pristine	wave dominated	0.15579	0.63311	0.30066		0.25367		0.39106		0.15577
NSW	TOMAGA RIVER	-35.837	150.185	largely unmodified	river dominated	0.15074		0.4281	0.09261	0.2407	0.19049	0.50033		0.69287
VIC	FITZROY RIVER	-38.263	141.85	modified	wave dominated	0.0538				0.20277			0.0259	0.57285
NSW	WAPENGO LAGOON	-36.635	150.021	largely unmodified	wave dominated		1.02044	1.81334	1.2867	0.18518	0.32905	0.31372		0.37153
NSW	WALLAGOOT LAKE	-36.795	149.959	largely unmodified	wave dominated	0.83244	3.10318	0.78572	0.81916	0.18359				0.26742
NSW	NADGEE LAKE AND INLET	-37.469	149.973	near pristine	wave dominated	0.19439	0.7555	0.06369	0.22166	0.17326		1.08824		0.04352
NSW	BERRARA CREEK	-35.209	150.548	largely unmodified	wave dominated				0.02972	0.15943			0.10808	0.23421
VIC	ANGLESEA RIVER	-38.413	144.191	modified	river dominated	0.02066			0.01919	0.15637				0.11086
VIC	BARHAM RIVER	-38.766	143.668	modified	wave dominated	0.01129				0.14536				0.13568
NSW	TOWAMBA RIVER	-37.112	149.913	largely unmodified	wave dominated	0.19625		3.42478	0.90409	0.12922		0.24554	0.2425	1.45473
NSW	CURRAMBEEN CREEK	-35.037	150.671	largely unmodified	river dominated	0.17871				0.11391	1.36417	0.79421	0.15286	0.54301
NSW	BURRILL LAKE	-35.39	150.445	largely unmodified	wave dominated	0.66203	3.39179	0.86128	0.20873	0.11232		0.0596	0.20922	0.33052

STATE	ESTUARYNAME	DLAT	DLONG	CONDITION	CLASSIFICATION	BARRIER_BACKBARRIER	CENTRAL_BASIN	FLUVIAL_BAYHEAD_DELTA	FLOOD_EBB_DELTA	INTERTIDAL_FLATS	MANGROVE	SALTMARSH_SALTFLAT	TIDAL_SANDBANKS	CHANNEL
NSW	WONBOYN RIVER	-37.25	149.966	largely unmodified	wave dominated	0.2825	0.97631	0.09755	1.07487	0.10481		0.65773		1.64798
NSW	MOLLYMOOK CREEK	-35.334	150.475	largely unmodified	wave dominated					0.09467		0.01012		0.01652
VIC	PAINKALAC CREEK/AIREYS INLET	-38.467	144.094	largely unmodified	wave dominated	0.00711				0.0945		0.0111		0.09726
VIC	SAINT GEORGE RIVER	-38.569	143.965	near pristine	wave dominated					0.08793	0.03006	0.02087		0.00301
VIC	SKENES CREEK	-38.725	143.712	modified	wave dominated				0.01003	0.08013				0.01602
NSW	MERINGO CREEK AND LAGOON	-35.978	150.15	largely unmodified	wave dominated	0.14685	0.06903		0.04137	0.07878	0.00909			
VIC	THOMPSON CREEK	-38.305	144.377	modified	wave dominated	0.12177			0.0156	0.07182		2.86322		0.41139
NSW	MURRAH LAGOON	-36.495	150.054	largely unmodified	wave dominated	0.53265	0.05888	2.90903	0.1061	0.06789		0.02009		0.82762
NSW	NELSON LAGOON	-36.691	149.994	largely unmodified	wave dominated	0.15487	0.18358	0.44907	0.31058	0.0613	0.2174	0.44009		0.29826
NSW	TERMEIL LAKE	-35.462	150.395	near pristine	wave dominated	0.04461	0.35115	0.13238	0.05896	0.04778		0.25146		0.11481
VIC	TIDAL RIVER	-39.035822	146.31218	largely unmodified	wave dominated	0.07508			0.06019	0.0445		0.05981		0.06227
VIC	SHERBROOK RIVER	-38.644	143.057	largely unmodified	wave dominated	0.00711				0.04393				0.02863
NSW	BUNGA LAGOON	-36.547	150.055	largely unmodified	wave dominated	0.13795	0.08782	0.08158	0.01469	0.04194				0.03391
NSW	CONGO CREEK AND LAGOON	-35.953	150.157	largely unmodified	wave dominated	0.12132			0.04457	0.03597		0.03765		0.10791
NSW	BARAGOOT LAKE	-36.471	150.065	largely unmodified	wave dominated	0.31216	0.47082	0.18258	0.05383	0.034				
NSW	TILBA TILBA LAKE	-36.339	150.1	largely unmodified	wave dominated	0.48394	0.79475	0.18942	0.2176	0.0331		0.04784		0.13862
NSW	NANGUDGA LAKE	-36.261	150.143	largely unmodified	wave dominated	0.2069	0.32358	0.05481	0.34174	0.03304				0.18646
VIC	GELLIBRAND RIVER	-38.707	143.157	modified	wave dominated	0.011	0.07912		0.03474	0.03161		2.05052		0.18932
VIC	RED RIVER	-37.727	149.563	near pristine	wave dominated	0.06418	0.05363	0.04748	0.03546	0.02974		0.11225		0.1093
NSW	ULLADULLA HARBOUR/MILLARDS CREEK	-35.357	150.485	extensively modified	wave dominated					0.02968				0.56358
NSW	CURALO LAGOON	-37.048	149.921	extensively modified	wave dominated	0.37575	0.42143	0.24083	0.25225	0.02855	0.02259	0.03181		0.12632
VIC	ERSKINE RIVER	-38.532	143.979	largely unmodified	wave dominated	0.00723				0.028	0.04256			0.02529
VIC	JAMIESON RIVER	-38.596	143.919	largely unmodified	wave dominated	0.02147			0.01896	0.02787				0.03154
NSW	LAKE TAROURGA	-36.115	150.134	near pristine	wave dominated	0.07245	0.24628	0.00344	0.02597	0.02786		0.04619		0.01747
VIC	YEERUNG RIVER	-37.791	148.775	near pristine	wave dominated	0.05276			0.00133	0.0256		0.06841		0.19176
NSW	WILLINGA LAKE	-35.5	150.391	near pristine	wave dominated	0.0897	0.13455	0.01145	0.01307	0.0238		0.31957		0.14063
NSW	WALLAGA LAKE	-36.365	150.079	largely unmodified	wave dominated	0.53982	7.50976	2.0683	1.76145	0.01965				0.45843
NSW	KIANGA LAKE	-36.2	150.132	modified	wave dominated	0.16067	0.1449		0.01417	0.01629				0.01947
NSW	CROOKED RIVER AND LAGOON	-34.772	150.815	largely unmodified	wave dominated	0.11955			0.02292	0.01598				0.23154
VIC	WYE RIVER	-38.635	143.891	largely unmodified	wave dominated	0.01752				0.01493		0.00245		0.02124
NSW	MERRICA RIVER	-37.297	149.951	near pristine	wave dominated	0.04198			0.02814	0.01446		0.00292		0.09435
NSW	CANDLAGAN CREEK AND LAGOON	-35.842	150.179	largely unmodified	river dominated	0.04712			0.04391	0.01441	0.03652	0.09934		0.11528
VIC	MERRI RIVER	-38.361	142.478	extensively modified	wave dominated				0.01938	0.01427				0.21102
NSW	MIDDLE LAGOON	-36.656	150.008	largely unmodified	wave dominated	0.32455	0.40076	0.41676	0.11697	0.01236	0.01644			0.17806
NSW	NULLICA RIVER	-37.092	149.872	largely unmodified	wave dominated	0.58832	0.09868	0.40679	0.13602	0.01134				0.26109
NSW	BACK LAGOON	-36.883	149.929	modified	wave dominated	0.33253	0.32766	0.14619	0.02481	0.0103				0.1042
VIC	KENNETT RIVER	-38.667	143.862	largely unmodified	wave dominated	0.01909				0.00919		0.00634		0.02245
NSW	NERRINDILLAH CREEK	-35.229	150.532	largely unmodified	wave dominated	0.05933			0.00912	0.00789	0.00786			0.05682
VIC	EASBY CREEK	-37.741	149.522	near pristine	wave dominated	0.01979			0.01414	0.0066		0.00634		0.04645
VIC	PORT CAMPBELL RIVER	-38.632	142.98	largely unmodified	tide dominated	0.01002			0.00965	0.00518		0.09131		0.0794
VIC	WILD DOG CREEK	-38.734	143.689	largely unmodified	wave dominated	0.01145				0.00452				0.02128
VIC	SPRING CREEK	-38.341	144.32	modified	river dominated	0.00868				0.00259		0.01262		0.072
NSW	CUTTAGEE LAKE	-36.495	150.054	largely unmodified	wave dominated	0.23647	1.10023	0.52849	0.09272					0.23334
VIC	SURREY RIVER	-38.26	141.704	largely unmodified	wave dominated	0.03366						0.32999		0.18336
NSW	CORUNNA LAKE	-36.288	150.133	largely unmodified	wave dominated	0.26975	1.79917	0.23851	0.25567					0.17244
NSW	LAKE MUMMUGA	-36.162	150.129	largely unmodified	wave dominated	0.22124	1.26345	0.17027	0.29737		0.02549	0.06433		0.11977
NSW	WERRI LAGOON	-34.728	150.839	modified	wave dominated	0.67116	0.19309		0.05174					0.0283
NSW	KIOLOA LAGOON	-35.549	150.383	largely unmodified	wave dominated	0.15608			0.02296			0.00399		0.02549
VIC	ELLIOT RIVER	-38.794	143.618	no assessment	wave dominated	0.00503								0.00834

APPENDIX C: FAUNA SPECIES LIST

Note – the following species have been recorded at the site. These lists include wetland-dependent and terrestrial species.

Mammal List

common name	Latin name
agile antechinus	*Antechinus agilis*
swamp antechinus	*Antechinus minimus*
dog	*Canis lupus*
eastern pygmy-possum	*Cercartetus nanus*
Gould's wattled bat	*Chalinolobus gouldii*
chocolate wattled bat	*Chalinolobus morio*
spot-tailed quoll	*Dasyurus maculatus*
cat	*Felis catus*
water rat	*Hydromys chrysogaster*
southern brown bandicoot	*Isoodon obesulus obesulus*
European hare	*Lepus europeaus*
eastern grey kangaroo	*Macropus giganteus*
house mouse	*Mus musculus*
lesser long-eared bat	*Nyctophilus geoffroyi*
Gould's long-eared bat	*Nyctophilus gouldi*
European rabbit	*Oryctolagus cuniculus*
koala	*Phascolarctos cinereus*
common ringtail possum	*Pseudocheirus peregrinus*
New Holland mouse	*Pseudomys novaehollandiae*
grey-headed flying-fox	*Pteropus poliocephalus*
bush rat	*Rattus fuscipes*
swamp rat	*Rattus lutreolus*
black rat	*Rattus rattus*
yellow-bellied sheathtail bat	*Saccolaimus flaviventris*
white-footed dunnart	*Sminthopsis leucopus*
short-beaked echidna	*Tachyglossus aculeatus*
white-striped freetail bat	*Tadarida australis*
common brushtail possum	*Trichosurus vulpecula*
large forest bat	*Vespadelus darlingtoni*
southern forest bat	*Vespadelus regulus*
little forest bat	*Vespadelus vulturnus*
common wombat	*Vombatus ursinus*
red fox	*Vulpes vulpes*
black wallaby	*Wallabia bicolor*

Reptile List

Common Name	Latin Name
tree dragon	*Amphibolurus muricatus*
lowland copperhead	*Austrelaps superbus*
eastern three-lined skink	*Bassiana duperreyi*
white-lipped snake	*Drysdalia coronoides*
swamp skink	*Egernia coventryi*
swamp skink	*Egernia coventryi*
southern water skink	*Eulamprus tympanum tympanum*
garden skink	*Lampropholis guichenoti*
McCoy's skink	*Nannoscincus maccoyi*
metallic skink	*Niveoscincus metallicus*
tiger snake	*Notechis scutatus*
red-bellied black snake	*Pseudechis porphyriacus*
southern grass skink	*Pseudemoia entrecasteauxii*
glossy grass skink	*Pseudemoia rawlinsoni*
weasel skink	*Saproscincus mustelinus*
blotched blue-tongued lizard	*Tiliqua nigrolutea*
common blue-tongued lizard	*Tiliqua scincoides*

Amphibian List

Common name	Latin Name
common froglet	*Crinia signifera*
common froglet	*Crinia signifera*
Victorian smooth froglet	*Geocrinia victoriana*
southern bullfrog (ssp. unknown)	*Limnodynastes dumerilii*
	Limnodynastes dumerilii insularis
spotted marsh frog (race unknown)	*Limnodynastes tasmaniensis*
southern brown tree frog	*Litoria ewingii*
growling grass frog	*Litoria raniformis*
southern toadlet	*Pseudophryne semimarmorata*

Avifauna List

Common Name	Latin Name
yellow-rumped thornbill	*Acanthiza chrysorrhoa*
striated thornbill	*Acanthiza lineata*
yellow thornbill	*Acanthiza nana*
brown thornbill	*Acanthiza pusilla*
eastern spinebill	*Acanthorhynchus tenuirostris*
collared sparrowhawk	*Accipiter cirrhocephalus*
brown goshawk	*Accipiter fasciatus*
common myna	*Acridotheres tristis*
Australian reed-warbler	*Acrocephalus australis*
common sandpiper	*Actitis hypoleucos*
Australasian darter	*Anhinga novaehollandiae*
European skylark	*Alauda arvensis*
azure kingfisher	*Alcedo azurea*
chestnut teal	*Anas castanea*
grey teal	*Anas gracilis*
Australasian shoveler	*Anas rhynchotis*
Pacific black duck	*Anas superciliosa*
red wattlebird	*Anthochaera carunculata*
little wattlebird	*Anthochaera chrysoptera*
regent honeyeater	*Anthochaera phrygia*
Australasian pipit	*Anthus novaeseelandiae*
fork-tailed swift	*Apus Pacificus*
wedge-tailed eagle	*Aquila audax*
cattle egret	*Ardea ibis*
intermediate egret	*Ardea intermedia*
eastern great egret	*Ardea modesta*
white-necked heron	*Ardea Pacifica*
short-tailed shearwater	*Ardenna tenuirostris*
ruddy turnstone	*Arenaria interpres*
dusky woodswallow	*Artamus cyanopterus*
hardhead	*Aythya australis*
musk duck	*Biziura lobata*
sulphur-crested cockatoo	*Cacatua galerita*
long-billed corella	*Cacatua tenuirostris*
fan-tailed cuckoo	*Cacomantis flabelliformis*
brush cuckoo	*Cacomantis variolosus*
chestnut-rumped heathwren	*Calamanthus pyrrhopygius*
sharp-tailed sandpiper	*Calidris acuminata*
sanderling	*Calidris alba*
red knot	*Calidris canutus*
curlew sandpiper	*Calidris ferruginea*
pectoral sandpiper	*calidris melanotos*
red-necked stint	*Calidris ruficollis*
great knot	*Calidris tenuirostris*
gang-gang cockatoo	*Callocephalon fimbriatum*
yellow-tailed black-cockatoo	*Calyptorhynchus funereus*
European goldfinch	*Carduelis carduelis*
European greenfinch	*Carduelis chloris*
Cape Barren goose	*Cereopsis novaehollandiae*
double-banded plover	*Charadrius bicinctus*

Common Name	Latin Name
greater sand plover	*Charadrius leschenaultii*
lesser sand plover	*Charadrius mongolus*
red-capped plover	*Charadrius ruficapillus*
whiskered tern	*Chlidonias hybridus*
white-winged black tern	*Chlidonias leucopterus*
Australian wood duck	*Chenonetta jubata*
silver gull	*Chroicocephalus novaehollandiae*
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*
swamp harrier	*Circus approximans*
golden-headed cisticola	*Cisticola exilis*
banded stilt	*Cladorhynchus leucocephalus*
red-browed treecreeper	*Climacteris erythrops*
grey shrike-thrush	*Colluricincla harmonica*
black-faced cuckoo-shrike	*Coracina novaehollandiae*
common cicadabird	*Coracina tenuirostris*
white-throated treecreeper	*Cormobates leucophaeus*
Australian raven	*Corvus coronoides*
little raven	*Corvus mellori*
forest raven	*Corvus tasmanicus*
stubble quail	*Coturnix pectoralis*
brown quail	*Coturnix ypsilophora*
grey butcherbird	*Cracticus torquatus*
pallid cuckoo	*Cuculus pallidus*
black swan	*Cygnus atratus*
laughing kookaburra	*Dacelo novaeguineae*
varied sittella	*Daphoenositta chrysoptera*
cape petrel	*Daption capense*
mistletoebird	*Dicaeum hirundinaceum*
emu	*Dromaius novaehollandiae*
little egret	*Egretta garzetta*
white-faced heron	*Egretta novaehollandiae*
black-shouldered kite	*Elanus axillaris*
black-fronted dotterel	*Elseyornis melanops*
galah	*Eolophus roseicapilla*
eastern yellow robin	*Eopsaltria australis*
white-fronted chat	*Epthianura albifrons*
red-kneed dotterel	*Erythrogonys cinctus*
little penguin	*Eudyptula minor*
brown falcon	*Falco berigora*
nankeen kestrel	*Falco cenchroides*
Australian hobby	*Falco longipennis*
peregrine falcon	*Falco peregrinus*
crested shrike-tit	*Falcunculus frontatus*
lesser frigatebird	*Fregata ariel*
Eurasian coot	*Fulica atra*
southern fulmar	*Fulmarus glacialoides*
Latham's snipe	*Gallinago hardwickii*
dusky moorhen	*Gallinula tenebrosa*
black-tailed native-hen	*Gallinula ventralis*
buff-banded rail	*Gallirallus philippensis*
gull-billed tern	*Gelochelidon nilotica*
musk lorikeet	*Glossopsitta concinna*
magpie-lark	*Grallina cyanoleuca*

Common Name	Latin Name
Australian magpie	*Gymnorhina tibicen*
sooty oystercatcher	*Haematopus fuliginosus*
pied oystercatcher	*Haematopus longirostris*
white-bellied sea-eagle	*Haliaeetus leucogaster*
whistling kite	*Haliastur sphenurus*
grey-tailed tattler	*Heteroscelus brevipes*
black-winged stilt	*Himantopus himantopus*
little eagle	*Hieraaetus morphnoides*
white-throated needletail	*Hirundapus caudacutus*
welcome swallow	*Hirundo neoxena*
tree martin	*Hirundo nigricans*
caspian tern	*Hydroprogne caspia*
kelp gull	*Larus dominicanus*
Pacific gull	*Larus Pacificus Pacificus*
swift parrot	*Lathamus discolor*
Lewin's rail	*Lewinia pectoralis*
yellow-faced honeyeater	*Lichenostomus chrysops*
white-eared honeyeater	*Lichenostomus leucotis*
white-plumed honeyeater	*Lichenostomus penicillatus*
bar-tailed godwit	*Limosa lapponica*
black-tailed godwit	*Limosa limosa*
northern giant-petrel	*Macronectes halli*
pink-eared duck	*Malacorhynchus membranaceus*
superb fairy-wren	*Malurus cyaneus*
noisy miner	*Manorina melanocephala*
little grassbird	*Megalurus gramineus*
brown-headed honeyeater	*Melithreptus brevirostris*
white-naped honeyeater	*Melithreptus lunatus*
little pied cormorant	*Microcarbo melanoleucos*
Jacky winter	*Microeca fascinans*
Australasian gannet	*Morus serrator*
satin flycatcher	*Myiagra cyanoleuca*
leaden flycatcher	*Myiagra rubecula*
red-browed finch	*Neochmia temporalis*
orange-bellied parrot	*Neophema chrysogaster*
blue-winged parrot	*Neophema chrysostoma*
southern boobook	*Ninox novaeseelandiae*
eastern curlew	*Numenius madagascariensis*
whimbrel	*Numenius phaeopus*
nankeen night heron	*Nycticorax caledonicus*
olive-backed oriole	*Oriolus sagittatus*
blue-billed duck	*Oxyura australis*
olive whistler	*Pachycephala olivacea*
golden whistler	*Pachycephala pectoralis*
rufous whistler	*Pachycephala rufiventris*
fairy prion	*Pachyptila turtur*
spotted pardalote	*Pardalotus punctatus*
striated pardalote	*Pardalotus striatus*
house sparrow	*Passer domesticus*
Australian pelican	*Pelecanus conspicillatus*
scarlet robin	*Petroica boodang*
flame robin	*Petroica phoenicea*
pink robin	*Petroica rodinogaster*

Common Name	Latin Name
ground parrot	*Pezoporus wallicus*
great cormorant	*Phalacrocorax carbo*
black-faced cormorant	*Phalacrocorax fuscescens*
little black cormorant	*Phalacrocorax sulcirostris*
pied cormorant	*Phalacrocorax varius*
common bronzewing	*Phaps chalcoptera*
brush bronzewing	*Phaps elegans*
common pheasant	*Phasianus colchicus*
tawny-crowned honeyeater	*Phylidonyris melanops*
New Holland honeyeater	*Phylidonyris novaehollandiae*
crescent honeyeater	*Phylidonyris pyrrhoptera*
yellow-billed spoonbill	*Platalea flavipes*
royal spoonbill	*Platalea regia*
crimson rosella	*Platycercus elegans*
eastern rosella	*Platycercus eximius*
glossy ibis	*Plegadis falcinellus*
Pacific golden plover	*Pluvialis fulva*
grey plover	*Pluvialis squatarola*
tawny frogmouth	*Podargus strigoides*
great crested grebe	*Podiceps cristatus*
hoary-headed grebe	*Poliocephalus poliocephalus*
purple swamphen	*Porphyrio porphyrio*
Australian spotted crake	*Porzana fluminea*
spotless crake	*Porzana tabuensis*
eastern whipbird	*Psophodes olivaceus*
great-winged petrel	*Pterodroma macroptera*
fluttering shearwater	*Puffinus gavia*
red-necked avocet	*Recurvirostra novaehollandiae*
grey fantail	*Rhipidura albiscarpa*
willie wagtail	*Rhipidura leucophrys*
rufous fantail	*Rhipidura rufifrons*
white-browed scrubwren	*Sericornis frontalis*
beautiful firetail	*Stagonopleura bella*
great skua	*Stercorarius skua*
common tern	*Sterna hirundo*
white-fronted tern	*Sterna striata*
little tern	*Sternula albifrons*
fairy tern	*Sternula nereis*
southern emu-wren	*Stipiturus malachurus*
pied currawong	*Strepera graculina*
grey currawong	*Strepera versicolor*
spotted turtle-dove	*Streptopelia chinensis*
common starling	*Sturnus vulgaris*
Australasian grebe	*Tachybaptus novaehollandiae*
Australian shelduck	*Tadorna tadornoides*
crested tern	*Thalaseus bergii*
black-browed albatross	*Thalassarche melanophris*
hooded plover	*Thinornis rubricollis*
Australian white ibis	*Threskiornis molucca*
straw-necked ibis	*Threskiornis spinicollis*
sacred kingfisher	*Todiramphus sanctus*
rainbow lorikeet	*Trichoglossus haematodus*
wood sandpiper	*Tringia glareola*

Common Name	Latin Name
common greenshank	*Tringa nebularia*
marsh sandpiper	*Tringa stagnatilis*
common blackbird	*Turdus merula*
painted button-quail	*Turnix varia*
Pacific barn owl	*Tyto javanica*
masked lapwing	*Vanellus miles*
banded lapwing	*Vanellus tricolor*
terek sandpiper	*Xenus cinereus*
bassian thrush	*Zoothera lunulata*
silvereye	*Zosterops lateralis*

Waterbird List

Common Name	Latin Name
common sandpiper	*Actitis hypoleucos*
chestnut teal	*Anas castanea*
grey teal	*Anas gracilis*
Australasian shoveler	*Anas rhynchotis*
Pacific black duck	*Anas superciliosa*
Australasian darter	*Anhinga novaehollandiae*
cattle egret	*Ardea ibis*
intermediate egret	*Ardea intermedia*
eastern great egret	*Ardea modesta*
white-necked heron	*Ardea Pacifica*
short-tailed shearwater	*Ardenna tenuirostris*
ruddy turnstone	*Arenaria interpres*
hardhead	*Aythya australis*
musk duck	*Biziura lobata*
sharp-tailed sandpiper	*Calidris acuminata*
sanderling	*Calidris alba*
red knot	*Calidris canutus*
curlew sandpiper	*Calidris ferruginea*
pectoral sandpiper	*calidris melanotos*
red-necked stint	*Calidris ruficollis*
great knot	*Calidris tenuirostris*
Cape Barren goose	*Cereopsis novaehollandiae*
double-banded plover	*Charadrius bicinctus*
greater sand plover	*Charadrius leschenaultii*
lesser sand plover	*Charadrius mongolus*
red-capped plover	*Charadrius ruficapillus*
whiskered tern	*Chlidonias hybridus*
white-winged black tern	*Chlidonias leucopterus*
Australian wood duck	*Chenonetta jubata*
silver gull	*Chroicocephalus novaehollandiae*
banded stilt	*Cladorhynchus leucocephalus*
black swan	*Cygnus atratus*
little egret	*Egretta garzetta*
white-faced heron	*Egretta novaehollandiae*
black-fronted dotterel	*Elseyornis melanops*
red-kneed dotterel	*Erythrogonys cinctus*

Common Name	Latin Name
little penguin	*Eudyptula minor*
Eurasian coot	*Fulica atra*
oriental pratincole	*Glarecola maldivarum*
Latham's snipe	*Gallinago hardwickii*
dusky moorhen	*Gallinula tenebrosa*
black-tailed native-hen	*Gallinula ventralis*
buff-banded rail	*Gallirallus philippensis*
gull-billed tern	*Gelochelidon nilotica*
sooty oystercatcher	*Haematopus fuliginosus*
pied oystercatcher	*Haematopus longirostris*
grey-tailed tattler	*Heteroscelus brevipes*
black-winged stilt	*Himantopus himantopus*
Caspian tern	*Hydroprogne caspia*
kelp gull	*Larus dominicanus*
Pacific gull	*Larus Pacificus Pacificus*
Lewin's rail	*Lewinia pectoralis*
bar-tailed godwit	*Limosa lapponica*
black-tailed godwit	*Limosa limosa*
pink-eared duck	*Malacorhynchus membranaceus*
little pied cormorant	*Microcarbo melanoleucos*
Australasian gannet	*Morus serrator*
eastern curlew	*Numenius madagascariensis*
whimbrel	*Numenius phaeopus*
nankeen night heron	*Nycticorax caledonicus*
blue-billed duck	*Oxyura australis*
Australian pelican	*Pelecanus conspicillatus*
great cormorant	*Phalacrocorax carbo*
black-faced cormorant	*Phalacrocorax fuscescens*
little black cormorant	*Phalacrocorax sulcirostris*
pied cormorant	*Phalacrocorax varius*
yellow-billed spoonbill	*Platalea flavipes*
royal spoonbill	*Platalea regia*
glossy ibis	*Plegadis falcinellus*
Pacific golden plover	*Pluvialis fulva*
grey plover	*Pluvialis squatarola*
great crested grebe	*Podiceps cristatus*
hoary-headed grebe	*Poliocephalus poliocephalus*
purple swamphen	*Porphyrio porphyrio*
Australian spotted crake	*Porzana fluminea*
spotless crake	*Porzana tabuensis*
red-necked avocet	*Recurvirostra novaehollandiae*
common tern	*Sterna hirundo*
white-fronted tern	*Sterna striata*
little tern	*Sternula albifrons*
fairy tern	*Sternula nereis*
Australasian grebe	*Tachybaptus novaehollandiae*
Australian shelduck	*Tadorna tadornoides*
crested tern	*Thalaseus bergii*
hooded plover	*Thinornis rubricollis*
Australian white ibis	*Threskiornis molucca*
straw-necked ibis	*Threskiornis spinicollis*
wood sandpiper	*Tringia glareola*
common greenshank	*Tringa nebularia*

Common Name	Latin Name
marsh sandpiper	*Tringa stagnatilis*
masked lapwing	*Vanellus miles*
banded lapwing	*Vanellus tricolor*
Terek sandpiper	*Xenus cinereus*

APPENDIX D: BIRD COUNT DATA ANALYSIS

Approach

Three data-sets were avialable for review in this study:

- DSE Fauna database records outlined in the file titled “fauna100_cornerinlet_ramsar_dd94”. This database has count data for fauna species recorded at stations within the Corner Inlet Ramsar site;
- Birds Australia database records (summary only), as outlined in the file titled “BA_shorebird_count_areas_aust”. This database has a total count of various bird species recorded at stations located throughout Australia. Times are pooled, so temporal trends can not be determined from the data.
- Birds Australia Altas data. The Atlas contains species records at monitoring locations in the Ramsar site. These data show number of records (not always counts) at each sampling station at various times. Data were provided for the New Atlas (1999-2008) and Old Atlas (1977-1984).

The Shorebird Habitat Mapping Project for West Gippsland (Clemens et al. 2007) provides a comprehensive description of trends in waterbird abundance in Corner Inlet based on Birds Australia count data. Clemens *et al*. (2007) also contained a larger data-set than supplied to the study team for this project. Readers should refer to Clemens et al. (2007) for a description of trends in shorebird abundance based on the Birds Australia data.

The analysis below is based on bird count data from the DSE database. A range of indicator species were selected for the assesment, as follows: black swan, grey teal, chestnut teal, pied oyster catcher, curlew sand piper, red-necked stint, bar-tailed godwit, eastern curlew, sooty oystercatcher and double-banded plover.

These species were selected on the basis that they (i) meet the one per cent of the total population criterion (see nomiation criteria 6); and/or (ii) are species that utilise the range of freshwater and coastal types found within the site; and/or (iii) are sensitive to changes associated with some key threats (for example, pied oyster catcher is sensitive to disturbance by humans and foxes); and/or (iv) were identified in Ecos (unpublished) as having a decline in abundance within the site. Note that other species are also identified as meeting the one per cent population criterion at the site, but data for these species were extremely limited and were therefore excluded from analyses.

For each species, the following was derived:

- plots of the maximum and average numbers of individuals recorded in each year (stations pooled). Note the average number of individuals is defined as the average number of individuals counted at a monitoring station at different sampling occasions within a year. This count is not standardised and there is great variability in numbers of stations sampled within and among years.
- descriptive statistics for count data for each year (shows number of records/episodes (not counts) per year), as well as average abundance per year (stations pooled) (Tables D1 to D15). The first column in these summary tables is the year of the surveys. Within each year, the mean (and standard deviation and standard error) number of birds recorded on each survey occasion

was calculated. The "Count" column is the number of survey occasions within each year in which the species was recorded (equivalent to reporting rate). The minimum and maximum values are the lowest and highest number of birds recorded in each year.

Key Trends

Figure D1 and D3 shows that there was great year to year variability in counts of the key waterbird species black swan, grey teal and chestnut teal. Based on summary statistics presented in Tables A to C and Figure D1:

- maximum and average annual counts were higher in the period pre-1993 than after this period. In particular, the period 1985 to 1993 had high numbers of all three species.
- the reporting rate (that is the number of sampling sites and episodes per year; the "Count" column), which is a coarse measure of sampling effort, was lower in the post-1992 period for these species. This suggests that 'changes' over time for these species were at least partly a response to differences in sampling effort.
- there was no clear association between annual flows from the Tarra River at Yarram (ML/day) and average bird counts.

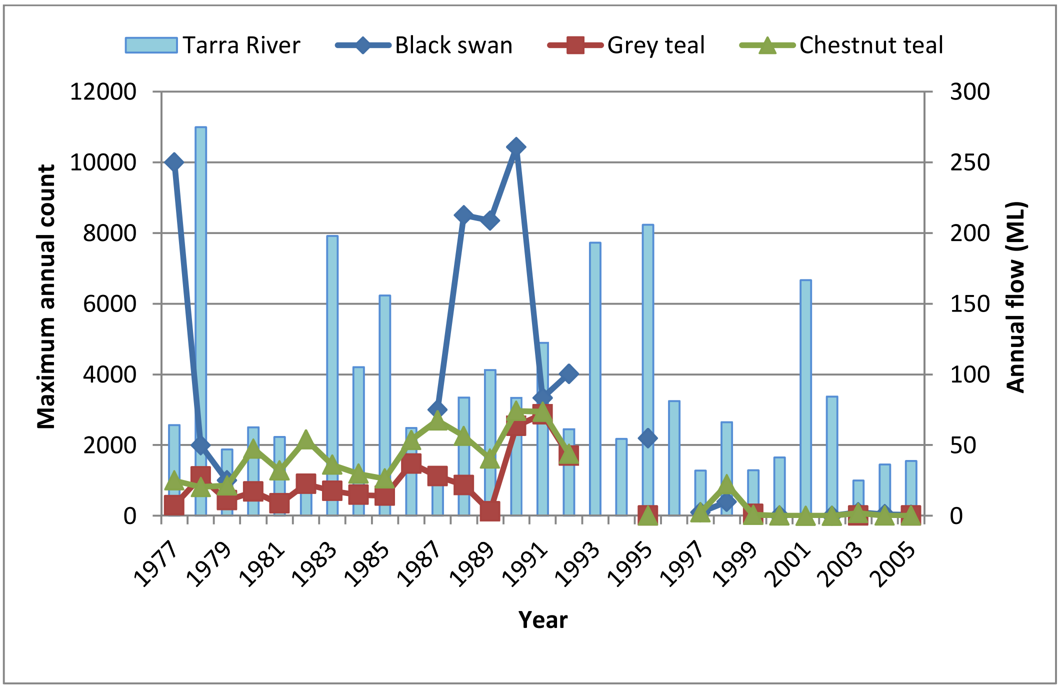


Figure D1 Maximum Annual Count of Black Swan, Chestnut Teal and Grey Teal Based on DSE (unpublished) Fauna Database Records. Average Annual Flow (ML/day) from the Tarra River at Yarram Monitoring Station (Source: Victorian Water Resources Data Warehouse) are Superimposed

Figure D2 shows the maximum annual count of selected marine shorebird species. Similar to trends for black swan and the two species of teal, counts were highly variable over time, with highest counts occurring in the period between 1985 and the early 1990's.

It is important to note the following when interpreting data:

- A variety of sampling methods have been used with varying levels of sampling effort applied;
- There are no metadata describing sampling effort at each station over time;
- Over time, there has been a change in species targeted in surveys. For example, there has been greater scientific interest and therefore survey effort given to Fairy Tern. While counts of this species have been higher in recent years compared to prior to listing, it is likely that this could relate to differnces in sampling effort over time.
- Therefore, data cannot be scaled as counts per unit effort in its existing format.

For these reasons, it is not possible to derive empirical indices describing changes in bird abundance over time or among stations based on DSE data. Systematic sampling using standardised count methods would be required to develop appropriate bird abundance metrics.

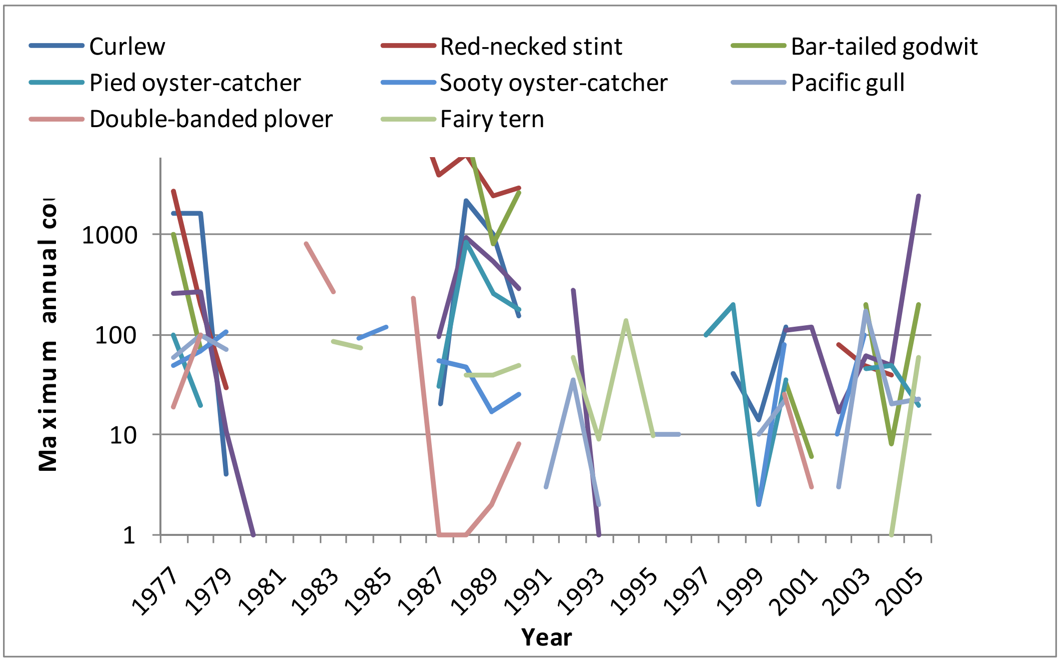
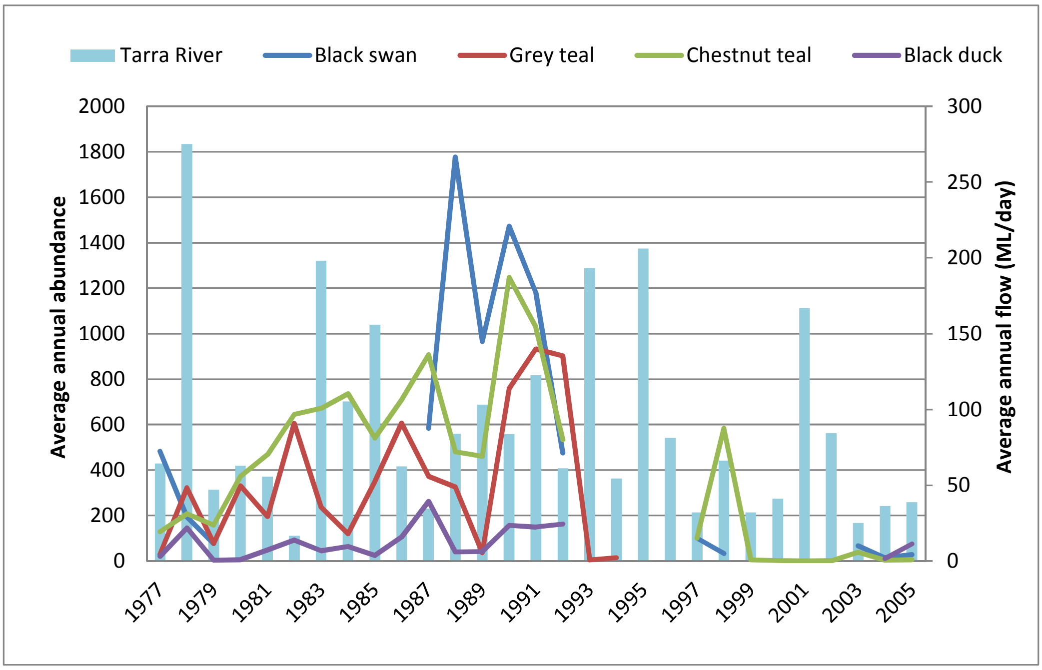


Figure D2 Maximum Annual Count of Selected Marine Shorebird Species Based on DSE (unpublished) Fauna Database Records



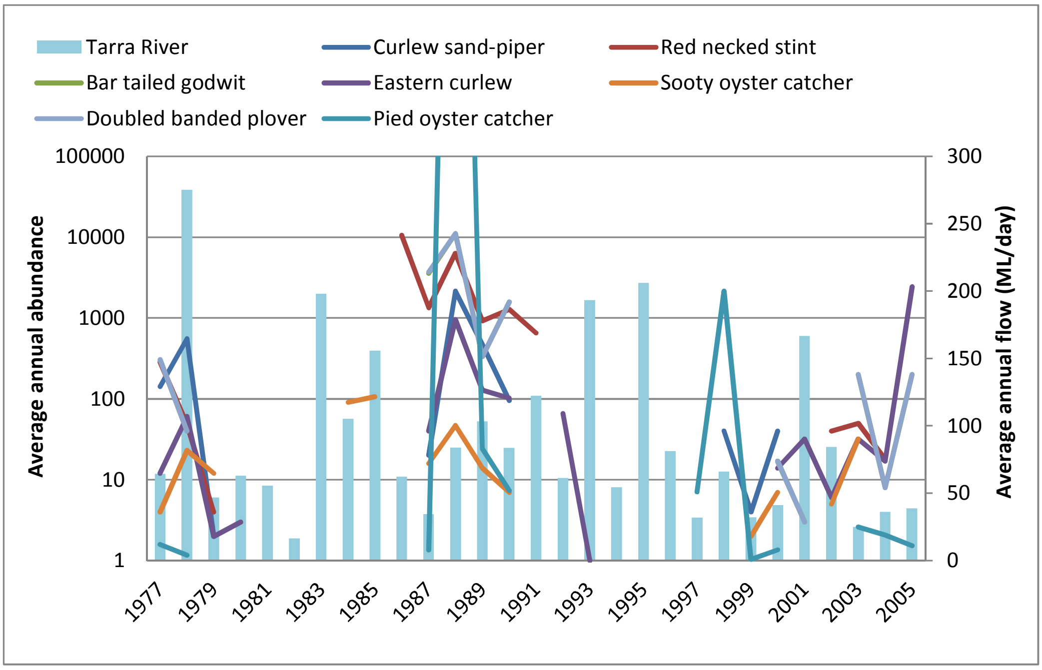


Figure D3 Average Bird Count (Per Sampling Occasion Per Station) for the Years 1977 to 2005, Based on DSE (unpublished) Fauna Database Records. Average Annual Flow (ML/day) from the Tarra River at Yarram Monitoring Station (Source: Victorian Water Resources Data Warehouse) are Superimposed

Table D1 – Summary Statistics for Black Swan Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: black swan from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	426	1373	95	208	0	10438	0
No., 1971	0	•	•	1	0	0	0
No., 1973	0	•	•	1	0	0	0
No., 1974	0	•	•	1	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	•	•	1	0	0	0
No., 1977	483	1728	296	34	0	10000	0
No., 1978	193	554	154	13	0	2000	0
No., 1979	76	249	60	17	0	1000	0
No., 1980	0	0	0	5	0	0	0
No., 1981	0	0	0	5	0	0	0
No., 1987	583	933	269	12	0	3000	0
No., 1988	1777	3319	1355	6	15	8507	0
No., 1989	965	1931	468	17	0	8356	0
No., 1990	1473	3027	913	11	0	10438	0
No., 1991	1180	1871	1080	3	100	3340	0
No., 1992	475	967	228	18	0	4020	0
No., 1995	661	738	279	7	10	2220	0
No., 1997	100	•	•	1	100	100	0
No., 1998	210	269	190	2	20	400	0
No., 1999	33	81	20	16	0	300	0
No., 2000	1	3	1	19	0	8	0
No., 2001	0	0	0	6	0	0	0
No., 2002	1	1	1	2	0	2	0
No., 2003	67	58	33	3	0	100	0
No., 2004	14	17	7	5	0	40	0
No., 2005	27	•	•	1	27	27	0

Table D2 – Summary Statistics for Grey Teal Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: Grey teal from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	335	490	38	167	0	2880	0
No., 1975	0	•	•	1	0	0	0
No., 1977	30	80	19	17	0	300	0
No., 1978	322	444	148	9	0	1108	0
No., 1979	77	130	33	16	0	438	0
No., 1980	331	253	89	8	3	682	0
No., 1981	195	113	38	9	2	349	0
No., 1982	605	169	53	10	377	902	0
No., 1983	237	308	126	6	2	708	0
No., 1984	120	184	61	9	10	592	0
No., 1985	348	152	51	9	140	565	0
No., 1986	606	560	187	9	1	1475	0
No., 1987	372	394	114	12	1	1123	0
No., 1988	326	333	126	7	1	868	0
No., 1989	36	42	15	8	1	128	0
No., 1990	759	728	195	14	8	2550	0
No., 1991	932	1086	362	9	16	2880	0
No., 1992	902	654	327	4	125	1698	0
No., 1995	5	•	•	1	5	5	0
No., 1999	14	26	13	4	0	52	0
No., 2000	0	•	•	1	0	0	0
No., 2002	0	•	•	1	0	0	0
No., 2003	5	•	•	1	5	5	0
No., 2004	0	•	•	1	0	0	0
No., 2005	6	•	•	1	6	6	0

Table D3 – Summary Statistics for Chestnut Teal Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: chestnut teal from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	529	748	49	229	0	4500	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	•	•	1	0	0	0
No., 1977	128	272	64	18	0	1000	0
No., 1978	208	312	90	12	0	814	0
No., 1979	158	238	53	20	0	857	0
No., 1980	373	557	161	12	0	1900	0
No., 1981	468	479	144	11	0	1281	0
No., 1982	644	629	199	10	123	2160	0
No., 1983	671	517	195	7	2	1445	0
No., 1984	735	405	135	9	140	1191	0
No., 1985	541	381	121	10	18	1054	0
No., 1986	710	770	222	12	9	2145	0
No., 1987	907	867	217	16	0	2704	0
No., 1988	480	744	206	13	4	2262	0
No., 1989	460	541	150	13	4	1619	0
No., 1990	1247	1129	266	18	2	2973	0
No., 1991	1029	1039	313	11	4	2953	0
No., 1992	533	776	259	9	0	1754	0
No., 1995	8	•	•	1	8	8	0
No., 1997	100	•	•	1	100	100	0
No., 1998	584	425	245	3	100	893	0
No., 1999	5	10	3	9	0	28	0
No., 2000	2	3	2	2	0	4	0
No., 2001	0	0	0	2	0	0	0
No., 2002	1	1	1	2	0	1	0
No., 2003	38	53	38	2	0	75	0
No., 2004	3	4	3	2	0	5	0
No., 2005	6	•	•	1	6	6	0
No., 2006	4500	•	•	1	4500	4500	0

Table D4 – Summary Statistics for Pied Oyster Catcher Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: pied oyster from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	36	125	9	177	0	1294	0
No., 1905	0	•	•	1	0	0	0
No., 1965	0	•	•	1	0	0	0
No., 1966	0	•	•	1	0	0	0
No., 1971	0	•	•	1	0	0	0
No., 1973	0	•	•	1	0	0	0
No., 1974	0	0	0	6	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	0	0	3	0	0	0
No., 1977	12	30	6	25	0	100	0
No., 1978	4	7	2	10	0	20	0
No., 1979	0	0	0	10	0	0	0
No., 1980	0	0	0	3	0	0	0
No., 1981	0	0	0	3	0	0	0
No., 1985	1294	•	•	1	1294	1294	0
No., 1986	0	0	0	3	0	0	0
No., 1987	8	13	6	5	0	31	0
No., 1988	856	•	•	1	856	856	0
No., 1989	83	97	32	9	6	260	0
No., 1990	52	60	16	14	0	180	0
No., 1992	46	63	16	16	2	185	0
No., 1995	62	78	19	16	1	285	0
No., 1997	51	69	49	2	2	100	0
No., 1998	200	•	•	1	200	200	0
No., 1999	2E-1	1	2E-1	13	0	2	0
No., 2000	8	12	3	17	0	36	0
No., 2001	0	0	0	3	0	0	0
No., 2002	0	0	0	2	0	0	0
No., 2003	25	30	22	2	3	46	0
No., 2004	19	27	15	3	2	50	0
No., 2005	11	10	6	3	0	20	0

Table D5 – Summary Statistics for Fairy Tern Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: fairy tern from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	16	28	4	52	0	140	0
No., 1893	0	•	•	1	0	0	0
No., 1899	0	•	•	1	0	0	0
No., 1973	0	•	•	1	0	0	0
No., 1974	0	0	0	5	0	0	0
No., 1976	10	•	•	1	10	10	0
No., 1977	12	21	6	11	0	50	0
No., 1979	0	•	•	1	0	0	0
No., 1980	0	•	•	1	0	0	0
No., 1981	0	0	0	3	0	0	0
No., 1983	44	62	44	2	0	87	0
No., 1987	76	•	•	1	76	76	0
No., 1988	27	19	11	3	5	40	0
No., 1989	14	18	9	4	2	40	0
No., 1990	15	18	7	6	4	50	0
No., 1992	33	39	28	2	5	60	0
No., 1993	5	6	5	2	0	9	0
No., 1994	140	•	•	1	140	140	0
No., 1995	8	3	2	2	6	10	0
No., 1996	0	•	•	1	0	0	0
No., 1997	2	•	•	1	2	2	0
No., 2003	1	•	•	1	1	1	0
No., 2004	60	•	•	1	60	60	0

Table D6 – Summary Statistics for Hooded Plover Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: hooded plover from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	2	2	3E-1	38	0	7	0
No., 1926	0	•	•	1	0	0	0
No., 1977	2	2	1	8	0	7	0
No., 1979	0	0	0	2	0	0	0
No., 1980	0	•	•	1	0	0	0
No., 1981	0	•	•	1	0	0	0
No., 1988	4	•	•	1	4	4	0
No., 1989	2	•	•	1	2	2	0
No., 1990	3	1	1	5	2	5	0
No., 1992	2	•	•	1	2	2	0
No., 1993	3	1	1	2	2	4	0
No., 1995	2	0	0	3	2	2	0
No., 1996	2	•	•	1	2	2	0
No., 1997	2	0	0	2	2	2	0
No., 1998	2	•	•	1	2	2	0
No., 1999	1	1	5E-1	5	0	2	0
No., 2001	3	1	1	2	2	4	0
No., 2004	5	•	•	1	5	5	0

Table D7 – Summary Statistics for Caspian Tern Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: caspian from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	10	26	3	78	0	140	0
No., 1905	0	•	•	1	0	0	0
No., 1973	0	•	•	1	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	•	•	1	0	0	0
No., 1977	2	6	1	20	0	26	0
No., 1978	1	1	1	8	0	4	0
No., 1979	1	1	1	3	0	2	0
No., 1980	0	0	0	4	0	0	0
No., 1981	0	•	•	1	0	0	0
No., 1987	1	1	5E-1	2	0	1	0
No., 1988	27	29	14	4	1	54	0
No., 1989	15	22	13	3	1	40	0
No., 1990	27	28	12	5	5	58	0
No., 1991	140	•	•	1	140	140	0
No., 1992	10	•	•	1	10	10	0
No., 1993	56	76	54	2	2	110	0
No., 1994	112	•	•	1	112	112	0
No., 1995	11	13	7	3	2	25	0
No., 1998	0	•	•	1	0	0	0
No., 1999	0	0	0	4	0	0	0
No., 2000	0	0	0	3	0	0	0
No., 2001	0	0	0	4	0	0	0
No., 2002	0	•	•	1	0	0	0
No., 2004	2	1	1	2	1	3	0
No., 2005	5	•	•	1	5	5	0

Table D8 – Summary statistics for Crested Tern based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: crested from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	50	178	16	126	0	1200	0
No., 1973	0	•	•	1	0	0	0
No., 1974	0	•	•	1	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1977	69	228	52	19	0	1000	0
No., 1978	13	24	7	13	0	80	0
No., 1979	5	12	5	6	0	30	0
No., 1980	0	0	0	4	0	0	0
No., 1981	0	0	0	5	0	0	0
No., 1987	3	4	3	2	0	6	0
No., 1988	72	101	36	8	2	286	0
No., 1989	75	108	63	3	10	200	0
No., 1990	65	99	38	7	0	220	0
No., 1991	1200	•	•	1	1200	1200	0
No., 1992	11	14	5	7	1	40	0
No., 1993	262	391	226	3	8	712	0
No., 1995	60	57	40	2	20	100	0
No., 1996	0	•	•	1	0	0	0
No., 1997	337	574	332	3	0	1000	0
No., 1999	2	4	2	6	0	10	0
No., 2000	5	12	3	15	0	35	0
No., 2001	0	0	0	5	0	0	0
No., 2002	8	14	8	3	0	24	0
No., 2003	26	42	19	5	2	100	0
No., 2004	4	2	1	3	2	5	0
No., 2005	50	71	50	2	0	100	0

Table D9 – Summary Statistics for Curlew sandpiper Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: curlew from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	247	496	68	53	0	2160	0
No., 1977	142	441	122	13	0	1605	0
No., 1978	558	902	521	3	25	1600	0
No., 1979	2	3	2	2	0	4	0
No., 1980	0	•	•	1	0	0	0
No., 1981	0	•	•	1	0	0	0
No., 1987	20	•	•	1	20	20	0
No., 1988	2160	•	•	1	2160	2160	0
No., 1989	467	462	267	3	200	1000	0
No., 1990	95	44	22	4	50	150	0
No., 1992	376	471	178	7	5	1100	0
No., 1995	448	549	224	6	5	1500	0
No., 1998	40	•	•	1	40	40	0
No., 1999	4	7	4	4	0	14	0
No., 2000	40	62	25	6	0	120	0

Table D10 – Summary Statistics for Red-necked Stint Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: red neck from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	755	2313	229	102	0	19900	0
No., 1898	0	•	•	1	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	•	•	1	0	0	0
No., 1977	285	694	163	18	0	2757	0
No., 1978	48	77	31	6	0	200	0
No., 1979	4	11	4	7	0	30	0
No., 1980	0	0	0	2	0	0	0
No., 1981	0	0	0	3	0	0	0
No., 1986	10588	13170	9312	2	1275	19900	0
No., 1987	1345	2299	1328	3	0	4000	0
No., 1988	6320	•	•	1	6320	6320	0
No., 1989	921	949	335	8	20	2500	0
No., 1990	1283	1175	480	6	200	3000	0
No., 1992	657	898	284	10	25	2500	0
No., 1995	1494	2467	712	12	14	8500	0
No., 1999	0	0	0	4	0	0	0
No., 2000	26	50	17	9	0	150	0
No., 2001	0	0	0	2	0	0	0
No., 2002	40	57	40	2	0	80	0
No., 2003	50	•	•	1	50	50	0
No., 2004	18	19	11	3	4	40	0

Table D11 – Summary Statistics for Bar-tailed Godwit Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: bar tailed godwit from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	1036	2465	299	68	0	13120	0
No., 1973	0	•	•	1	0	0	0
No., 1974	10000	•	•	1	10000	10000	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	•	•	1	0	0	0
No., 1977	305	458	118	15	0	1000	0
No., 1978	40	42	30	2	10	70	0
No., 1979	0	•	•	1	0	0	0
No., 1980	0	•	•	1	0	0	0
No., 1987	3751	6307	3153	4	0	13120	0
No., 1988	11070	•	•	1	11070	11070	0
No., 1989	333	338	138	6	0	800	0
No., 1990	1589	915	346	7	20	2600	0
No., 1992	609	488	184	7	110	1400	0
No., 1995	1980	2285	933	6	2	6000	0
No., 1999	0	0	0	5	0	0	0
No., 2000	17	19	10	4	0	33	0
No., 2001	3	4	3	2	0	6	0
No., 2003	200	•	•	1	200	200	0
No., 2004	8	•	•	1	8	8	0
No., 2005	200	•	•	1	200	200	0

Table D12 – Summary Statistics for Eastern Curlew Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: eastern curlew from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	86	274	23	140	0	2445	0
No., 1905	0	•	•	1	0	0	0
No., 1971	0	•	•	1	0	0	0
No., 1974	0	•	•	1	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1977	12	54	11	23	0	258	0
No., 1978	61	84	21	16	0	270	0
No., 1979	2	4	2	7	0	11	0
No., 1980	3E-1	1	3E-1	4	0	1	0
No., 1981	0	0	0	3	0	0	0
No., 1982	670	•	•	1	670	670	0
No., 1985	1630	•	•	1	1630	1630	0
No., 1987	40	47	24	4	0	97	0
No., 1988	955	•	•	1	955	955	0
No., 1989	129	190	67	8	10	550	0
No., 1990	102	106	40	7	5	290	0
No., 1992	66	84	25	11	0	280	0
No., 1993	1	0	0	2	1	1	0
No., 1995	140	147	39	14	1	460	0
No., 1997	2	•	•	1	2	2	0
No., 1999	0	0	0	7	0	0	0
No., 2000	14	39	14	8	0	110	0
No., 2001	32	52	21	6	0	120	0
No., 2002	6	10	6	3	0	17	0
No., 2003	21	35	20	3	0	61	0
No., 2004	17	21	10	5	1	50	0
No., 2005	2445	•	•	1	2445	2445	0

Table D13 – Summary Statistics for Sooty Oyster-catcher Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: sooty from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	12	24	2	129	0	118	0
No., 1959	0	0	0	2	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	•	•	1	0	0	0
No., 1977	4	12	3	16	0	48	0
No., 1978	23	25	8	10	0	67	0
No., 1979	12	35	12	9	0	105	0
No., 1980	0	0	0	4	0	0	0
No., 1981	0	0	0	6	0	0	0
No., 1984	91	•	•	1	91	91	0
No., 1985	106	18	13	2	93	118	0
No., 1987	16	22	10	5	1	55	0
No., 1988	47	•	•	1	47	47	0
No., 1989	14	4	2	5	6	17	0
No., 1990	7	8	3	9	2	25	0
No., 1992	14	14	5	8	1	35	0
No., 1995	14	19	5	13	1	70	0
No., 1999	2E-1	1	2E-1	9	0	2	0
No., 2000	7	20	5	16	0	80	0
No., 2001	0	0	0	4	0	0	0
No., 2002	5	7	5	2	0	10	0
No., 2003	32	47	23	4	1	100	0
No., 2005	0	•	•	1	0	0	0

Table D14 – Summary Statistics for Double-banded Plover Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: doubled banded plover from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	44	129	19	48	0	800	0
No., 1975	0	•	•	1	0	0	0
No., 1977	3	6	2	12	0	19	0
No., 1978	34	56	32	3	0	99	0
No., 1979	0	0	0	6	0	0	0
No., 1980	0	•	•	1	0	0	0
No., 1981	0	•	•	1	0	0	0
No., 1982	800	•	•	1	800	800	0
No., 1983	244	33	23	2	220	267	0
No., 1986	118	95	43	5	15	226	0
No., 1987	1	•	•	1	1	1	0
No., 1989	2	•	•	1	2	2	0
No., 1990	8	•	•	1	8	8	0
No., 1992	12	12	7	3	2	25	0
No., 1999	0	•	•	1	0	0	0
No., 2000	11	13	6	5	0	25	0
No., 2001	0	0	0	2	0	0	0
No., 2002	8	11	8	2	0	15	0

Table D15 – Summary Statistics for Pacific Gull Based on DSE Bird Count Data

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: pacific gull from fauna100_cornerinlet_ramsar_dd9 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
No., Total	7	23	2	169	0	172	0
No., 1965	0	•	•	1	0	0	0
No., 1966	0	•	•	1	0	0	0
No., 1971	0	•	•	1	0	0	0
No., 1973	0	•	•	1	0	0	0
No., 1974	0	•	•	1	0	0	0
No., 1975	0	•	•	1	0	0	0
No., 1976	0	0	0	3	0	0	0
No., 1977	4	13	3	24	0	60	0
No., 1978	15	32	8	18	0	100	0
No., 1979	5	19	5	13	0	70	0
No., 1980	0	0	0	5	0	0	0
No., 1981	0	0	0	6	0	0	0
No., 1987	27	47	17	8	0	140	0
No., 1990	0	0	0	2	0	0	0
No., 1991	3	•	•	1	3	3	0
No., 1992	13	14	5	8	0	35	0
No., 1993	2	1	1	2	1	2	0
No., 1995	10	•	•	1	10	10	0
No., 1997	10	•	•	1	10	10	0
No., 1998	0	•	•	1	0	0	0
No., 1999	1	3	1	15	0	10	0
No., 2000	2	7	1	25	0	23	0
No., 2001	0	0	0	8	0	0	0
No., 2002	1	1	1	4	0	3	0
No., 2003	34	61	20	9	0	172	0
No., 2004	6	7	3	7	0	20	0
No., 2005	12	16	12	2	0	23	0