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Department of Sustainability, Environment, Water, Population and Communities

Gippsland Lakes

Ramsar Site

Ecological Character Description

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March 2010

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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.

Introductory notes: This Ecological Character Description (ECD Publication) has been prepared in accordance with the National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands (National Framework) (Department of the Environment, Water, Heritage and the Arts, 2008).

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prohibits actions that are likely to have a significant impact on the ecological character of a Ramsar wetland unless the Commonwealth Environment Minister has approved the taking of the action, or some other provision in the EPBC Act allows the action to be taken. The information in this ECD Publication does not indicate any commitment to a particular course of action, policy position or decision. Further, it does not provide assessment of any particular action within the meaning of the EPBC Act (Cth), nor replace the role of the Minister or his delegate in making an informed decision to approve an action.

This ECD Publication 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.

from or connected to the currency, accuracy, completeness, reliability or suitability of the information in this ECD.

Note: There may be differences in the type of information contained in this ECD publication, to those of other Ramsar wetlands.

Use of terms and information sources: All definitions and terms used in this report were correct at the time of production in February 2011. Refer to the References (Section 8) for works cited and Glossary (Section 9) for a list of key terms and terminology used.

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LIST OF ABBREVIATIONS

ANZECC/ARMCANZ:	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
ASFB:	Australian Society of Fish Biologists
ASS:	Acid Sulfate Soils
AWSG:	Australian Wader Study Group
CAMBA:	China-Australia Migratory Bird Agreement
CEPA:	Communication, Education, Participation and Awareness
CMA:	Catchment Management Authority
CMS:	Convention on the Conservation of Migratory Species
DEWHA:	Former Department of the Environment, Water, Heritage and the Arts (Australian Government)
DoD:	Department of Defence
DSE:	Department of Sustainability and Environment (Victoria)
DSEWPaC	Department of Sustainability, Environmental, Water, Population and Communities (formerly DEWHA)
ECD:	Ecological Character Description
EGCMA:	East Gippsland Catchment Management Authority
EGSC:	East Gippsland Shire Council
EMP:	Ecological monitoring program
EPA:	Environment Protection Authority (Victoria)
EPBC:	*Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)*
ESO:	Environmental Significance Overlay
EVC:	Ecological Vegetation Class
EWR:	Environmental Water Reserve

FIS:	Flora Information System
GCB:	Gippsland Coastal Board
ICOL:	Intermittently Closing and Opening Lagoon
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
NES:	(matter of) National Environmental Significance
NRM:	Natural Resource Management
RIS:	Ramsar Information Sheet
ROKAMBA:	Republic of Korea- Australia Migratory Bird Agreement
SEPP:	State Environment Protection Policies
sp.:	Species (singular)
spp.:	Species (plural)
TSS:	Total Suspended Solids
VWCS:	Victorian Wetland Classification System
WGCMA:	West Gippsland Catchment Management Authority

EXECUTIVE SUMMARY

The Gippsland Lakes Ramsar site is one of 64 wetland areas in Australia that is 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). Gippsland Lakes was listed as a Ramsar site under the Convention in 1982 in recognition of its outstanding coastal wetland values and features.

This report provides the Ecological Character Description (ECD) for the Gippsland Lakes Ramsar site, prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands 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).

The Gippsland Lakes Ramsar site is located in coastal Victoria in the Southeast Coast Drainage Division, situated east of the Latrobe Valley and south of the Eastern Highlands. It consists of a group of coastal lagoons and marsh environments that are separated from the sea by a barrier system of sand dunes and fringed on the seaward side by the Ninety Mile Beach.

Eleven Ramsar wetland habitat types have been identified as occurring within the boundaries of the site. These include, most notably, coastal lagoons (Type J), subtidal seagrass and algal beds (Type B), and a range of saline, brackish and freshwater marsh environments (Types Sp and Tp).

The ecosystem processes that underpin the habitats of the Gippsland Lakes Ramsar site include hydrology and hydrodynamics (with the site heavily influenced by both freshwater riverine inputs and marine saline inflows), water quality and sediment nutrient dynamics, geomorphology, climate, shoreline and coastal processes and a range of biological processes.

The site supports a broad range of ecosystem services/benefits including nationally and internationally threatened wetland species, waterbird breeding and fish spawning sites. Cultural and socio-economic values are equally diverse, noting the particular importance of the site in a regional context in terms of recreational activities such as boating, recreational fishing and holiday tourism.

As part of the site overview, the ECD has reviewed the Ramsar Nomination Criteria under which the site was listed as a Wetland of International Importance and the applicability of the revised and new criteria under the Convention that have been added since the site was originally listed in 1982. In this context, the site is now seen as meeting six out of the nine Nomination Criteria recognising its representative wetland habitats at a bioregional level, vulnerable wetland species, support for key ecological life-cycle functions such as waterbird breeding, its importance for supporting waterbird abundance and diversity and its fish nursery and spawning habitats.

Following the methodology set out in the National ECD Framework, Table E-1-1 summarises the critical ecosystem components, processes and services/benefits for the site. 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 uniqueness of 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 to the component, process or service/benefit is reasonably likely to occur over short to medium term time scales (less than 100 years), and/or
- the change to the component, process or service/benefit will cause significant negative consequences if the change occurs.

In addition to critical components, processes and services/benefits, a range of other elements were identified as being important to the maintenance of the morphological, physio-chemical and biological processes. These supporting components, processes and services/benefits (also shown in Table E-1-1), while important to wetland functioning, were not considered to directly address the criteria listed above.

There are three descriptive groupings of wetland habitats for the site that form the basis for the conceptual models of the wetland. These habitat groupings include:

- marine subtidal aquatic beds (which contain seagrass or macroalgae)
- coastal brackish or saline lagoons (which are phytoplankton-dominated system)
- fringing wetlands, which are generally brackish in character but sometimes freshwater and sometimes hypersaline, and are vegetated with a wide range of vascular and non-vascular plants.

Conceptual models have been prepared for each of these, in order to represent the relationships between the critical components, processes and services/benefits.

The study has sought to define the natural variability and limits of acceptable change (LAC) for the critical components, processes and services/benefits identified. A summary of the limits of acceptable change is shown in Table E-1-2.

The study has also examined:

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

Recent or continuing threats that are notable in the context of the site and that may affect future ecological character have been identified in the Ramsar Site Strategic Management Plan (DSE 2003) and other plans and strategies that apply to the site. Key threats include altered water regimes, salinity, pollution, pest plants and animals, natural resource utilisation, dredging, activation of acid sulfate soils, recreation and tourism usage, fire and erosion. Contemporary threats include the prevalence and severity of recent algal blooms and the implications of climate change – particularly sea level rise – on the Gippsland Lakes.

A review of available data and specific studies on the site (and comparison against relevant LAC) demonstrate that an ecological character change is possible for some critical components since site listing in 1982. Relevant studies show a possible reduction in abundance and density of waterbirds (mainly those species that rely on or regularly use freshwater habitats), a possible reduction in abundance of key fish species such as black bream (based on commercial catch data only), possible reduction in density of seagrass assemblages and long term changes to vegetation communities in the fringing marsh wetlands of Lake Wellington (for example from *Phragmites* wetland to *Melaleuca* and swamp scrub dominated wetlands in Dowd Morass). The extent to which the changes are a result of natural and/or anthropogenic change (or a combination of both) is not able to be determined based on the current data set.

There is no clear or demonstrable evidence that the limits of acceptable change (LAC) defined for the site have been exceeded since listing. On this basis, it is determined that an empirical change to ecological character of the site cannot be established.

Information gaps, monitoring needs and recommendations in relation to communication, education, participation and awareness messages are also identified in the ECD. Thematic information gaps identified as being most important for consideration in future monitoring for the site include:

- Additional research and monitoring to establish an ecological character baseline for the key waterbodies/wetland habitats, with a priority on the transitional freshwater and brackish marshes that support important flora, fauna and life stage habitats (for example, breeding sites, roosting sites, spawning sites, etc.) and are at most risk of future ecological change from increasing salinity.
- The need for better information and data sets about the presence and natural history of critical wetland species and their habitats including for example, surveys of threatened plant species, aquatic fauna species such as Australian grayling and more systematic surveys of important avifauna and fish species and populations.
- Better information and understanding about the natural variability of wetland fauna populations and key attributes and controls on those populations.
- The ecological character threshold of particular habitats and communities to changes in key attributes/controls such surface and groundwater hydrology and salinity need additional investigation. Noting that the LAC stated in the ECD should be reviewed and revised as improved information becomes available.
- 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 future impacts.

In accordance with the above, monitoring needs and recommendations presented in this ECD relate broadly to obtaining data to assess future changes to ecological character as defined by the critical components, processes and services/benefits and associated LAC for the site. In this context, it should be recognised that the site requires more detailed broad-scale monitoring of ecological health in order to provide for a more sound understanding of natural variability and future ecological character changes.

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).

Table E-1-1 Summary of critical components, processes and services/benefits for the Gippsland Lakes Ramsar site

Critical components	**Critical processes**	**Critical services/benefits**
Wetland habitats: grouped as follows • (C1) marine subtidal aquatic beds (seagrass/aquatic plants). • (C2) coastal brackish or saline lagoons (open water phytoplankton-dominated habitats). • fringing wetlands that can occur within the site as– o (C3) predominantly freshwater wetlands o (C4) brackish wetlands o (C5) saltmarsh/ hypersaline wetlands. **Wetland flora and fauna:** • (C6) abundance and diversity of waterbirds. • (C7) presence of threatened frog species (green and golden bell frog; growling grass frog). • (C8) presence of threatened wetland flora species.	**Hydrological regime:** (P1) patterns of inundation and freshwater flows into the wetland system, groundwater influences and marine inflows that affect habitat structure and condition. **Waterbird breeding functions:** (P2) critical breeding habitats for a variety of waterbird species.	**Threatened species:** (S1) the site supports an assemblage of vulnerable or endangered wetland flora and fauna that contribute to biodiversity. **Fisheries resource values:** (S2) the site supports key fisheries habitats and stocks of commercial and recreational significance.
Supporting Components	**Supporting Processes**	**Supporting services/benefits**
Other wetland habitats: supported by the site (sand/pebble shores, estuarine waters, etc.). **Other wetland fauna:** supported by the site (for example, fish, aquatic invertebrates).	**Climate:** patterns of temperature, rainfall and evaporation. **Geomorphology:** key geomorphologic/ topographic features of the site. **Coastal and shoreline processes:** hydrodynamic controls on coasts and shorelines through tides, currents, wind, erosion and accretion. **Water quality:** water quality influences aquatic ecosystem values, noting the key water quality variables for Gippsland Lakes are salinity, dissolved oxygen, nutrients and sediments. **Nutrient cycling, sediment processes and algal blooms:** primary productivity and the natural functioning of nutrient cycling/flux processes in waterbodies. **Biological processes:** important biological processes such as primary productivity.	**Tourism and recreation:** the site provides and supports a range of tourism and recreational activities that are significant to the regional economy. **Scientific research:** the site supports and contains features important for scientific research.

Table E-1-2 Limits of acceptable change (LAC) – Gippsland Lakes 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	Marine sub-tidal aquatic beds (for example, within Lake King, Lake Victoria, Lake Tyers, Bunga Arm and Lake Bunga)	Long Term	• Total seagrass extent will not decline by greater than 50 per cent of the baseline value of Roob and Ball 1997 (that is, 50 per cent of 4330 hectares = 2165 hectares) in two successive decades at a whole of site scale. • Total mapped extent of dense and moderate *Zostera* will not decline by greater than 80 per cent of the baseline values determined by Roob and Ball (1997) in two successive decades at any of the following locations: ○ Fraser Island ○ Point Fullerton, Lake King ○ Point King, Raymond Island, Lake King ○ Gorcrow Point – Steel Bay, Lake Victoria ○ Waddy Island, Lake Victoria	Sampling to occur at least twice within the decade under consideration. Baseline mapping against which this LAC can be tested is within Roob and Ball 1997. Note that the seagrass assessment by Hindell (2008) did not produce mapping but did use similar sampling sites to Roob and Ball.	Level B - Recent quantitative data describes seagrass condition at various sites but over a limited timeframe. There is no available seagrass condition data prior to listing.	P1
C2	Coastal brackish or saline lagoons (for example, Lake King, Lake Victoria, Lake Wellington, Lake Tyers)	Long Term Long Term Short Term	• No change in wetland typology from the 1980 classification of Corrick and Norman (1980), as presented in Figure 2-3. • A long-term change in ecosystem state at Lake King, Lake Victoria or Lake Tyers from relatively clear, seagrass-dominated estuarine lagoons to turbid, algae dominated system (characteristic of Lake Wellington) will represent a change in ecological character. • No single cyanobacteria algal bloom event will cover greater than 10 per cent of the combined area of coastal brackish/saline lagoons (that is, Lake King, Victoria, Wellington and Tyers) in two successive years.	To be determined based on expert review. To be determined based on expert review. Algal bloom extent (per cent lakes area and location) and number should be reported annually, but assessed on an ongoing basis.	Level B - VMCS mapping data describes wetland extent. This is coarse scale mapping and should be considered as indicative only. Level A - The occurrence of cyanobacteria algal blooms are well documented. The extent of algal blooms historically has not been assessed, including at the time of site declaration.	P1, S2

[1] Short Term – measured in years; Medium Term – 5 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
C3	Fringing wetlands – predominantly freshwater marsh at Macleod Morass and Sale Common	Long Term	• No change in wetland typology from the 1980 classification (Corrick and Norman 1980; See Figure 2-3). In this regard, the conversion of vegetation communities at Sale Common and Macleod Morass from a predominantly freshwater character (for example, giant rush, common reed, cumbungi) to those of a brackish water character (brackish or swamp scrub/saltmarsh species) will represent a change in ecological character. • The total mapped area of freshwater marshes (shrubs and reed wetland types) at Sale Common and Macleod Morass will not decline by greater than 50 per cent of the baseline value outlined in VMCS for 1980 (that is, 50 per cent of 402 hectares = 201 hectares) in two successive decades.	To be determined based on expert review. Sampling to occur at least twice within the decade under consideration.	Level B - VMCS mapping data describes wetland extent during 1980. This is coarse scale mapping and should be considered as indicative only. There is no available community data prior to listing.	P1, P2, C6, C7, C8
		Short Term	• In existing freshwater wetland areas, the annual median salinity should not be greater than one grams per litre in two successive years. *Note that where ambient water quality characteristics fall outside the range of these baseline levels, and ecosystem health indicators shows no signs of impairment, the LAC may need to be adjusted accordingly.*	Annual median based on at least eight sampling periods per year, encompassing wet and dry periods.	Level C - No available baseline data. Value based on species salinity tolerances.	
C4	Fringing wetlands – brackish marsh (for example, Dowd Morass; The Heart Morass; Clydebank Morass, Lake Coleman {Tucker Swamp})	Long Term	For all fringing brackish wetlands: • No change in wetland typology from the 1980 classification (Corrick and Norman 1980).	To be determined based on expert review.	As for C3.	P1, P2, C6, C7, C8
		Medium Term	For Dowd Morass and the Heart Morass: • The annual median salinity will be less than four grams per litre in five successive years. *Note that where ambient water quality characteristics fall outside the range of these baseline levels, and ecosystem health indicators shows no signs of impairment, LAC may need to be adjusted accordingly.*	Annual median based on at least eight sampling periods per year, encompassing wet and dry periods.	Level C - No available baseline data. This value is based on species tolerances and requirement for salinity to be less than four grams per litre to allow reproduction (refer Tilleard and Ladson 2010).	
		Long Term	• The total area of common reed at Dowd Morass will not decline by greater than 50 per cent of the 1982 baseline value (that is, 50 per cent of 480 hectares = 245 hectares) outlined in Boon et al. (2007) in two successive decades.	Sampling to occur at least twice within the decade under consideration.	Level A - Boon et al. (2007) provides good quality mapping data relevant to time of listing.	

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
C5	Fringing wetlands – saltmarsh/hypersaline marsh (for example, Lake Reeve)	Medium Term	• No change in wetland typology from the 1980 classification (Corrick and Norman 1980). • The total mapped area of salt flat, saltpan and salt meadow habitat at Lake Reeve Reserve will not decline by greater than 50 per cent of the baseline value outlined in VMCS for 1980 (that is, 50 per cent of 5035 hectares = 2517 hectares) in two successive decades.	To be determined based on expert review. Sampling to occur at least twice within the decade under consideration.	As for C3.	P1, C6
C6	Abundance and diversity of waterbirds	Medium Term	• The number of standard 20 minute searches (within any ten year period) where waterbird abundance is less than 50 individuals will not fall below 50 per cent of the 'baseline' value (based on Birds Australia count data – 1987-2010), for the following species: o black swan = 15 per cent of surveys o chestnut teal = 10 per cent of surveys o Eurasian coot = 11 per cent of surveys. • The absence of records in any of the following species in five successive years will represent a change in character: red-necked stint, sharp-tailed sandpiper, black swan, chestnut teal, fairy tern, little tern, musk duck, Australasian grebe, grey teal, Eurasian coot, great cormorant, red knot, curlew sandpiper. • Median abundance (derived from at least three annual surveys {summer counts} over a 10-year period) falls below the 20th percentile baseline value. *Note: An adequate baseline will need to be established to assess this LAC (for example, at least three annual surveys (summer counts) over a 10-year period).*	Sampling to be undertaken at least twice a year over any 10 year period at stations containing favourable habitat for these species (see Table E8 for locations). Surveys should consist of standardised 20 minute counts. Sampling to be undertaken at least twice a year (during summer) at stations containing favourable habitat for these species (see section 3.4.1 for important locations). Recommended baseline monitoring program should include: • A combination of aerial and ground surveys. • Representative coverage of primary habitats within the site.	Level A - Birds Australia data, while standardised in terms of sampling effort per site, is not standardised in terms of frequency of sampling events at any given sampling location. Data should be considered indicative only. Level A - Records for these species are reliable. Birds Australia and DSE data can be used to assess this qualitative LAC. There are no baseline data available for this LAC.	P1, 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
C7	Presence of threatened frogs	Medium Term	• The site will continue to support suitable habitat for growling grass frog and green and golden bell frog. In this regard, the LAC for Component 3 applies. • There is insufficient data to develop a LAC relating directly to site usage by these species, which represents a critical information gap. Should baseline data become available in the future, the following LAC will apply: a significant reduction (greater than 25 per cent over a period of 5 years) in the local adult population within the site, especially for important local populations (for example, within Macleod Morass, Sale Common, Ewings Marsh, Roseneath wetlands (Morley Swamp and Victoria Lagoon), the Heart Morass and freshwater pools on Rotamah Island).	Refer to C3. Recommended baseline monitoring program should comprise a minimum two annual sampling periods separated by at least one year (and within a 5 year period).	Level C - Surveys for these species have been opportunistic. The most recent record for growling grass frog is 2007, whereas the green and golden bell frog was recorded at the site in 1998. There are no empirical data describing abundances at the site.	P1
C8	Presence of threatened wetland flora species	Long Term	• The three threatened flora species (*Rulingia prostrata*, *Thelymitra epipactoides* and *Xerochrysum palustre*) continue to be supported within the boundaries of the Gippsland Lakes Ramsar site.	Based on opportunistic searches.	Level C - Setting of empirical limits of acceptable change is not possible at present, given the absence of quantitative estimates of population size of threatened species within the site, and more importantly the viability of populations (and their key controls) within the site.	P1

<table>
<tr><th>Number</th><th>Indicator for Critical Component / Process/Service for the LAC</th><th>Relevant timescale[1]</th><th>Limit(s) of Acceptable Change</th><th>Spatial scale/temporal scale of measurements</th><th>Underpinning baseline data</th><th>Secondary critical C,P,S addressed through LAC</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Critical processes</td></tr>
<tr><td>P1</td><td>Hydrological regime</td><td>Short Term – Medium Term</td><td>Wetland wetting frequency, flushing frequency and flushing volume are maintained as follows:
<table>
<tr><td>Wetland</td><td>Wetting Frequency</td><td>Flushing Frequency</td><td>Required Flushing Volume</td></tr>
<tr><td>Sale Common</td><td>Annual with 100 per cent reliability</td><td>2-3 times/decade</td><td>4 GL</td></tr>
<tr><td>Dowd Morass</td><td>5-7 times/decade</td><td>2-3 times/decade</td><td>15GL</td></tr>
<tr><td>The Heart Morass</td><td>5-7 times/decade</td><td>2-3 times/decade</td><td>15GL</td></tr>
</table>
From Tilleard and Ladson (2010); note that larger flushing volumes (~20GL) are identified as being needed for Dowd and the Heart Morasses following saline flood events in the Lake Wellington system (for example, when the wetlands are filled with saline water from Lake Wellington and this corresponds with low flows in the Latrobe River).</td><td>Refer to LAC for details. Values measured at existing gauging stations in the lower reaches of the Rivers or otherwise in the wetlands themselves.</td><td>LAC have been identified for these wetlands on the basis that they are the best indicators of freshwater flows into the broader Gippsland Lakes system.

Level C - LAC based on Tilleard and Ladson (2010) ‘Hydrological Analyses to Support Determination of Environmental Water Requirements in the Gippsland Lakes’. This is a threshold-based LAC that is based on modeling and ecological assessments. Note that these values should be considered as indicative only at this stage, and should be constantly reviewed.
Tilleard and Ladson (2010) indicate no work has been done for wetlands on the Mitchell (Macleod Morass); McLennan Straits (Morley Swamp, Lake Betsy); or Jones Bay.</td><td>C1 – C8
S1, S2</td></tr>
<tr><td>P2</td><td>Waterbird breeding</td><td>Short Term</td><td>Abandonment or significant decline (greater than 50 per cent) in the productivity of two or more representative breeding sites (based on two sampling episodes over a five year period) within any of the following site groupings:

Lake Coleman, Tucker Swamp and Albifrons Island - Australian pelican.
Bunga Arm and Lake Tyers – little tern and fairy tern.
Macleod Morass, Sale Common and Dowd Morass – black swan, Australian white ibis, straw-necked ibis, and little black cormorant.
</td><td>Recommended baseline monitoring program should comprise a minimum two annual sampling periods separated by at least one year (and within a 5 year period).</td><td>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.</td><td>C6</td></tr>
</table>

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 services/benefits						
S1	Threatened species	N/A	No LAC are proposed for painted snipe and Australasian bittern at the current time until greater information is available about patterns of usage and populations in the Ramsar site. Other threatened species are dealt with in the critical components above.	N/A	Level C - Site records are not recent, uncommon and the location within the Ramsar boundary not known.	P1, C3
		Long Term	Australian grayling continues to be supported in one or more of the catchments draining into the Gippsland Lakes.	Setting of more empirical limits of acceptable change not possible at present, given the absence of quantitative population data for this species for any of the rivers and creeks that drain into the site.	Level C - This species has been recorded in the major drainages that drain into the site. Juveniles have an apparent obligate estuarine phase, and therefore must use the site in order for this species to persist in these drainages. There are no data describing the population status of this species in these drainages.	P1, C1, C2
S2	Fisheries resource values	Medium Term	• Total annual black bream commercial fishing catch per unit effort will not fall below the 10th percentile historical baseline value of 6.1 (see Section 3.8.2) in a five successive year period. • Sub-optimal black bream spawning conditions should not occur in any successive five year period within key spawning grounds (that is, mid-lower estuaries and adjacent waters of main lakes) during the peak spawning period (October to December). Based on Tilleard (2009), optimal conditions are as follows: • Water column salinity is maintained in brackish condition (for example, between 17-21 grams per litre median value) in the middle of the water column in the mid-lower estuaries and adjacent waters of the main lakes • The salt wedge is located within the mid-lower section of the estuarine river reaches or just out into the main lakes as opposed to far upstream or well-out into the Lakes.	Median measured over five years. Annual median value for the period October to December. As above.	Level B - While some commercial fish data has been accessed and reviewed as part of the current study, the abundance and usage of the Gippsland Lakes by key fish species of commercial and recreational significance is not well quantified. The baseline data used in this LAC has limited duration (five years), and is unlikely to be representative of patterns in abundance over longer timeframes. This LAC will need to reviewed and refined. Level C – based on conditions outlined in Tilleard (2009).	C1, C2, C3, C4, C5

1 INTRODUCTION

1.1 Background

The Gippsland Lakes Ramsar site is one of 64 wetland areas in Australia that is 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). Gippsland Lakes was listed as a Ramsar site under the Convention in 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 attributes 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 therefore aims to describe the ecological character at the date of listing (1982).

This report provides the ECD for the Gippsland Lakes 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 discussed in Section 1.2.

1.2 Scope and Purpose

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

The key purposes of undertaking an ECD (from DEWHA 2008) 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.

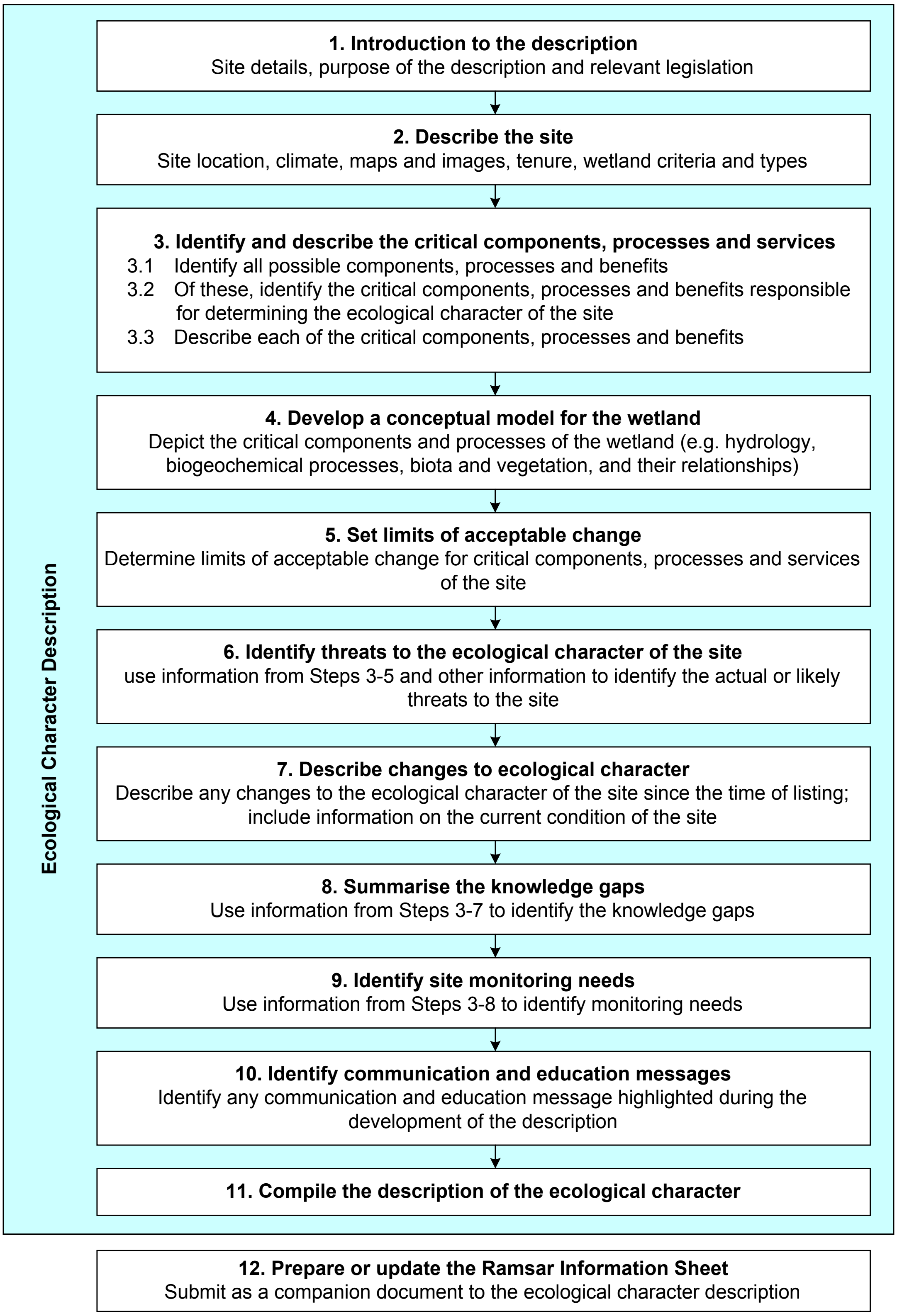


Figure 1-1 Key steps in preparing an Ecological Character Description

(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 Gippsland Lakes 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 1975. 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, as noted in Section 1.2 above.

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 dictates standards for managing Ramsar wetlands (refer s335) through the Australian Ramsar management principles that are listed within Schedule 6 of the EPBC Regulations 2000.

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 including vegetation management.

Coastal Management Act 1995

The Act was enacted to establish the Victorian Coastal Council in order to provide for the establishment of Regional Coastal Boards, 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.

The State Environment Protection Policy (Waters of Victoria) 2003, Schedule F3 (Gippsland Lakes and Catchment) No S 13, Gazetted 26/2/1988 sets out environmental quality objectives for surface waters in the State. However due to a lack of data the SEPP does not include specific environmental quality objectives for wetlands at present.

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 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”.

Local Planning Policy Frameworks in the Gippsland Region for the Shire of Wellington and East Gippsland Shire also make specific references to wetlands in their area and the need to protect such areas. As a result many of the larger, higher value wetlands, such as those of international and national significance, are already protected by environmental significance overlays (ESOs) and zonal controls.

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 GENERAL DESCRIPTION OF THE SITE

2.1 Location and Brief Description

The Gippsland Lakes Ramsar site is located east of the Latrobe Valley and south of the Eastern Highlands in the State of Victoria, approximately 300 kilometres east of the capital city of Melbourne. It consists of a group of coastal lagoons separated from the sea by a barrier system of sand dunes and fringed on the seaward side by the Ninety Mile Beach. Summary details for the Ramsar site are provided in Table 2-1.

The Gippsland Lakes system is linked to the sea by an artificial entrance, opened in 1889, where the town of Lakes Entrance is now situated. The main lagoons/lakes are fed by a number of river systems. The largest of the rivers are the Latrobe, Macalister, Thomson, Avon (flowing into Lake Wellington), Mitchell, Nicholson and Tambo (flowing into Lake King).

As shown in Figure 2-1 (provided by DSE), the Ramsar site boundary (and wetlands within) can be described as follows:

- In general, the site is a system of lakes and swamplands extending from Sale eastward to their outlet to the sea at Lakes Entrance.
- The main lagoons/lakes of the site are Lake Wellington (area 148.19 square kilometres), Lake Victoria (area 78.14 square kilometres) and Lake King (area 96.84 square kilometres). Lake Wellington is connected to Lake Victoria by McLennan Strait. Other wetlands associated with the Strait area include Morley Swamp and Victoria Lagoon.
- Lake Tyers is the other major lagoon within the site boundary but is not part of the larger Lake King-Victoria-Wellington lakes system. It is situated to the east of Lakes Entrance with its own intermittent connection to Bass Strait.
- The elongated saltmarsh-dominated Lake Reeve is also contained within the Ramsar site, extending from Loch Sport southwest to Seaspray. The site boundary at this location includes the lake and associated wetlands only and does not include terrestrial areas, dunal areas and the ocean beaches of the Gippsland Lakes Coastal Park.
- Other wetlands of the site include Jones Bay and Macleod Morass which lie immediately south of Bairnsdale at the head of Lake King and on either side of the Mitchell River. The Nicholson River (flowing into Jones Bay) is also included within the site, with the site boundary extending upstream to about the location of the town of Sarsfield (but downstream from the Nicholson River Dam).
- In addition to the lakes and lagoons, the site boundaries also include wetlands that occur on the margins of the lakes, hereafter referred to as fringing wetlands.
- The major fringing wetlands of Lake Wellington that are within the Ramsar site boundary include the eastern sections of Lake Coleman (including Tucker Swamp), Dowd Morass, the Heart Morass and Clydebank Morass.

- Large areas of Lake Coleman (western portion) are outside of the boundaries of the Ramsar site. The lake is mainly Commonwealth land that is managed and used by the Department of Defence for training purposes.
- Sale Common is the westernmost feature of the Ramsar site, situated along the Latrobe River near the town of Sale. Sale Common is a predominantly freshwater wetland.
- The Ramsar site does not include dryland (for example, non-wetland) areas.

Table 2-1 Details of the Gippsland Lakes Ramsar site

Ramsar Site Name	**Gippsland Lakes Ramsar Site**
Location in Coordinates	Latitude: 37° 49' to 38° 12'S Longitude: 147° 04' to 148° 08'E
General Location	The lakes and wetlands that make up the Gippsland Lakes Ramsar site extend eastwards from Sale Common to Lake Tyers. The site is located east of the Latrobe Valley and south of the Eastern Highlands, approximately 300 kilometres from Melbourne.
Area	60 015 hectares
Date of Listing	15 December 1982
Dates Used for Description	1982 (time of listing); 2010 (time of preparation of the ECD)
Original Description Date	This is the first ECD undertaken for the site. As part of this project, the Ramsar Information Sheet has also been updated.
Compiler's Name	BMT WBM Pty Ltd with expert input from Austecology Pty Ltd and Dodo Environmental under contract with the Department of Sustainability, Environment, Water, Population and Communities.
Ramsar Information Sheet	Last updated 1999. Updated as part of current ECD by BMT WBM (2010). Australian Ramsar Wetlands webpage: http://www.environment.gov.au/water/topics/wetlands/database/pubs/21-ris.pdf Ramsar Site No.: 269 (Australian Ramsar Site No.: 21)
Management Plan	Gippsland Lakes Ramsar Site Strategic Management Plan published in July 2003 by the Department of Sustainability and Environment (DSE 2003)
Management Authority	Managed by Parks Victoria – approximately 58 108 hectares (97 per cent) Department of Sustainability and Environment – approximately 1600 hectares (2.5 per cent) Private Freehold – approximately 192 hectares (0.3 per cent) Local Government – approximately 115 hectares (0.2 per cent)

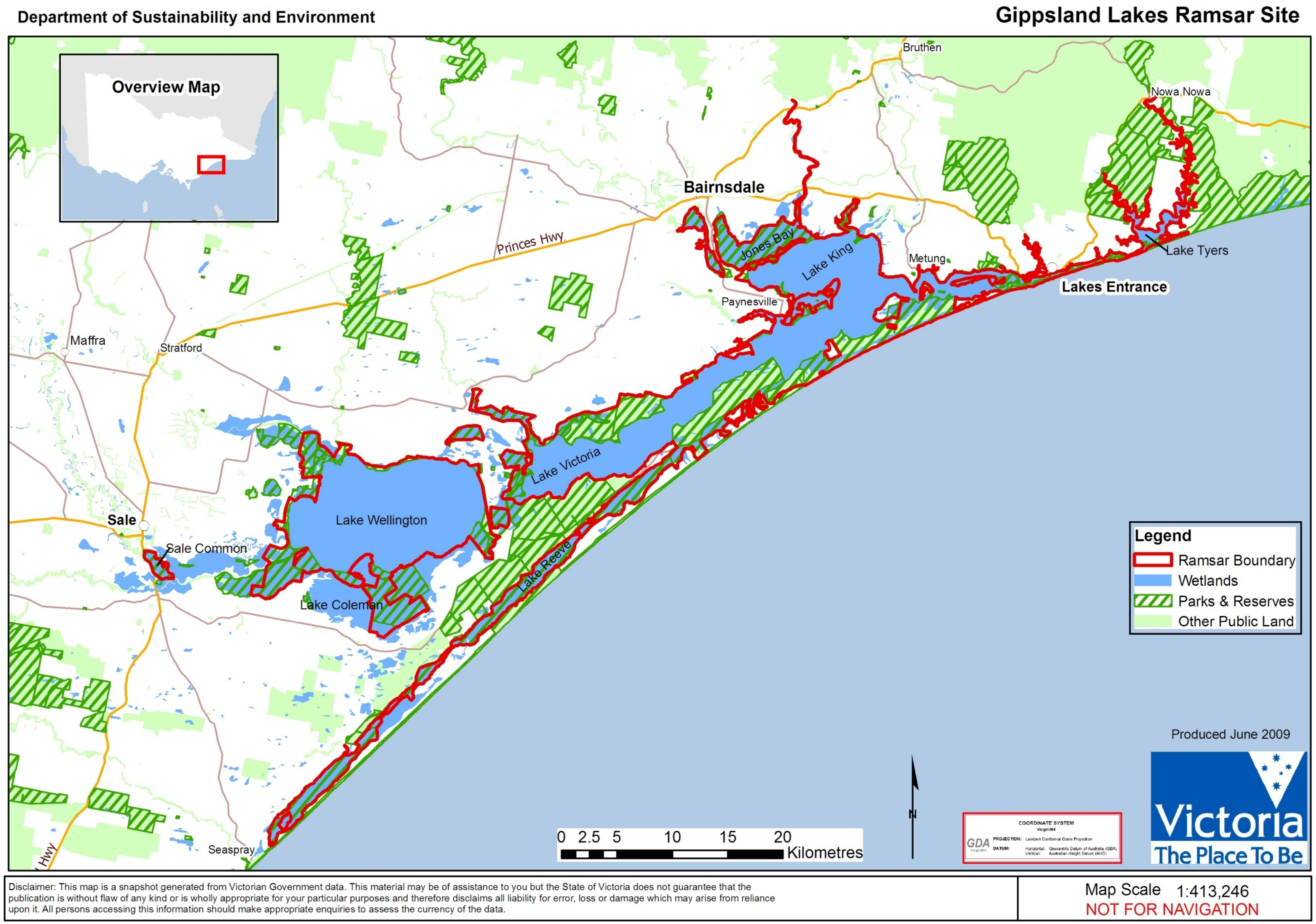


Figure 2-1 Gippsland Lakes Ramsar site map (Source: DSE unpublished)

2.2 Land Use and Tenure

The land use and tenure within and adjacent to the site are described in this section. Relevant treaties, legislation and management plans relevant to the site are listed in Section 1 of this ECD.

2.2.1 Land Use Within and Adjacent to the Site

The land and waters of the Gippsland Lakes Ramsar site have a variety of tenures and are managed in accordance with the Gippsland Lakes Ramsar Site Strategic Management Plan (DSE 2003).

A range of agencies are responsible for ensuring that management of the site complies with the broad range of legislative requirements. The successful management of the Gippsland Lakes Ramsar site therefore relies on effective cooperation and partnership between the various management agencies. Table 2-2 and Table 2-3 summarise the land tenure and management arrangements including the roles and responsibilities of lead management agencies.

As outlined in the tables, the majority of the site (approximately 38 000 hectares) is reserved under the *Crown Land (Reserves) Act 1978* as Nature Conservation Reserve, Natural Features Reserve, and Public Purpose Reserve. Approximately one third of the Gippsland Lakes Ramsar site is located within the Lakes National Park (2390 hectares) and Gippsland Lakes Coastal Park (17 610 hectares) (Parks Victoria 1998). Both Parks are proclaimed under the *National Parks Act 1975*. Located south of the Ramsar site is the Ninety Mile Beach Marine National Park, proclaimed in November 2002. A small area (0.3 per cent) of the site near Paynesville (on Lake Victoria) is held as private, freehold land.

Nature Conservation Reserves and other land managed primarily for conservation surround 45 per cent of the Ramsar site, and include parks and reserves (20 per cent) and coastal and waterway areas (25 per cent). Non-conservation land that surrounds the site includes grazing (45 per cent), residential (five per cent) and industrial (five per cent). In general, urban development is increasing in areas bordering the site, while agriculture is decreasing.

The site is located in two local government shires. The East Gippsland Shire covers the eastern area of the Gippsland Lakes Ramsar site from where McLennan Strait enters Lake Victoria and the eastern edge of the Lakes National Park (Sperm Whale Head) and covering all of Lake Victoria, Lake King, Lake Bunga and Lake Tyers. The Wellington Shire covers the western area of the Gippsland Lakes Ramsar site including Lake Wellington, Lake Reeve, McLennan Strait and the land south of Lake Victoria covering the Ninety Mile Beach, Loch Sport and the Lakes National Park (Sperm Whale Head).

East Gippsland and Wellington Shires implement the state planning provisions which control development and land use changes within the area.

Table 2-2 Land tenure and management of the Ramsar site (updated from DSE 2003)

Wetland	Land tenure	Legal status	Management
Sale Common	Nature Conservation Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Dowd Morass (part)	State Wildlife Reserve classified as State Game Reserve (also part privately owned)	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Hearts Morass (part)	State Wildlife Reserve classified as State Game Reserve (also part privately owned)	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Clydebank Morass	State Wildlife Reserve classified as State Game Reserve*	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Lake Wellington (western shoreline)	Public Purposes Reserve	*Crown Land (Reserves) Act 1978*	DSE
Lake Wellington (shoreline – Disher Bay)	Public Purpose Reserve, Unreserved Crown Land	*Crown Land (Reserves) Act 1978*	DSE
Lake Wellington (shoreline – Swell Point to Roseneath Point)	Public Purpose Reserve	*Crown Land (Reserves) Act 1978*	DSE
Lake Wellington (eastern shoreline)	Public Purpose Reserve, Salt Lake – Unreserved Crown Land	*Crown Land (Reserves) Act 1978*	DSE
Lake Wellington	Crown Land Reserve	*Crown Land (Reserves) Act 1978*	DSE
Lake Coleman[2]	State Wildlife Reserve classified as State Game Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Land adjoining Lake Coleman Wildlife Reserve to south	Land vested in Gippsland Water	*Water Act 1989*	Gippsland Water
Lake Reeve	Gippsland Lakes Coastal Park	*National Parks Act 1975*	Parks Victoria
Gippsland Lakes Coastal Park	Coastal Park	*National Parks Act 1975*	Parks Victoria
Land near McLennan Strait	Part of Gippsland Lakes Coastal Park	*National Parks Act 1975*	Parks Victoria
	Public Purpose Reserve	*Crown Land (Reserves) Act 1978*	DSE
Morley Swamp	Natural Features Reserve – Gippsland Lakes Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Backwater Morass	Natural Features Reserve – Gippsland Lakes Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Red Morass	Natural Features Reserve – Gippsland Lakes Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Victoria Lagoon	Natural Features Reserve – Wildlife Reserve classified as State Game Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Lake Victoria	Crown Land Reserve	*Crown Land (Reserves) Act 1978*	DSE
The Lakes National Park	The Lakes National Park	*National Parks Act 1975*	Parks Victoria
Blond Bay	Natural Features Reserve – Wildlife Reserve classified as State Game Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Lake King	Public Purposes Reserve	*Crown Land (Reserves) Act 1978*	DSE
Macleod Morass	Natural Features Reserve – Wildlife Reserve classified as State Game Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Jones Bay	Natural Features Reserve – Wildlife Reserve classified as State Game Reserve and Natural Features Reserve – Gippsland Lakes Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Mitchell River	Water Reserve	*Land Act 1958*	Parks Victoria
Swan Reach	Natural Features Reserve – Gippsland Lakes Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Lake Tyers	Forest Park	*Crown Land (Reserves) Act 1978*	DSE, Shire
Land to the south of Lake King	Gippsland Lakes Coastal Park	*National Parks Act 1975*	Parks Victoria
North Arm (near Lakes Entrance)	Public Purpose Reserve	*Crown Land (Reserves) Act 1978*	DSE
Lakes Entrance to Lake Tyers including Lake Bunga	Lakes Entrance – Lake Tyers Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria, EGSC

[2] Only a portion of Lake Coleman is within the Ramsar site boundary. The balance of the wetland is part of the Dutson Range Training Area, managed by the Australian Department of Defence.

Table 2-3 Lead management agencies and their key responsibilities (updated from DSE 2003)

Agency	Overarching Responsibility	Responsibility to Gippsland Lakes
Parks Victoria	Manage parks and reserves. Parks Victoria has a role in the management of Ramsar wetlands that occur within parks and reserves managed by Parks Victoria, and also a role in contributing to overall management of sites outside parks and reserves with other management agencies.	Manage areas including The Lakes National Park, Gippsland Lakes Reserve, Macleod Morass, The Sale Common, Mitchell River Water Reserve as well as Heart, Dowd and Clydebank Morasses.
Department of Sustainability and Environment (Gippsland Regional Office)	Strategic direction for park and reserve management; flora and fauna management and implementation of the Ramsar Convention in Victoria; catchment and water management, forest management, coastal and port management; leasing, licensing and management of public land.	Policy advice for the management of the Gippsland Lakes Ramsar site. Management of hunting at the Gippsland Lakes Ramsar site. Management of waterbody lake beds. Strategic and operational catchment management services, for example, soil conservation, vegetation management, salinity management, water quality monitoring and management.
Department of Primary Industries (Gippsland Regional Office)	Provides strategic direction for fisheries management and research, agricultural services and sustainable development of Victoria's energy and mineral resources.	Manage commercial and recreational fishing for the Ramsar site in accordance with *Fisheries Act 1995*.
Department of Planning and Community Development	Strategic and statutory land use planning including the administration of the Victorian State Planning Provisions.	Broad strategic planning role for the Gippsland Lakes as well as approval/review of planning schemes.
Local Government (East Gippsland Shire and Wellington Shire)	Regulation of local land use and development through planning schemes, on-ground works and management of urban and some rural drainage.	Administer the planning scheme as well as some resource management functions such as vegetation management.
Rural Water Authority (Southern Rural Water)	Provide irrigation, drainage, water supply, and manage specific water supply catchments.	Supply rural water across southern Victoria including bulk supply to non-metropolitan urban water authorities and Latrobe Valley electricity generators.
Non Metropolitan Urban Water Authority (East Gippsland Water and Gippsland Water)	Provide urban water supplies and wastewater disposal services.	Provide water and sewerage services to townships in the vicinity of the Ramsar site. Manage water supply catchments and sewage treatment plants.
Victorian Catchment Management Council (West Gippsland CMA and East Gippsland CMA)	Advise State Government on catchment management, and land and water resource issues and priorities. Encourage cooperation between land and water managers. Promote community awareness on catchment management issues.	Develop and implement Regional Catchment Management Strategies and Regional River Health Strategies. Prepare and implement Action Plans. Manage surrounding catchment and inflowing streams and drainage. Manage environmental water requirements.
Committees of Management (DSE, local government, elected committees)	Manage reserved Crown land on behalf of the Minister. Committees are usually the Local Shire or publicly elected.	Manages reserves for the purposes for which they are gazetted.
Environment Protection Authority (EPA East Region)	Responsibility for and coordination of all activities relating to the discharge of waste into the environment and the generation, storage, treatment, transport and disposal of industrial waste and the emission of noise and for preventing or controlling pollution and noise and protecting and improving the quality of the environment.	Licence sewage and other discharges. Monitor water quality.

Agency	Overarching Responsibility	Responsibility to Gippsland Lakes
Victorian Coastal Council (Gippsland Coastal Board)	Strategic State-wide coastal planning; preparation of the Victorian Coastal Strategy; advise the Minister; monitor development of Coastal Action Plans; and coordinate the implementation of the Victorian Coastal Strategy and Coastal Action Plans.	Develop Coastal Action Plans and guidelines for coastal planning and management within the region; provide advice to Minister and Council on coastal development within the region; and implementation of, and facilitating public awareness of the Victorian Coastal Strategy, Coastal Action Plans and coastal guidelines.
Department of Defence	While the Dutson Range Training Area is not contained within the boundaries of the Ramsar site, the Department of Defence plays a significant role in the management of Lake Coleman in cooperation with Parks Victoria.	Selected areas of Dutson Range have been identified as conservation zones to maintain and enhance significant environmental values (HLA 2007). A range of environmental management plans are implemented (fire, weed control, water management) to maintain wetland values.
Gippsland Ports	Establish, manage, dredge and maintain channels in port waters; provide and maintain navigation in connection with navigation of port waters; direct and control movement of vessels within port waters.	Operation of commercial port of Lakes Entrance. Maintenance of navigational aids and channels. Management of public facilities.

2.2.2 Catchment Land Use

The catchment of the Gippsland Lakes covers an area of over two million hectares and supports many land uses as shown in Figure 2-2 (based on DCE 1991). It includes several large towns and cities (Sale, Bairnsdale, Warragul, Traralgon, Morwell and Moe), Victoria's major electricity generating facilities, the Latrobe Valley industrial area, extensive dryland and irrigated farmland and a significant proportion of Victoria's hardwood and softwood timber resources (DCE 1991).

The water resources of the river systems that drain into the Gippsland Lakes have been extensively developed to support agricultural activities, urban water supply, industrial use and as cooling water for thermal electricity generation (DCE 1991). A significant portion of the lower reaches of the Latrobe, Macalister and Mitchell Rivers are surrounded by irrigation areas, primarily comprising dairy farming and horticulture.

The Latrobe River receives a number of licensed discharges of waste, the major contributions being treated sewage from Warragul, Moe and Morwell, and industrial wastewater from the power generating companies (DCE 1991). The lower reaches of the rivers in the western part of the catchment are experiencing elevated groundwater tables and associated saline discharge, as well as nutrient and sediment discharges from irrigation drainage.

The Tambo, Avon and Nicholson Rivers also drain into the lakes system. Within the Tambo catchment there are former mining areas around Cassillis that have eroded in the past created large slugs of sand within the lower reaches of the river near Bruthen and Tambo Upper and erodible agricultural areas, particularly in granitic areas. Both the Avon and Nicholson Rivers drain from vegetated upper catchments into areas that are dominated by cleared agricultural land along their lower reaches.

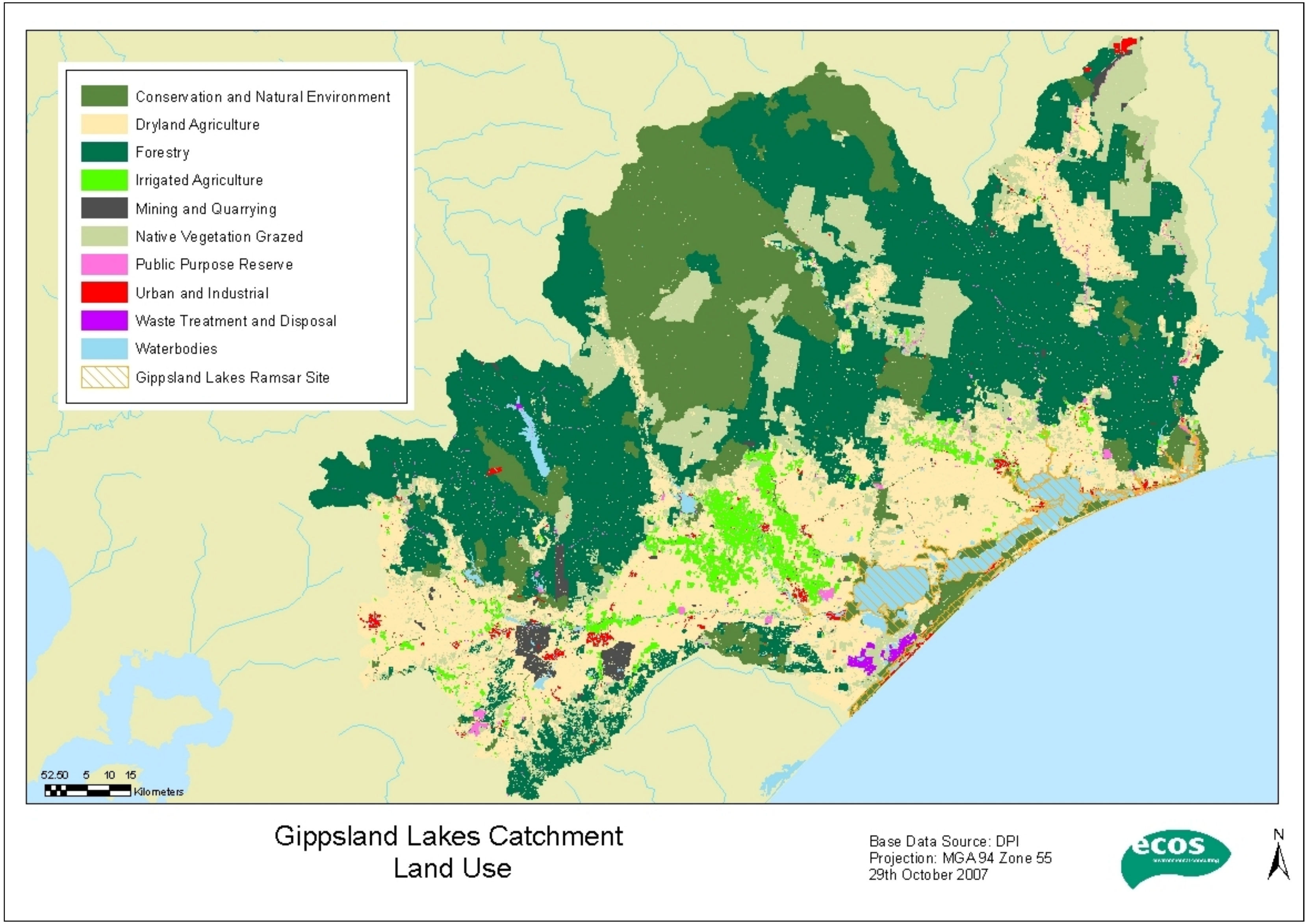


Figure 2-2 Gippsland Lakes catchment land use (reproduced from Ecos unpublished)

2.3 Description of Wetland Types

The Gippsland Lakes Ramsar site contains an extensive system of estuarine, fresh and brackish coastal wetlands, with a diversity of wetland types present including lagoons, marshes and tree-swamps. 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) is used. Wetland categorisation under the Ramsar typology provides up to 12 marine/coastal wetland types, 20 inland wetland types and 10 human-made wetland types.

To date, no mapping according to Ramsar wetland types of Gippsland Lakes has been undertaken. Therefore, in order to refine the presence of Ramsar wetland types within the site, information was collated and reviewed from the following sources: the 1999 RIS (Casanelia 1999), the Victorian Wetland Classification System (VWCS) (based on Corrick and Norman 1980) and Ecological Vegetation Class (EVC) mapping by DSE.

Although direct overlaps between the different wetland types as classified by the three systems are limited, the most likely equivalent wetland types were determined and are presented in Table 2-4. Using the VWCS mapping, a map of wetland types within the Ramsar site was generated (refer Figure 2-3) and areas of each wetland type were calculated (refer Table 2-4 using equivalent Ramsar wetland types).

Based on the review, the following Ramsar wetland types are seen as being represented within the site at the current time:

- five marine/coastal wetland types (B, E, F, H, J)
- five inland wetland types (L, M, Sp, Tp and Xf)
- one man-made wetland type (Type 8).

All of the wetland types listed above are considered to have been supported by the site at the time of listing in 1982 based on the information presented in the original listing document (Victorian Ministry for Conservation 1980).

Table 2-4 Ramsar wetland types as translated from the Victorian Wetland Classification System (VWCS) wetland types within the Ramsar site

Ramsar Wetland Type	Interpreted VWCS Category	Area*
B – Marine subtidal aquatic beds	No specific VWCS category (but within 7.01 – Permanent saline - shallow)	5013 hectares
E - Sand, shingle or pebble shores	No equivalent VWCS category	N/A
F - Estuarine waters	No equivalent VWCS category	N/A
H - Intertidal marshes	6.02 – Semi-permanent saline – salt meadow	7137 hectares
	6.03 – Semi-permanent saline - salt flats	
	6.04 – Semi-permanent saline – sea rush	
	6.99 – Semi-permanent saline – island	
J – Coastal brackish/saline lagoons	6.01 – Semi-permanent saline – salt pan	39 034 hectares
	5.01 – Permanent open freshwater – shallow	
	7.01 – Permanent saline – shallow	
	7.02 – Permanent saline - deep	
L - Permanent inland deltas	No equivalent VWCS category	N/A
M - Permanent rivers, streams or creeks	No equivalent VWCS category	N/A
Sp - Permanent saline/brackish/alkaline marshes/pools[3] and Tp - Permanent freshwater marshes and pools	3.01 – Shallow freshwater marsh - herb	4713 hectares
	4.02 – Deep freshwater marsh – reed	
	4.05 – Deep freshwater marsh – open water	
	4.99 – Deep freshwater marsh - island	
	6.01 – Semi-permanent saline – salt pan	
Xf - Freshwater tree-dominated wetlands	4.01 – Deep freshwater marsh - shrub	

*Based on mapping of corresponding VWCS categories; except for Type B which is based on EVC mapping.

[3] There is no 'brackish' wetland category within the VWCS. Saline wetlands are those in which salinity exceeds 3000 milligrams per litre (three grams per litre) throughout the entire year. Type Sp has been grouped with Type Tp on the basis that many of the wetlands that were classified by Corrick and Norman in 1980 as 'Deep freshwater marshes' in the Gippsland Lakes are now predominantly brackish in character. This is further discussed in the ecological character change section of this ECD.

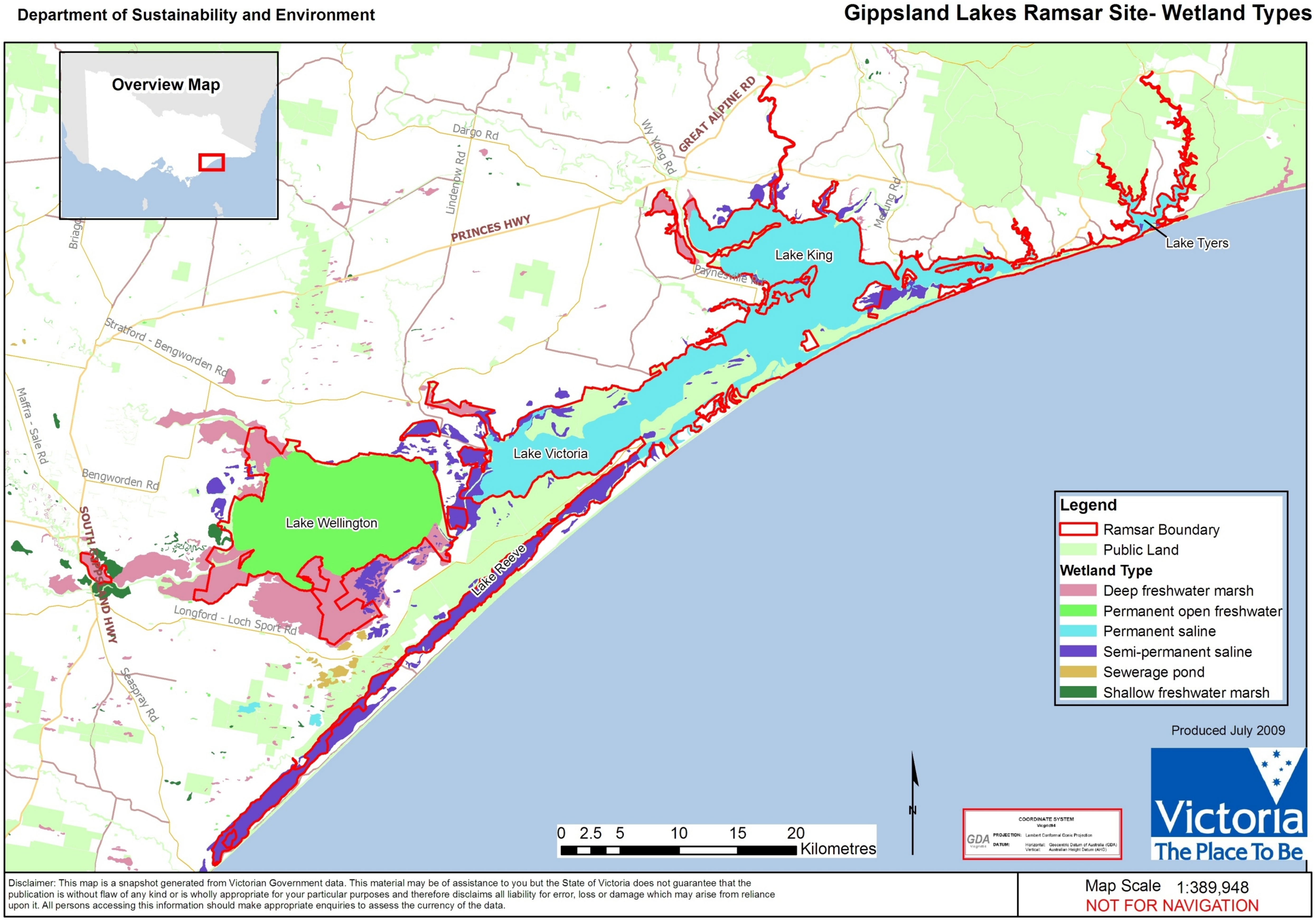


Figure 2-3 Wetland types within the Gippsland Lakes Ramsar site based on Victorian wetland classification system mapping (Source: DSE unpublished)

2.3.1 Coastal Wetlands

Type B: Marine subtidal aquatic beds

This wetland type is represented by seagrass beds that cover a total area of 5013 hectares within the site (based on EVC mapping). Seagrass beds are widely distributed within the site, particularly within the eastern parts including Lake Tyers, Lake Victoria and Lake King (Roob and Ball 1997, Hindell 2008). Species of seagrass that are present include *Zostera muelleri*, *Heterozostera tasmanica*, *Ruppia spiralis* and *Lepilaena cylindrocarpa* (Roob and Ball 1997). Seagrass beds are an ecologically significant habitat, providing breeding grounds, nursery areas, food and shelter for a variety of aquatic fauna, and also provide a food source for black swans and other herbivorous waterbirds.

Type E: Sand, shingle or pebble shores

This wetland type incorporates sand, shingle or pebble shores, including sand bars, spits, sandy islets, dune systems and humid dune slacks. Sandy shores are present within the site in the Gippsland Lakes Coastal Park, which forms a component of the barrier system of sand dunes that separate the coastal lagoons from the ocean.

Sand shore near Lakes Entrance (photo: Paul Boon)

Type F: Estuarine waters

EVC mapping classifies a large proportion of waters within the site as estuarine. Waters within the Lake King, Lake Tyers, Jones Bay and the lower reaches of Lake Victoria are of an estuarine nature as a result of the permanent entrance to Bass Strait at Lakes Entrance.

Gippsland Lakes near Lakes Entrance (photo: Paul Boon)

Type H: Intertidal marshes

This wetland type is represented within the site by saltmarsh communities that border saline-influenced wetlands as well as shorelines that are infrequently inundated by saline water. Approximately 7137 hectares of intertidal marshes are present within the Ramsar site (based on VWCS mapping). Representative examples of saltmarsh communities are located at Blond Bay, Lake Reeve, Point Fullarton and Eagle Point Bay. Characteristic saltmarsh species present include beaded glasswort (*Sarcocornia quinqueflora*) and sea rush (*Juncus kraussii*) (DSE 2003).

Type J: Coastal brackish/saline lagoons

This wetland type incorporates brackish to saline lagoons with at least one relatively narrow connection to the sea. Representative examples of coastal brackish/saline lagoons include Lake Tyers, Lake King, Jones Bay and Lake Bunga.

Lake Tyers (photo: Paul Boon)

2.3.2 Inland Wetlands

Type L: Permanent inland deltas

This wetland type is represented by the Mitchell Delta. The Mitchell Delta is a classic form of digitate delta located near the western shoreline of Lake King at Eagle Point Bluff, extending into the lake as silt jetties formed by alluvial deposition of sediment. Representing one of the finest examples of this type of landform in the world, the Mitchell Delta is a site of international geomorphological significance (Rosengren 1984).

Type M: Permanent river, streams or creeks

The lower reaches of a number of permanent rivers are located within the boundary of the site. Representative examples include the Nicholson River as well as portions of the lower Latrobe, Avon, and Perry Rivers.

Type Sp: Permanent saline/brackish/alkaline marshes and pools and Type Tp: Permanent freshwater marshes and pools

Permanent marshes and swamps on inorganic soil, with emergent vegetation that is water-logged for at least most of the growing season, are a major feature of Gippsland Lakes. As such, these two wetland types are extensively represented within the Ramsar site, covering an area of approximately 4713 hectares (based on VWCS mapping). Permanent marshes within the site are typically composed of common reed (*Phragmites australis*) beds and provide habitat for a variety of aquatic fauna (particularly in the juvenile stage) and small terrestrial birds.

Common reed at Lake Bunga (photo: Paul Boon)

Type Xf: Freshwater tree-dominated wetlands

This wetland type is viewed as being present within the site, represented by swamp paperbark (*Melaleuca ericifolia*) dominated woodlands and forests. Although swamp paperbark woodlands are largely freshwater (for example, Sale Common), they are also generally able to persist under estuarine conditions (in the brackish morasses such as Dowd and The Heart). swamp paperbark woodlands provide important habitat for a range of fauna, especially colonially roosting waterbirds.

Ibis rookery in swamp paperbark woodland at Dowd Morass (photo: Paul Boon)

2.3.3 Human-made Wetlands

Type 8: Wastewater treatment areas

This wetland type is represented within the Ramsar site by a two hectare sewage pond in the vicinity of Macleod Morass (DSE 2003).

2.4 Nomination Criteria Met by the Site

2.4.1 Original Criteria under which the Site was Listed

The original nomination documentation indicated that the site met criteria 1(a) 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 2.4.2).
- *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 2.4.2).

The documentation supporting the original listing (Victorian Ministry for Conservation 1980) outlines the following justification for these criteria:

The Gippsland Lakes and their associated swamps and morasses regularly support an estimated 40 to 50 thousand ducks, swans, coots, and other waterfowl. Tucker Swamp, on the edge of Lake Wellington, supports one of only two breeding colonies of Pied Cormorants in Victoria. The Gippsland Lakes support an estimated four per cent of Victoria's wader population. The permanence of the main lakes and the relatively regular flooding of the adjacent wetlands mean that this wetland is an important drought refuge for many waterfowl.

The most recent RIS (Casanelia 1999) for the site indicated that the site meets the following criteria (based on the Ramsar Convention Criteria adopted at the 1996 Conference of Parties – CoP 6 criteria):

- 1(a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region.
- 3(a) it regularly supports 20 000 waterfowl.
- 3(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity.
- 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.

Based on the National ECD Framework, Appendix 5, these pre-1999 criteria translate to the following current Nomination Criteria (2005):

- 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.
- 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.
- Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.

- 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.

As part of the current study, there is a requirement to re-assess the applicability of all criteria to the site which is presented below.

2.4.2 Assessment Based on Current Information and Ramsar Criteria

The site is considered to meet Ramsar Nomination Criteria 1, 2, 4, 5, 6 and 8 based upon the information reviewed when preparing this ECD (refer Table 2-5). Justification statements for each criterion are provided below. In the context of the criteria, the relevant biogeographic region used is the Australian Drainage Division and River Basins.[4] For Gippsland Lakes, this is the 'Southeast Coast' Region which extends from the NSW border to the Millicent River in Western Victoria.

4 Guidelines under the Ramsar Convention (contained in the Ramsar Handbook v.3) favour the use of international or national biogeographic regions in the context of interpretation of Ramsar Nomination Criteria and other aspects of the Convention. The Australian Drainage Divisions and Interim Marine and Coastal Regionalisation for Australia (IMCRA - version 4 - June 2006) have been adopted as the most relevant national bioregionalisation schemes for this ECD.

Table 2-5 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 6 criteria	Victorian Ministry for Conservation (1980) RIS using COP 1 'Cagliari' 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 6 criteria	Victorian Ministry for Conservation (1980) RIS using COP 1 'Cagliari' 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 (✓)

The Gippsland Lakes Ramsar site forms one of the largest coastal lagoon systems in the Drainage Division and contains a distinctive landscape of wetlands and flat coastal plains. The site supports a broad range of wetland types in close proximity to each other, including periodically inundated palustrine marshes, permanently inundated palustrine marshes, shallow lacustrine (lake) features, deep lacustrine features, lagoons with narrow inlets, and broad embayments. The site also includes the lower reaches of several river systems, including a large reach of the Nicholson River which feeds into Jones Bay.

None of the individual wetland types within the site are considered rare or unusual on a bioregional scale. However this criterion is seen to be met given that the site contains excellent examples of particular wetland types within the bioregion, most notably the following:

- The Mitchell River Delta is a particularly outstanding example of a permanent inland delta (Ramsar wetland Type L). The Mitchell Delta is a classic form of digitate delta that is considered to representing one of the finest examples of this type of landform in the world (Rosengren 1984) (see Section 2.3.2).
- The site supports two waterbodies that remain in a near-natural state that are considered excellent representative examples of that wetland type in the drainage division (Southeast Coast). These waterbodies are Lake Tyers (an intermittently opening and closing lagoon or ICOL with a predominantly undeveloped catchment) and Lake Reeve (a coastal barrier lagoon and saltmarsh complex adjacent to Ninety Mile Beach).[5] Further information about these two areas is contained in the critical components section of this ECD.

The site does not appear to meet the criterion from a 'hydrological importance' perspective. While the hydrology of the site is undoubtedly an important driver of wetland ecosystem processes at a site-scale (see Critical Process 1), it is not seen to meet as particularly important characteristic of the wetland at broader spatial scales. It is also noted that the fringing wetlands around the edges of the lakes remove a significant amount of nutrients from river water before it enters the lake system (DSE 2003), however the water quality of the system cannot be considered to be of an excellent standard and therefore this part of the criterion is not considered to apply.

Criterion 2 - Met (✓)

The site supports several nationally threatened wetland fauna species at various stages of their life-cycle (DSE 2003, Ecos unpublished, Birds Australia 2009, DSE 2009). This includes:

- Resident frog populations – Two nationally threatened species utilise the site: green and golden bell frogs (*Litoria aurea*) and growling grass frogs (*Litoria raniformis*). Both species have been recorded regularly (though not systematically over time) within the site, with known and potentially suitable habitat occurring within the site (Tyler 1997, Gillespie 1996, Cleman and Gillespie 2004).

5 Lake Tyers and Lake Reeve were selected following discussions with the Steering Committee as the wetland areas within Gippsland Lakes that best reflect the nomination criteria in terms of representativeness.

- The cryptic wetland birds Australian painted snipe (*Rostratula australis*) and Australasian bittern (*Botaurus poiciloptilus*) have been recorded on an irregular basis or rarely, though potentially suitable habitat for these species occurs within the site (Blakers et al. 1984, Garnett and Crowley 2000, Rogers *et al*. 2005, DSE 2010). There is insufficient information to determine patterns in usage within the site. The Australian painted snipe is listed as vulnerable under the EPBC Act, while the Australasian bittern is not EPBC listed, but is listed as endangered on the 2010 IUCN Red List of Threatened Species (IUCN 2010).

- Habitat for the juvenile life-history stage of the Australian grayling (*Prototroctes maraena*) - This species is listed as vulnerable under the EPBC Act and Australian Society of Fish Biologists (ASFB 2001), and near threatened on the 2010 IUCN Red List (IUCN 2010). While this species spends most of its life in freshwaters, larvae are passively swept into estuarine and marine waters before maturing and are thought to migrate (during spring) back into freshwaters at approximately 6 months of age (McDowall 1996). As this species has been recorded in the freshwater streams that feed directly into the Ramsar site (that is, Tambo, Thomson, Latrobe, Avon and Mitchell Rivers – see Backhouse et al. 2008), it is almost certain that this species relies on the lagoons of the site to complete the estuarine part of its life-cycle.

- Threatened flora habitat - Three nationally vulnerable and endangered wetland-associated flora species have been recorded as within the site: dwarf kerrawang (*Rulingia prostrata*) (Carter and Walsh 2008), swamp everlasting (*Xerochrysum palustre*) (Bayer 2001, DSE 2008) and metallic sun-orchid (*Thelymitra epipactoides*) (BDFNC 2005, Parks Victoria 2003).

Criterion 3 – Not Met (☒)

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

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

There is no evidence to suggest that the site represents a ‘hot-spot’ of biological diversity on a bioregional scale, and the site is not located in a centre of local endemism. While the site does support high biodiversity values at a local scale and a broad range of wetland types (see discussion for Criterion 1 above), there is presently insufficient information to determine whether the site supports the range of species or habitats occurring in the bioregion. The site does not support a large proportion of species adapted to special environmental conditions. Based on the above, the site does not support this criterion.

Criterion 4 - Met (✓)

The site supports habitat and conditions that are important for critical life cycle stages of a variety of wetland-dependent fauna species. These stages are important because if they should be interrupted or prevented from occurring, the long-term conservation of those species may be threatened.

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

1. *Critical habitat for mobile or migratory species which contain high proportions of populations gathered in a relatively small area at a particular life history stage.*

As outlined in the Gippsland Lakes Ramsar site nomination document (Victorian Ministry of Conservation 1980), "*the permanence of the main lakes and the relatively regular flooding of the adjacent wetlands mean that this wetland is an important drought refuge for many waterfowl".* These waterbirds are comprised of seasonal migratory species and 'resident' waterbirds, both of which are considered 'mobile'. As discussed in Section 3.4.1, the site in general contains high abundances of waterbirds (Parks Victoria 2003), with particularly large aggregations occurring in deep freshwater marshes (for example, Dowd Morass, the Heart Morass, Sale Common), as well as salt marsh and shallow permanent saline wetlands (for example, Lake Reeve). The site supports moulting habitat for waterbird species, which is considered by the Ramsar Convention Secretariat (2007) as a critical function underpinning this criterion.

2. *Refugia habitat for non migratory wetland dependent species.*

The site supports refugia habitat for a range of non-migratory wetland-dependent species. In particular, the freshwater marshes (Sale Common, Macleod Morass) are seen as particularly important refugia for aquatic species (see section 3.3.3), including permanent refugia (and breeding sites) for two nationally threatened species; that is, growling grass frog (*Litoria raniformis*) (DSE 2010) and the green and golden bell frog (*Litoria aurea*) (Parks Victoria 2003).

Criterion 5 - Met (✓)

The site has previously been attributed with regularly supporting approximately 40 000 to 50 000 waterbirds (refer ANCA 1995, NPS 1995, DSE 2003). Whilst systematic data collection has not been undertaken across the site, data analysis undertaken in 2008 (refer Ecos unpublished) found that the site continues to regularly support more than 20 000 waterbirds.

Section 3.4.1 provides a detailed account of patterns in abundance of various waterbird species.

Criterion 6 - Met (✓)

Waterbird species which are considered to have occurred within the site in such abundance so as to meet the one per cent population threshold are: red-necked stint (*Calidris ruficollis*), black swan (*Cygnus atratus*), sharp-tailed sandpiper (*Calidris acuminate*), chestnut teal (*Anas castanea*), musk duck (*Biziura lobata*), fairy tern (*Sterna nereis*) and little tern (*Sterna albifrons*) (Parks Victoria 2003, Bamford et al. 2008).

However, there is a lack of recent or comprehensive waterbird count data for the site and as a result, the justifications for these species in terms of meeting the one per cent criterion draws upon a range of published and unpublished data sources.

Section 3.4.1 provides a detailed account of patterns in abundance of various waterbird species.

Criterion 7 - Not Met (☒)

The Ramsar Handbook emphasises that the term diversity under this criterion can encompasses number of life-history stages, species interactions and complexity of fish-environmental interactions. 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.

In this context, six fish groups were identified in Ecos (unpublished) to utilise the site:

- estuarine residents, for example black bream, river garfish and estuary perch
- estuarine dependent (freshwater), for example, Australian bass, Australian grayling, Cox's gudgeon, empire gudgeon, freshwater herring, spotted galaxias, striped gudgeon
- estuarine dependent (marine), for example silver fish, smallmouth hardyhead
- estuarine opportunists (freshwater), for example, longfin and shortfin eels
- estuarine opportunists (marine), for example, whiting, mullet, pipefish, seahorse
- marine stragglers, for example, a large group of oceanic fishes that use the site periodically.

Overall, Gippsland Lakes contains an appreciable number of fish species, with approximately 179 fish species represented (Ecos unpublished). However, there are insufficient data to determine the proportion of fish (or shellfish) species that the site supports relative to the total fish diversity in bioregion.

Ramsar Secretariat (2007) also considers endemism as an important element of biodiversity. No fish species that are endemic to the IMCRA Twofold Shelf meso-scale bioregion are known to occur at the site. While species that are endemic to the broader region exist at the site, the site is not known to be particularly important in maintaining populations of these species, and therefore the site does not meet this criterion from an endemicity perspective.

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 (✓)

Gippsland Lakes 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 include European carp, yellow eye mullet, black bream, tailor, river garfish, estuary perch, Australian anchovy, dusky flathead, luderick, Australian salmon, silver trevally, leatherjackets and sea mullet. With the exception of carp, all these 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 3.8.2).

The site supports important breeding habitat for numerous species, of which black bream is considered particularly outstanding. This species spawns in mid-lower estuaries and adjacent waters of main lakes (that is, areas with salinities between 17 and 21 grams per litre) during October to December (Tilleard 2009). A detailed account of the specific habitat values of the site for coastal fish species is provided in Section 3.8.2.

In terms of the second element, the brackish marshes, lakes and rivers are known to support important spawning, nursery and migratory pathways for numerous species (see Criterion 7). Of particular note is the role of the riverine/lake continuum in providing a nursery habitat and movement corridor for larval Australian grayling. The values of the site for this threatened species are discussed under Nomination Criterion 2.

<u>Criterion 9 – Not Met (☒)</u>

Criterion 9 relates to non-avian wetland taxa including, inter alia, mammals, reptiles, amphibians, fish and aquatic macro-invertebrates. Some of the key non-avian wetland species within Gippsland Lakes that are appropriate to consider in the context of Criterion 9 include:

- Australian grayling
- dwarf galaxias
- spiny crayfish[6];
- green and golden bell frog
- growling grass frog.

[6] Several spiny crayfish which are endemic to the bioregion were also considered, namely Gippsland crayfish *Euastacus kershawi*, South Gippsland spiny crayfish *Euastacus neodiversus* and Orbost spiny crayfish *Euastacus diversus*. There are no records of these species in the site. The habitat conditions in which *E. neodiversus* and *E. diversus* have been recorded are not supported in the site, that is, undisturbed freshwater streams, high altitude rainforest (*E. diversus*) or coastal heath/schelorophyll forest (*E. neodiversus*). *Euastacus kershawi* occurs in broader range of habitats than the other two species, including tree lined creeks surrounded by cleared pasture (sea level to 250 metres elevation).

In interpreting the application of Criterion 9 to these species, Ramsar Handbook 14 indicates that reliable population size limits from published sources must be included in the justification for the application of the Criterion.

Investigation of survey data for these species as part of the current study has shown such data is largely incomplete and forms an information gap. On this basis, there is not definitive data from which to determine the applicability of the criterion.

3 DESCRIPTION OF ECOLOGICAL CHARACTER

3.1 Basis of the ECD

The basis of an ECD is the identification, description and where possible, quantification of the critical components, processes, benefits and services of the site. Wetlands are complex ecological systems and the complete list of physical, chemical and biological components and processes for even the simplest of wetlands would be extensive and difficult to conceptualise. It is not possible, or in fact desirable, to identify and characterise every organism and all the associated abiotic attributes that are affected by, or cause effect to, that organism to describe the ecological character of a system. This would result in volumes of data and theory but bring us no closer to understanding the system and how to best manage it. What is required is to identify the key components, the initial state of the systems, and the basic rules that link the key components and cause changes in state. Thus, we need to identify and characterise the key or critical components, processes, benefits and services that determine the character of the site. These are the aspects of the ecology of the wetland, which, if they were to be significantly altered, would result in a significant change in the system.

3.1.1 Interaction of Wetland Elements

Figure 3-1 from the National ECD Framework shows a generic conceptual model of the interaction between ecosystem processes, components 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).

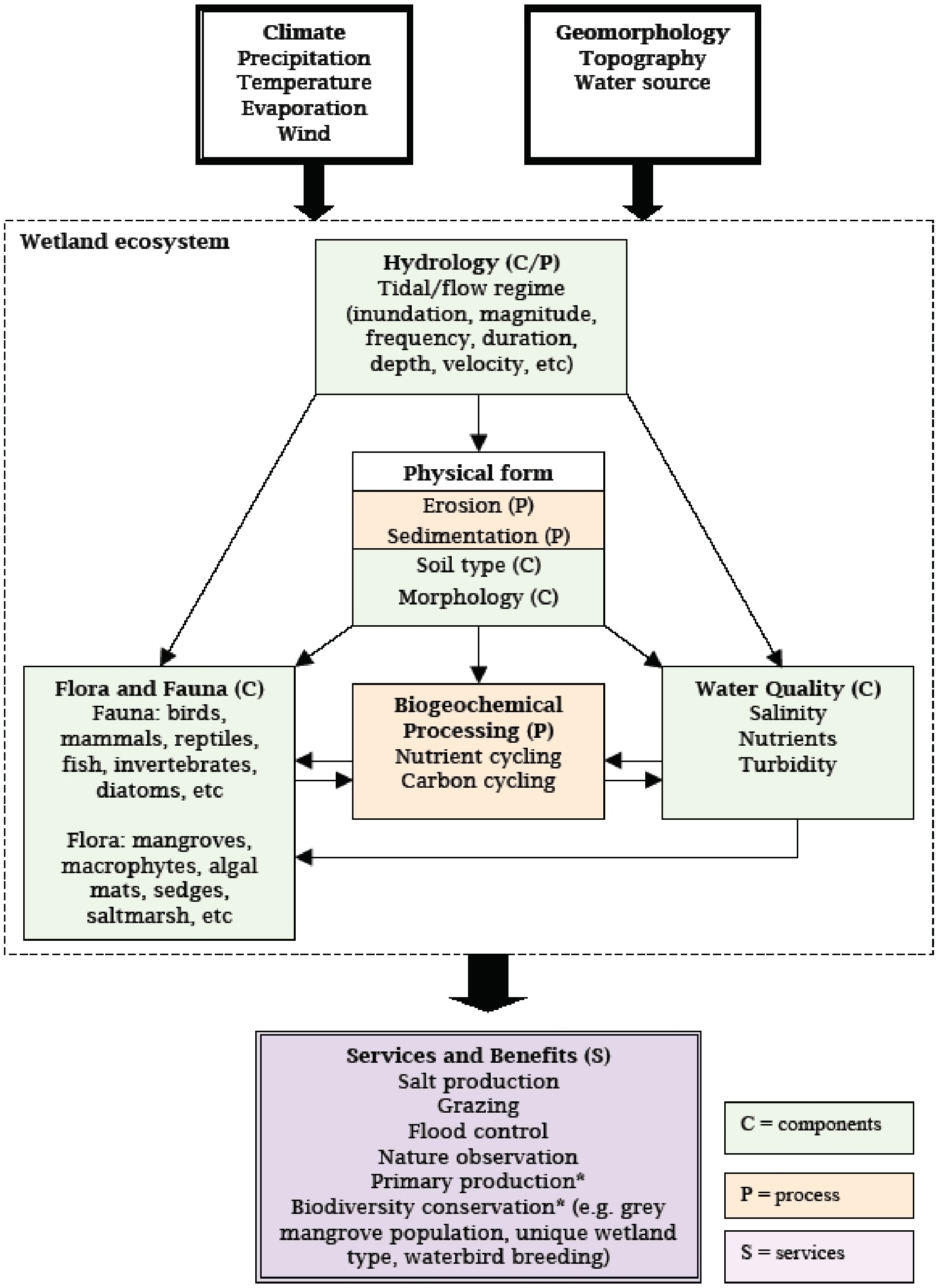


Figure 3-1 Generic conceptual model showing interaction between wetland ecosystem processes, components and services/benefits

(Source: National ECD Framework, DEWHA 2008)

3.1.2 Study Approach

The method employed to identify critical components, processes and services/benefits is presented in Appendix A. Following the direction provided within the National 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
- 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), 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.

3.2 Overview of Critical Components, Processes and Services/Benefits

A summary of the critical components, processes and services/benefits for the Gippsland Lakes Ramsar site are shown in Table 3-1.

In summary, the following have been identified:

- eight critical components and two supporting components
- two critical processes and six supporting processes
- two critical services/benefits and two supporting services/benefits.

Table 3-1 Summary of critical components, critical processes and critical services/benefits of the Gippsland Lakes Ramsar site

Critical components	Critical processes	Critical services/benefits

Wetland habitats: grouped as follows.
• (C1) marine subtidal aquatic beds (seagrass/aquatic plants).
• (C2) coastal brackish or saline lagoons (open water phytoplankton-dominated habitats).
• fringing wetlands that can occur within the site as–
  o (C3) predominantly freshwater wetlands
  o (C4) brackish wetlands
  o (C5) saltmarsh/ hypersaline wetlands.
 	
Wetland flora and fauna:
• (C6) abundance and diversity of waterbirds.
• (C7) presence of threatened frog species (green and golden bell frog; growling grass frog).
• (C8) presence of threatened wetland flora species.
	Hydrological regime: (P1) patterns of inundation and freshwater flows into the wetland system, groundwater influences and marine inflows that affect habitat structure and condition.
	
	Waterbird breeding functions: (P1) critical breeding habitats for a variety of waterbird species.
		Threatened species: (S1) the site supports an assemblage of vulnerable or endangered wetland flora and fauna that contribute to biodiversity.
		
		Fisheries resource values: (S2) the site supports key fisheries habitats and stocks of commercial and recreational significance.

Supporting components	**Supporting processes**	**Supporting services/benefits**
Other wetland habitats: supported by the site (sand/pebble shores, estuarine waters, etc.). **Other wetland fauna:** supported by the site (for example, fish, aquatic invertebrates).	**Climate:** patterns of temperature, rainfall and evaporation. **Geomorphology**: key geomorphologic/ topographic features of the site. **Coastal and shoreline processes: h**ydrodynamic controls on coasts and shorelines through tides, currents, wind, erosion and accretion. **Water quality:** water quality influences aquatic ecosystem values, noting the key water quality variables for Gippsland Lakes are salinity, dissolved oxygen, nutrients and sediments. **Nutrient cycling, sediment processes and algal blooms:** primary productivity and the natural functioning of nutrient cycling/flux processes in waterbodies. **Biological processes:** important biological processes such as primary productivity.	**Tourism and recreation:** the site provides and supports a range of tourism and recreational activities that are significant to the regional economy. **Scientific research:** the site supports and contains features important for scientific research.

3.3 Critical Components – Wetland Habitats

The Gippsland Lakes system supports a wide range of habitats including planktonic systems in the water column of the main lakes, submerged and emergent macrophytes, and extensive zones of freshwater-saltwater interface that is dominated by vegetation types such as rushes, reeds and sedges.

The following sections describe wetland habitat critical components. Where data are available, trends in wetland extent over time (and space) are described, mostly on the basis of wetland mapping described in Section 2. In most cases, there are few data describing baseline conditions in wetland habitats at the time of listing. Where data from other periods (typically post-listing) have been adopted as the baseline data set, commentary is provided on whether it is likely that these data are likely to be representative of conditions at the time of listing. When describing wetland habitat critical components, vegetation community extent has typically been adopted as the primary indicator given its ecological relevance (particularly as fauna habitat), and that it is likely to reflect the range of hydrological and water quality conditions existing at the time of vegetation community mapping.

Ecos (unpublished) and other sources (DSE 2003, Parks Victoria 2008) refer to and group wetland habitats within the site under common attributes as follows:

- ‘Marine subtidal aquatic beds’ (waterbodies with seagrass and/or algae species present).
- ‘Coastal brackish or saline lagoons’ (waterbodies generally).
- ‘Fringing wetlands’, often brackish but sometimes freshwater and sometimes hypersaline, that are vegetated with a wide range of vascular and non-vascular plants.

Table 3-2 presents the groupings applied to the major named wetland/waterbodies within the site and their equivalent Ramsar wetland type. This approach has been adopted in the ECD to ensure consistency with source information (including DSE 2003 and other management plans) and lends itself well to describing the critical components related to habitat, LAC and conceptual models presented in later sections.

Table 3-2 Groupings of Gippsland Lakes wetlands according to major habitat (Source: various)

Major Habitat Groupings	Equivalent Ramsar Wetland Types	Locations
Coastal Brackish or Saline Lagoons (that also include marine subtidal aquatic beds)	Type B	Lake King, Lake Victoria, Reeve Channel, Lake Tyers, Bunga Arm and Lake Bunga
Coastal Brackish or Saline Lagoons	Types J and F	Lake King, Lake Victoria, Reeve Channel, Lake Tyers Bunga Arm and Lake Bunga, Jones Bay Lake Wellington
Fringing Wetlands	Types E, H, Sp, Tp or Xf	Sale Common* Tucker Swamp Lake Reeve** Backwater Morass Balfour Swamp Blond Bay Area Blue Horizons Estuary - Main Swamp Bosses Swamp Clydebank Morass Cygnet Swamp Dowd Morass# Dolomite Swamp Half Moon Swamp The Heart Morass# Hickey Swamp Lake Betsy Lake Coleman Lake Kilarny Lake Morley (aka Morley Swamp) Macleod Morass* Phiddians Swamp Red Morass Russels Swamp Salt Creek Marsh Salt Lake Snipes Wetland Spoon Bay Victoria Lagoon Waddy Point Swamp Yendalock Swamp

NOTES:
* Sale Common and Macleod Morass are considered to be predominantly freshwater wetlands
** Lake Reeve is a saltmarsh-dominated, hypersaline wetland.
The remaining fringing wetlands in this category are variably saline (brackish), except (#) Dowd Morass and The Heart Morass that while brackish, are being managed as predominantly freshwater wetlands under the Lake Wellington Wetlands Management Plan (Parks Victoria 2008).

3.3.1 Critical Component 1 - Marine Subtidal Aquatic Beds

Reasons for selection as 'critical'

Seagrass and other marine subtidal aquatic beds are present in several of the main lagoons including Lakes King, Victoria and Tyers. The values of seagrass to ecosystem functioning (and ecological character of the site) are well documented (Roob and Ball 1997, Hindell 2008, Ecos, unpublished) and include the following:

- primary production by seagrasses and associated algae
- direct grazing of living seagrass tissue in herbivory-based food webs

- direct grazing of algae in herbivory-based food webs
- decomposition of plant material by sediment bacteria and consequent effects on sediment biogeochemistry
- consumption of dead plant material and microbes in detritus-based food webs
- predation by higher consumers in complex food webs
- stabilisation of sediments and reduction in flow velocities, creating quiescent and sheltered habitats.

Description

Four species of seagrass occur in the Gippsland Lakes: *Heterozostera tasmanica*, *Lepilaena cylindrocarpa*, *Ruppia spirilis* and *Zostera muelleri*. In addition to these aquatic angiosperms, the charophyte *Lamprothamnium papulosum* has been recorded in the Gippsland Lakes (Roob and Ball 1997).

Zostera muelleri is widely distributed throughout the Gippsland Lakes and grows in sheltered and moderately exposed sand and silts to a water depth of approximately 2.5 metres (Roob and Ball 1997). It is generally more tolerant of desiccation than the other species of seagrass, which accounts for it commonly being found in the intertidal zone. *Heterozostera tasmanica* is also widely distributed in the Gippsland Lakes and like *Z. muelleri* grows to a depth of approximately 2.5 metres. Poore (1978) reported that these Zosteracea and other seagrass in the Gippsland Lakes were most abundant where salinities rarely fell below 25 grams per litre.

The third species, *Ruppia spiralis,* is usually found growing among *Z. muelleri* meadows. It is a robust perennial species that can tolerate a wide range of salinities and thus is found in environments varying from fresh water to hypersaline. The fourth angiosperm, *Lepilaena cilindrocarpa*, is a small native annual about 20 centimetres long. Like *R. spirilis*, it can tolerate a wide range of salinities and is found commonly in ephemeral fresh or brackish waters.

A diverse flora is associated with seagrasses but can be grouped into two functional categories:

- Periphyton: thin biofilms of microbes growing on seagrass leaves
- Epiphytes: algae growing on seagrass leaves.

Periphyton communities associated with seagrasses are diverse and highly productive; although Ecos (unpublished) indicates that no work has been undertaken on estimating productivity of seagrass periphyton in southern Australian waters.

Epiphytes are abundant on seagrass leaves and may account for between 10 and 90 per cent of the total primary productivity of seagrass beds (Keogh and Jenkins 1995). Diatoms, hydroids, coralline and filamentous red algae are common epiphytes, as well as bryozoans such as *Densipora corrugata*. Roob and Ball (1997) noted that epiphyte cover on seagrasses of the Gippsland Lakes was confined to areas that were of low energy and with relatively little tidal flow; high-energy environments seemed to cleanse seagrass blades of attached algae and/or provided limited opportunities for the algae to attach.

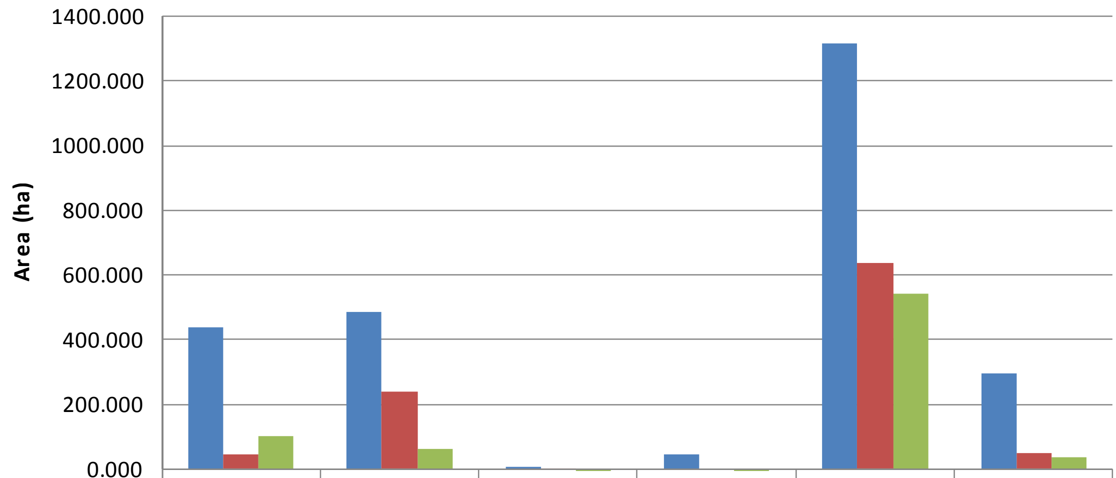
Patterns in variability

There is great inter-annual variability in seagrass cover within the Gippsland Lakes (Roob and Ball 1997). A near-complete loss of seagrasses was reported for the Gippsland Lakes between the 1920s and the 1950s (Coles et al. 2003). Between 1959 and 1997, there was a peak in seagrass cover in the late 1960s and in the late 1990s, with complex patterns that varied among lakes (Roob and Ball 1997). Roob and Ball (1997) showed that there had been a continual fluctuation in seagrass cover at the five sites sampled within the Gippsland Lakes Ramsar site over their study period of 1959 to 1997.

There are no empirical estimates of seagrass cover and extent around the time of site declaration (1982). Based on qualitative historical assessments undertaken by Roob and Ball (1997), it is noted that for the year 1976, three of the locations examined had ‘medium’ cover and two locations sparse cover, which was generally lower than recorded in 1969. The three locations examined in 1979 had denser seagrass cover than recorded in 1976. By 1984, the sample period closest to the time of site declaration, four of the five locations had sparse cover, whereas one location (Fraser Island) had dense cover that was similar to that recorded in 1969. Roob and Ball (1997) noted that 1984 was ‘clearly the year in which seagrass cover was its lowest for the years examined’.

Roob and Ball (1997) noted that there was a general increase in seagrass cover between 1984 and 1997. A more recent study of seagrass extent and density to assess the impacts of recent algal blooms on seagrass communities in Lake King, Lake Victoria and Lakes Entrance, showed a reduction in density at sampling sites when compared to Roob and Ball’s study. However it was noted in the findings of the report that these differences could ‘reflect natural cycles in productivity and/or changes in environmental conditions that could be independent of the current phytoplankton bloom’ (refer Hindell 2008).

The overall patterns in temporal variability matches the long-term (decadal) variability observed for seagrass beds in south-eastern Australia since the 1970s. Given the dynamic nature of seagrass meadows here and the absence of empirical estimates of seagrass coverage around the time of listing, it is not possible to define an empirical baseline value describing seagrass extent. The most reliable estimate of seagrass extent within the site is from Roob and Ball (1997) (see Figure 3-2), which is based on assessments undertaken in 1997 (15 years after site declaration). Based on this mapping it was estimated that total seagrass extent was approximately 4330 hectares. It should be noted that 1997 represented the maximum recorded extent of seagrass at two of the five locations assessed by Roob and Ball (1997). EVC mapping indicates that seagrass extent within the site was 5013 hectares in 2005. Based on temporal trends observed by Roob and Ball, it is considered highly unlikely that these values are representative of baseline conditions around the time of listing.



	Mixed Seagrass – clean	Mixed Seagrass with Epiphytic Algae	Ruppia – clean	Ruppia with Epiphytic Algae	Zostera – clean	Zostera with Epiphytic Algae
Dense	440.276	488.869	9.011	47.606	1319.371	300.195
Medium	44.012	240.632	2.023	0.000	636.323	47.800
Sparse	103.185	65.144	0.648	0.366	543.638	40.948

Figure 3-2 Seagrass cover estimates for Gippsland Lakes (source: Roob and Ball 1997)

3.3.2 Critical Component 2 - Coastal Brackish or Saline Lagoons

Reasons for selection as 'critical'

The main waterbodies of the Gippsland Lakes Ramsar site include the connected lagoons of Lake Wellington, Lake Victoria, Lake King, and Jones Bay as well as Lake Tyers (which is intermittently connected to Bass Strait) and Lake Bunga. These waterbodies make up the bulk of the brackish or saline lagoons of the site.

The lagoons play an important role in nutrient and energy dynamics throughout the Lakes system, providing for the consumption of phytoplankton biomass by a range of herbivores, including zooplankton (Ecos unpublished). These systems provide the building blocks of the site's ecosystem, on which higher trophic levels such as macroinvertebrates, fish and waterbirds ultimately depend. As such they are critical to the ecological character of the site.

Description

The large areas of open water in the Gippsland Lakes and abundance of phytoplankton suggest that planktonic food webs are a critical component of the lagoon systems. These food webs operate in the lagoons as well as in the fringing wetlands of the waterbodies, especially the hypersaline ones where vascular plants are less abundant. Phytoplankton are consumed by a range of herbivores, including zooplankton (animals larger than 50 micrometres). Larger filter-feeding animals, such as mussels, also consume phytoplankton.

Concentrations of phytoplankton (expressed in terms of chlorophyll *a*) in the Gippsland Lakes are commonly around five to 20 micrograms per litre, but can exceed 20 micrograms per litre at times. Deposition of phytoplankton biomass, which contributes to sediment accretion, is also important in controlling patterns of anoxia and nutrient release from the sediments.

Periodic and severe algal blooms, mostly of cyanobacteria such as *Nodularia* but also sometimes of dinoflagellates, can affect ecosystem integrity and human amenity value in the Gippsland Lakes. The saline or brackish lagoons of the Gippsland Lakes are highly sensitive to eutrophication (and subsequent algal blooms), for four reasons (CSIRO 2001):

- They are shallow, so loads per unit area from catchment runoff translate into high loads per unit volume of water.
- They experience episodic periods of very high nutrient loads from catchments that can result in marked increases in nutrient concentrations in the water column.
- The water column in at least some of the lagoons stratifies vertically due to differences in salt concentrations.
- Submerged macrophytes, such as seagrasses or the freshwater angiosperm *Vallisneria*, cover little of the sediment area.

Fundamental hydrological differences among the lagoons mean that the ecological processes operating within each lagoon are also dissimilar. Lake Wellington is a shallow body of water that is rarely if ever stratified, is characterised by highly disturbed and suspended sediment and while predominantly fresh, undergoes episodic saline intrusion that has affected its aquatic vegetation and fringing wetland communities. Lakes King and Victoria are deeper, less well mixed and more estuarine in character whereas Lake Tyers is an intermittently opening and closing lagoon with greater coastal hydrodynamic influences.

Lake Victoria (source: Parks Victoria, Tamara Boyd)

Patterns in variability

The ecology of the main lakes (King, Victoria and Wellington) is underpinned by a combination of freshwater inflows, marine inflows, ambient water quality and nutrient cycling processes associated with bed sediments. Salinity levels, water temperature and levels, dissolved oxygen concentrations, growth of aquatic vegetation and turbidity levels vary substantially over time in response to these underlying ecosystem processes.

As an intermittently closing and opening lagoon (ICOL), Lake Tyers is frequently closed to the ocean by a sand berm, but has been periodically broached as a result of beach erosion processes (that is, storm waves), flooding or by human intervention. The ecology of Lake Tyers therefore responds both to freshwater inflows (from its largely undeveloped catchment of forestry reserves) as well as natural and artificial entrance opening and closure regimes (Ecos unpublished).

Further discussion about these underlying processes and how they affect the ecology of the various lagoons are described in the sections on critical and supporting processes. Long term and more recent changes in the ecology of the lagoons are detailed in the section on changes to ecological character (refer Section 6).

3.3.3 Critical Component 3 - Fringing Wetlands (Predominantly Freshwater)

Reasons for selection as 'critical'

The predominantly freshwater wetland habitats of Gippsland Lakes include Sale Common and Macleod Morass. However, Sale Common is regarded by Tilleard and Ladson (2010) as the only 'true' remaining freshwater wetland in the entire system.

The presence and continued functioning of these predominantly freshwater habitats are critical to the ecological character of the site for freshwater-dependent species such as amphibians and freshwater specialist avifauna as well as providing drought refuge for a broad range of waterbird species. Fringing vegetation in these wetlands also provides a dense, complex structure for nesting birds (DSE 2003).

Description

The dominant vegetation communities in the predominantly freshwater fringing wetlands are common reed (*Phragmites australis*), and native cumbungi (*Typha orientalis*). Extensive areas of giant rush (*Juncus ingens*) are also present but are in direct competition with cumbungi expansion in Macleod Morass. Swamp paperbark (*Melaleuca ericifolia*) are also present along the margins of the swamps.

A description of the two predominantly freshwater wetlands within the site is provided below.

<u>Sale Common</u>

Sale Common is a deep freshwater Nature Conservation Reserve which comprises 308 hectares. Directly influenced by the flows from the Thomson and Latrobe Rivers, Sale Common experiences seasonal variations in water levels with periodic flooding and draw down from evaporation. The site has had natural draw down of water as a result of drought in 1983 and managed draw downs in 1985, 1987, 1991 and 1995 and can dry out naturally as a result of seasonally dry conditions. Water levels can be controlled in the Common through constructed waterway control works (Parks Victoria 2008).

Sale Common is regarded as having the following attributes (refer WGCMA 2007) which contribute to its conservation value:

- relatively undisturbed vegetation
- diverse flora and fauna species
- presence of frog species of conservation significance (growling grass frog)
- presence of flora species of conservation significance (dwarf kerrawang)
- presence of avifauna species listed as threatened under National (EPBC Act) and State (*Flora and Fauna Guarantee Act*) legislation such as the little bittern, Australasian bittern, painted snipe and great egret.

<u>Macleod Morass</u>

Macleod Morass is a freshwater marsh forming an extensive wetland on the Mitchell River floodplain. The site supports the following (Parks Victoria 2003):

- up to 50 plant species with a number of ecological vegetation classes (EVCs) that are threatened in Victoria
- a diverse range of 141 fauna species within or in close vicinity of the wetland

- presence of frog species of conservation significance (green and golden bell frog)
- over 100 bird species including 53 waterbird species
- important breeding site for Australian white ibis, straw necked ibis and black winged stilt.
- state-level geomorphologic and geological significance.

Water inflows into Macleod Morass are dominated by catchment run-off from Cobbler Creek and several smaller intermittent streams, urban stormwater and direct rainfall. Treated sewage effluent from East Gippsland Water's Bairnsdale wastewater treatment plant also contributes about 14 per cent of freshwater input into the wetland. Major flood events in the Mitchell River result in complete inundation of Macleod Morass and serve to 'flush' the entire system (Parks Victoria 2003).

Patterns in variability

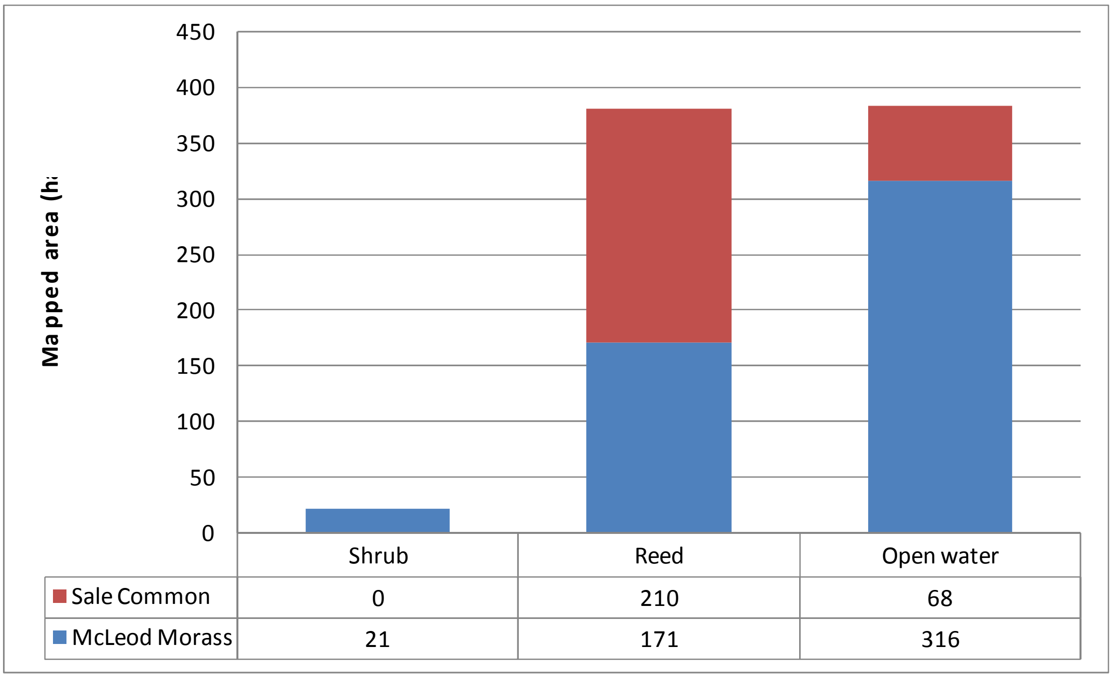
The ecology of both Sale Common and Macleod Morass have been influenced by long term changes in the surface water hydrology of the sites as a result of catchment modification and water control works within the sites. The sites are now actively managed to ensure a more natural wetting and drying regime is maintained.

Longer term trends in vegetation structure and condition in these wetlands includes the proliferation of cumbungi and *Phragmites australis*, generally at the expense of giant rush (Parks Victoria 2003). Quantitative studies of changes in vegetation condition and extent have not been conducted, although the following are noted:

- Both waterbodies are managed as predominantly freshwater wetlands by Parks Victoria, water quality within both wetland areas is characterised as having average salinities of generally less than two grams per litre.
- The Victorian Wetland Classification System (VWCS) maps 'primary category' and 'subcategory' wetland habitats around the time of listing[7] (refer to Figure 2-3 for the VMCS map of the site). Sale Common and Macleod Morass[8] are classified as "Deep Marsh" (primary category), and also includes shrub, reed and open water sub-categories (Figure 3-3). These data indicate that reeds form the dominant sub-category type at Sale Common, whereas open water tended to dominate at Macleod Morass. Note the data presented in Figure 3-3 should be considered as indicative only, recognising that wetland vegetation communities can show great variation over time, which is not accounted for in this snap-shot mapping assessment.

[7] The '1994' VWCS data is derived from the Corrick and Norman (1980) wetland assessments and is therefore an applicable baseline around the time of site listing

[8] Search based on "Main_name" categories of "Sale Common" and "Macleod Morass"



	Shrub	Reed	Open water
Sale Common	0	210	68
McLeod Morass	21	171	316

Figure 3-3 Mapped area of VWCS wetland subcategories at Sale Common and Macleod Morass in 1980 (Source: DSE unpublished data)

3.3.4 Critical Component 4 - Fringing Wetlands (Brackish)

Reasons for selection as 'critical'

The brackish fringing wetland habitats of Gippsland Lakes including Dowd Morass, the Heart Morass, eastern Lake Coleman and Tucker Swamp, and Clydebank Morass. The broad values of this habitat type to wetland functioning is as follows:

- habitat for juvenile fish and other marine and estuarine organisms
- stabilisation of soils
- detritus production and role in organic enrichment of substrate and sedimentation process
- fringing vegetation which provides a dense, complex structure for breeding and nesting birds.

The natural variability of these habitats to accommodate a range of hydrologic and salinity states is recognised as being important to the biodiversity of the Ramsar site.

Description

The permanent opening at Lakes Entrance means that many of the wetlands that fringe the Gippsland Lakes experience a mixture of fresh water and sea water, and therefore are brackish to varying degrees.

The dominant vegetation communities of the brackish fringing wetlands are swamp paperbark (*Melaleuca ericifolia*), common reed (*Phragmites australis*), and various saltmarsh communities that occurs as an understorey associated with swamp paperbark woodlands or as the predominant vegetation type in the more highly saline wetlands.

The brackish wetlands of the site (as outlined in Parks Victoria 2008) support:

- a diverse array of wildlife including 45 fauna species listed as threatened in Victoria
- over 187 bird species that use the wetlands for wide array of life cycle functions including important breeding sites at Dowd Morass for Australian white ibis and straw-necked ibis and breeding habitat for pied cormorant at Tucker Swamp
- a range of flora including 11 species listed as rare or threatened in Victoria
- four Ecological Vegetation Classes (EVC) that are threatened in Victoria
- sites of state or regional geomorphologic significance.

Patterns in variability

There are no data describing patterns in condition and community structure of brackish fringing wetlands at a whole of site scale. As discussed in Section 3.3.3, existing vegetation mapping does not have consistent analogues with the Ramsar wetland typology or the broad definition of a brackish wetland adopted here, and therefore is of limited value in terms of describing baseline conditions and changes over time.

There is some available information describing long term patterns in variability in this component within different parts of the wetland. *Phragmites* reed beds are in long term decline within the brackish wetlands of the site and along the margins of Lake Wellington. Although the hypothesis most commonly cited to explain the loss of reed beds is an increase in salinity due to the inexorable salinisation of the Gippsland Lakes following the opening of the channel at Lakes Entrance in 1889, other reasons for the loss of common reed in the Lake Wellington region may include:

- high salinities in Lake Wellington during drought years
- shallow water tables discharging saline water into the root zone
- limited grazing pressure.

Boon et al. (2008) mapped changes in vegetation communities at Dowd Morass between 1964 and 2003, which provides the most comprehensive description of baseline conditions of this critical component (albeit at a local scale) at the time of site listing. On the basis of data presented in Figure 3-4, the following trends are apparent:

- There was a marked decline in common reed over time, ranging from approximately 490 hectares in 1964, to approximately 480 hectares in 1982 (that is, at site listing) to approximately 340 hectares in 2003.
- There was an increase in the extent of (*Melaleuca*) swamp paperbark, ranging from approximately 350 hectares in 1964, to approximately 400 hectares in 1982 (at site listing) and approximately 600 hectares in 2003.

These data show that (i) common reed was gradually being replaced by swamp paperbark over the measurement period, and (ii) this process was occurring at the time of site declaration in 1982.

Similar studies have not been undertaken to quantify changes to vegetation structure within the other brackish morasses of the site, but similar patterns of change have been observed (refer DSE 2003).

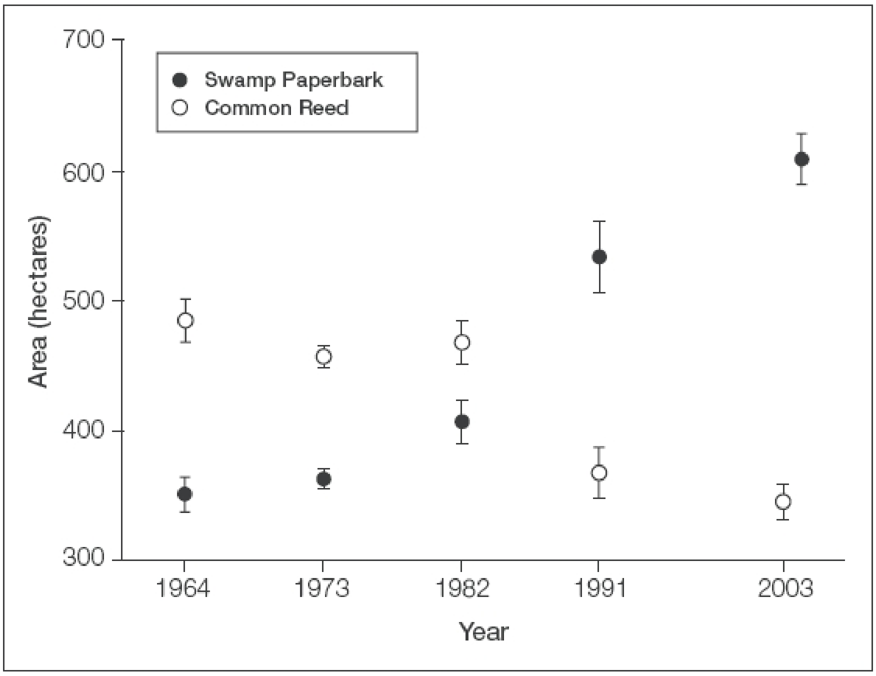


Figure 3-4 Changes in total area of swamp paperbark and common reed at Dowd Morass between 1964 and 2003 (Source: Boon et al. 2007)

The brackish fringing wetland areas of the site are naturally variable in terms of salinity over time depending on marine inflows, rainfall, catchment run-off and evaporation. Electrical conductivity measurements at Dowd Morass (1991 to 2001) by Boon et al. (2007) had a mean of 4.0 ± 0.33 SE millisiemens per centimetre (approximately 2.6 grams per litre), and a maximum value of 19.4 millisiemens per centimetre (approximately 12 grams per litre). Similar salinity conditions have been observed at the Heart Morass. There are no good quality salinity data available for Dowd Morass or other brackish water wetland sites around the time of site listing (see Appendix B).

Lake Coleman (east) and Clydebank Morass experience and maintain much higher ambient salinity levels than either Dowd Morass or the Heart Morass with surface waters between 6.7 and 29 grams per litre and groundwater between 21 and 27 grams per litre (Ecos unpublished; Tilleard and Ladson 2010; Parks Victoria 2008).

The high salinity levels results from the fact that these wetlands have a more direct connection to Lake Wellington (Parks Victoria 2008; Tilleard and Ladson 2010). Water levels and salinity in the lower section of the Clydebank Morass have resembled those of Lake Wellington since the breaching and erosion of the barrier between the Morass and the Lake by a flood in the Avon catchment in 1990. The hydrology of Lake Coleman has been altered by construction of channels connecting it to Lake Wellington (Parks Victoria 2008).

Vegetation communities in these areas are therefore more characteristically salt tolerant (Tilleard and Ladson 2010, Ecos unpublished) and both wetlands are currently being managed as estuarine wetlands based on the current Parks Victoria management plan (Parks Victoria 2008).

3.3.5 Critical Component 5 – Fringing Wetlands (Saltmarsh/ Hypersaline)

Reasons for selection as 'critical'

While saltmarsh can be found across a range of brackish wetland habitat types within the site (as discussed above), saltmarsh represents the main vegetation community in Lake Reeve as a result of the hypersaline conditions of the lake and its surrounds from tidal processes.

In the Management Plan for The Lakes National Park and Gippsland Lakes Coastal Park (Parks Victoria 1998), Lake Reeve is described as a significant feature of the Coastal Park and is a site of special scientific interest. The Plan indicates that the fringing saltmarsh of the lake contains a number of plant species relatively uncommon in Victoria east of Seaspray.

Description

Lake Reeve is a long, narrow wetland that runs parallel to the coast for nearly 60 kilometres alongside the south-westerly parts of the Gippsland Lakes Ramsar site, from Rotamah Island in the north-east to Seaspray in the south-west (SKM 2004).

The combination of shallow water levels and regular (seasonal) filling of the lake and inundation of its margins and drying as a result of evaporation creates the conditions suited for development of saltmarsh communities. The saltmarsh of Lake Reeve provide habitat and food for a wide range of animals. A large part of their habitat value derives from their providing a complex mosaic of low, dense vegetation in areas that are otherwise periodically inundated with saline water.

Whilst sharing the broad wetland values identified for brackish wetlands, saltmarsh such as Lake Reeve also provide notable roosting habitat for shorebirds as well as valuable fisheries nursery habitat. In particular, the saltmarsh of Lake Reeve provides summer feeding and roosting grounds for migratory waterbirds of international importance.

Lake Reeve also differs fundamentally from other lagoons in the Gippsland Lakes in its geomorphology. The bed of Lake Reeve is of sand, shell and mud, and as large areas of the lagoon frequently dry up completely, extensive saltmarsh areas develop. Along much of the shoreline of Lake Reeve, are sets of low, curving parallel ridges, the ridge crests commonly only five centimetres to 30 – 40 centimetres above the intervening swales. The ridges are often shelly, or of silty sand. They indicate a progressive reclamation of Lake Reeve by shoreline progradation and have been termed contraction ridges or concentric ridges. They are best developed on the eastern shoreline due to the predominance of wave action here generated by westerly winds. For these reasons Lake Reeve is identified as a geological and geomorphological site of State significance (DPI 2007) and is an excellent representative hypersaline saltmarsh that is both rare and unique in the context of the bioregion/drainage division and at greater spatial scales.

Lake Reeve showing saltmarsh wetlands (source: Paul Boon)

Patterns in variability

In terms of hydrology, Lake Reeve is periodically inundated with saline water and then dries out to form an intermittently wet-and-dry saltmarsh environment. Water enters Lake Reeve from the eastern end near Lake Victoria and permanent water extends westwards for about 13 kilometres. Water levels in Lake Reeve are usually lowest in summer and early autumn when stream flows are low but may be tens of centimetres above sea level during floods. Only the eastern end of Lake Reeve contains permanent water. The rest of the lake is shallow and usually dries up by early summer.

In terms of water quality, Lake Reeve can range from freshwater at its northeast end to 100 grams per litre in some isolated lagoons. Salinity levels vary seasonally, with lower salinity during wet (winter) compared with dry (summer) seasons (Davis and Fitzgerald 2004). Given the wide range of variability in hydrology and water quality in space and time, together with the paucity of data describing these patterns, it is not possible to establish a reliable empirical 'baseline' description of conditions at the time of site declaration, or present day.

To a large extent, patterns in hydrology and water quality will be reflected in vegetation community structure. While broad-scale mapping of wetland and vegetation community types exists (for example, Ecological Vegetation Class mapping), there are no data describing the range of natural temporal variability in extent of different saltmarsh vegetation communities and the controls on these changes. Based on VWCS mapping for the year 1980 (DSE unpublished), Lake Reeve is classified as a semi-permanent saline wetland (Figure 2-3). Based on VWCS data approximately 2322 hectares of saltpan was mapped for areas coded as "Lake Reeve Nature Reserve", which represented approximately 67 per cent of the total saltpan habitat resource of the site (Figure 3-5). Salt flat habitat within "Lake Reeve Nature Reserve" covered 318 hectares, which was approximately 43 per cent of the total salt flat habitat area of the site, and the area of salt meadow habitat within

Lake Reeve was 85 hectares (approximately two percent of the total salt meadow habitat within the site).

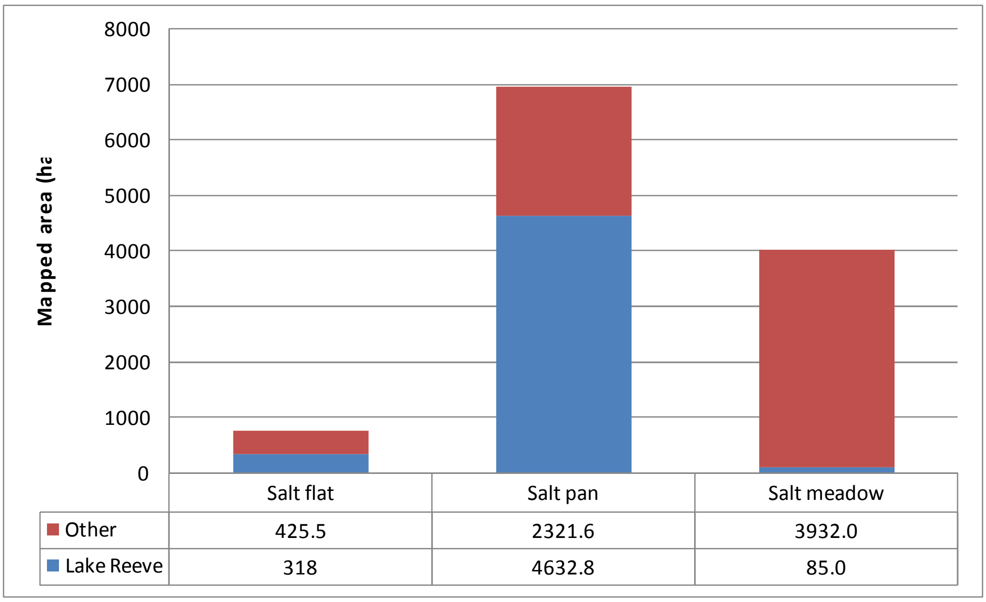


Figure 3-5 Area of saltmarsh, saltpan and salt meadow VWCS subcategories at the 'Lake Reeves Nature Reserve' and other parts of the site based on 1980 mapping (Source: DSE unpublished data)

3.4 Critical Components – Wetland Flora and Fauna

Within the wetland habitat types described above, a rich diversity of wildlife exists from all the major groups of organisms (from planktonic organisms to vertebrates) which make up the ecosystem components of the wetland.

3.4.1 Critical Component 6 - Abundance and Diversity of Waterbirds

Reasons for selection as 'critical'

Waterbird abundance and diversity of the site are referred to within several site management plans (DSE 2003, Parks Victoria 2003, Parks Victoria 2008) as being significant and underpin listing of the site under Ramsar Nomination Criteria 4 and 5 (and the original site nomination documentation - see Section 2.4.1). The abundance and diversity of waterbirds are therefore fundamental to the site's ecological character.

Description

Gippsland Lakes provide important feeding, resting and breeding habitat for 86 waterbird species (DSE 2003, Corrick and Norman 1980 – see Appendix D for species lists). Many are listed under JAMBA, CAMBA, ROKAMBA and/or the CMS. In terms of carrying capacity, it is documented that the

Gippsland Lakes and associated swamps and morasses regularly support approximately 40 000 to 50 000 waterbirds (DSE 2003).

The high conservation value of the Gippsland Lakes Ramsar site for avifauna results from the range of freshwater, brackish, and estuarine habitats present.

Corrick and Norman (1980) undertook four-weekly counts in selected representative wetland habitats within the Gippsland Lakes in 1980 which is one of the few data sets available to describe conditions at the time of listing. The study recorded 86 species of waterbirds (including seabirds) with highest usage of the site occurring in deep freshwater marshes (for example, Dowd Morass, the Heart Morass, Sale Common) but with salt marsh and shallow permanent saline wetlands also important areas for waterbird usage (for example, Lake Reeve). Migratory species were present during summer (snipe, sandpipers, godwit, Eastern curlew and common tern) or winter (cattle egret and double banded dotterel). Several nomadic species were observed all year round (white-eyed duck, pink-eared duck and grey teal) (Corrick and Norman 1980).

A total of 86 waterbird species are currently recorded for the site (DSE 2009, Birds Australia 2009) which represents approximately 93 per cent of the waterbird avifauna diversity recorded in Victoria (Barrett et al. 2003).

The Ecos (unpublished) analysis of waterbird data (total biomass and total species diversity) generally supports the findings of Corrick and Norman (1980), noting large open water bodies (coastal brackish or saline lagoons) of the site were relatively unimportant compared with marine sub-tidal aquatic beds (seagrass) and fringing wetlands. Whilst a variety of waterbirds (mainly piscivores) forage on large open water bodies, feeding activity of waterbirds is mainly concentrated along the margins of the lakes and/or shallow wetlands where conditions support foraging opportunities.

Specific waterbird values listed at a wetland-specific scale in the Strategic Management Plan (DSE 2003) include:

- Clydebank Morass, Macleod Morass and Jones Bay supporting many species of migratory waterbird.
- Lake Wellington, Lake Victoria and Lake King supporting migratory waterbirds, including the little tern and fairy tern.
- Lake Reeve providing highly significant habitat for a large number of migratory shorebirds, and is one of the five most important areas for shorebirds in Victoria.
- Bunga Arm supporting breeding populations of species of little tern, fairy tern, hooded plover and white-bellied sea-eagle

Information contained in DSE (2003) and within Ecos (unpublished) identified the most notable locations for waterbirds in terms of abundance within the site as follows:

- the southern sector of the Roseneath Wetlands (Victoria Lagoon and Morley Swamp)
- Macleod Morass and the western end of the Silt Jetties
- Dowd and the Heart Morass

- Swan Reach Bay and Bosse's Swamp
- the southern part of Lake Tyers and Reeve Channel
- shorelines of the Gippsland Coastal Park, including Bunga Arm.

Appendix C of this report presents analyses of waterbird count data provided by DSE (Flora and Fauna Database) and Birds Australia. While broad trends in habitat use can be derived from the data, there are insufficient data to develop a robust baseline description of abundance for most waterbird species. Analysis of the Birds Australia and DSE database data revealed similar spatial trends to that described by DSE (2003) and Ecos (unpublished). Key findings from the analysis of Birds Australia and DSE Fauna Database data are highlighted below.

In terms of avifauna species that meet Nomination Criterion 6 for regularly supporting one per cent of the individuals within a population, Bamford et al. (2008) lists two species which have been recorded at the site in numbers exceeding the one per cent population threshold, that is, the red-necked stint (*Calidris ruficollisi*) and sharp-tailed sandpiper (*Calidris acuminate*).

- Red-necked stint - approximately 8000 red-necked stints were recorded as part of a flock of shorebirds at Lake Reeve in January 1995 (cf. previous published total of 5397 as reported in Barter 1995; current flyway one per cent threshold is 3250, Bamford et al. 2008). Ecos (unpublished) notes that the site may not be expected to regularly support internationally significant numbers of this species. There is an absence of reliable data to substantiate the one per cent population threshold occurring and/or on a regular basis. The Birds Australia database contains 99 records of red-necked stint at the site, with a maximum count of 147 individuals per 20 minute search (at Swan Bay Reach). The DSE database contains 244 records of red-necked stint at the site, with counts of 1800 to 2570 individuals per station recorded on four occasions in March-April 2006, and a count of 1000 individuals recorded in 1987. All other DSE records for this species had counts less than 1000 individuals.
- Sharp-tailed sandpiper – this entry is for a recorded flock of 3187 in 2003 (AWSG 2003). The current flyway one per cent threshold is 1600 (Bamford et al. 2008). Since 2003, there is an absence of reliable data to substantiate the one per cent population threshold occurring and/or the frequency that this occurs. The Birds Australia database contains 28 records of sharp-tailed sandpiper at the site, with a maximum count of 70 individuals per 20 minute search (at Swan Bay Reach). The DSE database contains 205 records of sharp-tailed sandpiper at the site, with counts of 712 to 2300 individuals per station recorded on 11 occasions (1991, 1992, 1993 and 2006). The one per cent population threshold was exceeded on two occasions: 1660 and 2300 birds recorded in March 2006. All other DSE records for this species had counts less than 1000 individuals.

Other waterbird species which have occurred (or are considered likely to occur) in internationally significant numbers at the site include (after Ecos unpublished):

- Black swan (*Cygnus atratus*) –11 530 birds recorded in 1991 at Roseneath Wetlands. Areas of potential importance include: Russell's Swamp; areas of eel grass beds (*Vallisneria* spp.) along southern shores and bays (Lake Victoria and Tyers, and the Bunga Arm); southern part of Lake Reeve; and Sale Common (breeding site; 300 to 500 breeding pairs recorded). The one per cent population threshold for this species is 10 000 birds (Wetlands International 2006). Ecos (unpublished) notes that overall numbers probably exceed 10 000 almost all of the time, but this is speculation. Based on DSE database data, counts of greater than 10 000 birds occurred on three occasions: 10 000 individuals were recorded twice in January 1987 and 11 530 individuals were recorded in December 1991. Furthermore, counts approaching the one per cent threshold have been recorded in January 1987 (7500 individuals) and November 1991 (9000 individuals). Note that these counts are for individual monitoring stations within the site, and that total abundances at a whole of site would likely be far greater.

- Chestnut teal (*Anas castanea*) – undated records of 3730 birds at Lake Reeve and 3308 birds at Roseneath Wetlands (Ecos unpublished). Other areas of potential importance include: Bunga Arm (eel grass beds *Vallisneria* spp.); Macleod Morass; Sale Common; Raymond Island (northern tip); and Russell's Swamp (north-east corner of Lake Wellington). The one per cent population threshold (south-east Australia) for this species is 1000 birds (Wetlands International 2006). The 1999 RIS (Casanelia 1999) included this species within a group of waterbirds in support of Ramsar criteria 3(b) for the following reason - 6300 recorded in Lake King, Lake Victoria and Lake Wellington wetlands. The DSE database includes 45 records where the one per cent population threshold was exceeded: 1976, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1998, 1991, 2001 and 2006. Based on this, the site can be considered to support internationally significant numbers of this species.

- Fairy tern (*Sterna nereis*) – undated record for up to 80 birds recorded at Lake Tyers (Ecos unpublished). Other areas of potential importance include: the Bunga Arm (breeding site); and Metung-Lakes Entrance area (breeding sites). The one per cent population threshold for *Sterna nereis nereis* (of south-eastern Australia) is 25 birds (Wetlands International 2006). The DSE database includes 34 records where the one per cent population threshold was exceeded: 1987, 1988, 1993, 2001, 2002 and 2003. Based on this, the site can be considered to support internationally significant numbers of this species.

- Little tern (*Sterna albifrons*) - undated record for up to 300 birds at Jones Bay (Ecos unpublished). Other areas of potential importance include: Metung-Lakes Entrance area (feeding habitat; breeding site for 200-300 pairs); Lake Tyers (breeding site for up to 40 pairs); Crescent Island (breeding site for up to 25 pairs); and Roseneath Wetlands and Morley Swamp (feeding habitat for post-breeding adults and juveniles). The one per cent population threshold for *Sterna albifrons sinensis* is 1000 birds, and for *Sterna albifrons placens* is 150 birds (Wetlands International 2006). The DSE database includes 31 records where there were greater than 150 little terns: 1987, 1988, 1991, 1993, 2000, 2001, 2002, 2003, 2004 and 2006. However, there are no records where bird abundance exceeded 1000 individuals. It is uncertain at this stage whether the one per cent population threshold is exceeded due to lack of information on whether the records are for *S. albifrons placens* or *sinensis*.

- Musk duck (*Biziura lobata*) - Areas of importance include: Jones and Swan Reach Bays (feeding and sheltering areas for up to 200 birds); and Roseneath Wetlands (pre-breeding aggregations of 400-500 birds). The one per cent population threshold for this species (in south-eastern Australia) is 250 birds (Wetlands International 2006). The DSE database includes three records where the one per cent population threshold was approach or exceeded: 1992 (233 birds/station), 1994 (212 birds/station) and 1998 (250 birds/station). Note that these counts are for individual monitoring stations within the site, and that total abundances at a whole of site would likely be far greater.

Other notable waterbird species (listed within Casanelia 1999) that may not meet the one per cent threshold due to uncertainty with data sets, but are likely to exist in substantial numbers within the site are:

- Australasian grebe (*Tachybaptus novaehollandiae*). The 1999 RIS (Casanelia 1999) reported a count of 4500 individuals at Lake King wetlands. The DSE database includes four records where more than 200 individuals per station were recorded, including one record of 1000 individuals. Wetlands International (2006) does not identify a one per cent population threshold because of the "considerable" uncertainty in regards to overall population estimates. The Ecos (unpublished) data analysis identifies this species has declined substantially and is not present in significant numbers. That report also raises concerns about the validity of the previous large count reported in the 1999 RIS (Casanelia 1999) as annual average counts are low and the species could have been easily misidentified for the hoary-headed grebe.

- Grey teal (*Anas gracilis*). The 1999 RIS (Casanelia 1999) provided the following information - 7270 recorded in Lake King, Lake Victoria and Lake Wellington wetlands. The one per cent population threshold for this species is 20 000 birds, though noting that aerial survey data suggests that the population can exceed two million in Australia (Wetlands International 2006). The Ecos (unpublished) data analysis identifies this species has not been present in significant numbers, nor would the site population exceed the current one per cent population threshold required for this species. The DSE and Birds Australia database records examined in the present study support this argument, with a maximum of 4500 birds recorded on any one occasion and monitoring station.

- Eurasian coot (*Fulica atra*). The 1999 RIS (Casanelia 1999) provided the following information – 10 000 recorded at Lake King wetlands, 1000 at Lake Victoria wetlands, 2000 at Lake Wellington wetlands. The current one per cent population threshold for the subspecies *australis* (of Australia and New Zealand) is 10 000 birds (Wetlands International 2006). The Ecos (unpublished) data analysis identifies this species has declined substantially, though acknowledges that total abundance for the site could exceed the one per cent population threshold though the regularity of this is speculation. The DSE database does not contain any records where bird counts exceeded 10 000 birds, however there were three records with counts greater than 5000 birds: twice in March 1990 (8000 and 9350 birds per station) and May 1992 (5000 individuals per station). Based on this, there is insufficient information to determine if site can be considered to support internationally significant numbers of this species.

- Great cormorant (*Phalacrocorax carbo*). The 1999 RIS (Casanelia 1999) provided the following information - 7000 recorded at Lake Victoria wetlands, 440 at Lake Wellington wetlands. Wetlands International (2006) does not identify a one per cent population threshold because of the "considerable" uncertainty in regards to overall population estimate. The Ecos (unpublished) data analysis identifies that there is no evidence of a substantial change in numbers compared to the early 1980s, though the regular total population for the site as a whole is not known.

- Red knot (*Calidris canutus*). The 1999 RIS (Casanelia 1999) provided the following information – Lake Reeve has supported the largest concentration recorded in Victoria, that is, 5000 birds. The

DSE database does not contain any records of bird counts greater than 150 birds. The current flyway one per cent threshold is 2200 (Bamford et al. 2008). However, there is an absence of reliable data to substantiate the one per cent population threshold occurring and/or the frequency that this occurs.

- Curlew sandpiper (*Calidris ferruginea*). The 1999 RIS (Casanelia 1999) recorded up to 1800 birds at Lake Reeve. The current flyway one per cent threshold is 1800 (Bamford et al. 2008). Apart from the before mentioned exceptional count at Lake Reeve in the mid-1990s, it is only usual to record small numbers of less than 50 birds (see also DSE and Birds Australia data; Appendix C). Bamford identifies this species has not been present in significant numbers at the site since 2000, nor would the site population exceed the current one per cent population threshold required for this species.

Patterns in variability

Patterns in abundances of all avifauna species are thought to vary across a range of spatial and temporal scales in the site. While 23 per cent of the waterbirds regularly occurring within the site are migratory shorebirds (21 species), a small proportion may remain within the site during the Australian winter. Populations of migratory species can fluctuate seasonally and the reasons for such changes may be influenced by local factors and/or influenced by external factors (within other parts of the populations' migratory routes and/or breeding grounds).

As outlined above, in terms of carrying capacity, the site has previously been attributed with regularly supporting approximately 40 000 to 50 000 waterbirds. Whilst data collection has not provided systematic survey treatments across the extent of the site, data analysis found that the site continues to regularly support more than 20 000 waterbirds, though significantly less than population estimates of the early 1990s (based on analysis within Ecos unpublished).

Declines in waterbird abundance and community composition have been recorded within the site (Ecos unpublished) though the sampling data does not permit a sound basis to assess natural variability (or other factors) which may influence the site's population. Empirical estimates of the abundance of key waterbird species are provided in Appendix C. As discussed in Appendix C, due to uncertainties regarding survey effort it is difficult to determine clear long-term trajectories in bird abundance.

Periodic freshwater inputs appear to be essential to maintaining the site's importance for notable waterbird species in the long term, and occasional increases in bird numbers are likely to be critical for long-term carrying capacity. Ecos (unpublished) identifies that bird numbers at broader regional spatial scales are likely to depend on the Gippsland Lakes as a source of breeding productivity.

Generally though, analysis of site usage by various waterbird species since listing of the site in 1982 indicates that those species that utilise the freshwater habitats of the site have generally declined since 1982 whilst waterbirds that can withstand greater salinity and estuarine conditions have maintained or increased their numbers (Ecos unpublished).

3.4.2 Critical Component 7 - Threatened Frog Species

Reasons for selection as 'critical'

Threatened frog species that have been recorded regularly (though not systematically over time) within the site with known and potentially suitable habitat include green and golden bell frog and growling grass frog.

The presence of populations of these threatened fauna contributes to Ramsar Nomination Criterion 2 and Ramsar Nomination Criterion 4 in that the site also supports breeding habitat for these species.

Description

A summary of the nationally threatened frog species occurring within the Gippsland Lakes Ramsar site is contained in Table 3-3.

The green and golden bell frog (*Litoria aurea*) is listed as vulnerable under the EPBC Act and endangered under the IUCN Red List (IUCN 2010). This species mostly occurs within the eastern parts of the Ramsar site, with areas of particular importance being the Macleod Morass and freshwater pools on Rotamah Island. Site records for this species are recorded from the early 1960s up to the most recent record in 1998 (DSE 2003; Ecos unpublished; DSE 2009).

The green and golden bell frog has been recorded in various terrestrial habitats including lowland forest, Banksia woodland, wet heathland, riparian scrub complex, riparian shrubland, riparian forest, damp forest, shrubby dry forest and cleared pastoral lands (Gillespie 1996). Within these habitats, this species is known to use a wide variety of waterbodies, though avoids fast flowing streams (Pyke and White 1996). In Victoria, this species is predominantly found on the coastal plains and low hinterland foothills of the south-east within habitats with little human disturbance (cf. use of disturbed sites in other parts of range) which support a range of lentic (still water; low salinity) permanent or ephemeral wetland habitats (Pyke and White 1996; Gillespie 1996; Pyke et al. 2002). The following are regarded as threats to the green and golden bell frog: predation by introduced fish (especially *Gambusia holbrooki,* although this species is not presently known to be a key threat in the site), water pollution (herbicides, insecticides, biocides), and disease (chytrid fungus) (DEWHA 2009).

The growling grass frog (*Litoria raniformis*) is listed as vulnerable under the EPBC Act. The most recent record within the Ramsar site for this species was recorded in 2007 in the Heart Morass (DSE 2010) with a prior record in 1975. This species mostly occurs within the western parts of the site, with areas of particular importance including the southern end of the Roseneath wetlands (for example, Morley Swamp and Victoria Lagoon).

The growling grass frog is found mostly amongst emergent vegetation (for example, bullrush *Typha* sp., sedges and reeds (for example, *Phragmites* sp. and *Eleocharis* sp.), in or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds and farm dams (DEWHA 2009). 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 (esp. *Gambusia holbrooki*), chemical pollutions of water bodies (herbicides, insecticides, biocides), salinisation, and disease (chytrid fungus) (NSW DEC 2005, DEWHA 2009).

Table 3-3 Nationally threatened frog species occurring within the Gippsland Lakes Ramsar site

Species	Status	Habitat	Key locations within Ramsar site
Litoria reniformis (growling grass frog)	V	Emergent vegetation (for example, bullrush *Typha* sp., sedges and reeds (for example, *Phragmites* sp. and *Eleocharis* sp.), in or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds and farm dams	Southern end of Roseneath Wetlands (for example, Morley Swamp, Victoria Lagoon) Lake Coleman and Tucker Swamp Sale Common The Heart Morass
Litoria aurea (green and golden bell frog)	V	Lowland forest, Banksia woodland, wet heathland, riparian scrub complex, riparian shrubland, riparian forest, damp forest, shrubby dry forest and cleared pastoral lands	Macleod Morass Rotamah Island

*Conservation status as listed under the EPBC Act, V=vulnerable.

Patterns in variability

As information on the key populations for both species within the site is currently insufficient, it is not possible to appreciate natural variation in population size. Key habitat and populations for both frog species needs to be identified and monitoring implemented in order for their proper management.

Anecdotal advice indicates a substantial reduction in the presence of growling grass frogs at areas of particular importance, such as the southern Roseneath Wetlands (Ecos unpublished). Rising salinity and lack of freshwater input is thought to have a continued significant negative impact on habitat for all amphibians, including the growling grass frog and green and golden bell frog (Ecos unpublished).

Green and golden bell frog and growling grass frog are capable of hybridising, thus there is a hybrid zone in the Gippsland Lakes Ramsar site where the species, and hybrids, co-occur. As shown in Table 3-3, growling grass frog mostly occurs in the western portions of the Ramsar site and is replaced by green and golden bell frog further east.

Maintaining the populations of these threatened species over time is most dependent on the following:

- Water Quality - Maintenance of high quality freshwater habitats (low nutrient levels, adequate dissolved oxygen, low salinity).
- Hydrology - Maintenance of natural patterns of freshwater inundation and prevention of increases in saline intrusion (noting the preferred habitat for these species are in predominantly freshwater wetlands).

- Biological/Biophysical Processes - Maintenance of natural vegetation patterns, extent, condition, and habitat interconnectivity. Maintenance of key biological processes occurring at the site such as growth, reproduction, recruitment, feeding and predation.

3.4.3 Critical Component 8 - Threatened Flora Species

Reasons for selection as 'critical'

The site supports nationally listed (under the EPBC Act) wetland-associated flora species: the endangered dwarf kerrawang and metallic sun-orchid; and the vulnerable swamp everlasting. The presence of these threatened flora species contribute to Ramsar Nomination Criterion 2.

Description

A summary of the nationally threatened flora species occurring within the Gippsland Lakes Ramsar site is contained in Table 3-4.

The habitat preferences of these species incorporate various terrestrial wetland types such as mesic heathlands, ephemeral wetlands, swamps and waterbody margins.

With the exception of *T. epipactoides* (see Calder et al. 1989; Cropper and Calder 1990), an understanding of the ecology and biology of these threatened species is highly limited. Consequently a number of knowledge gaps regarding the factors influencing their survival of these species exist (refer Table 7-1 for further details).

Table 3-4 Nationally threatened wetland-associated flora species occurring within the Gippsland Lakes Ramsar site

Scientific name	Status	Habitat	Key locations within Ramsar site
Rulingia prostrata (dwarf kerrawang)	E	Ephemeral wetlands and lake margins; peaty soils	Blond Bay Sale Common
Thelymitra epipactoides (metallic sun-orchid)	E	Mesic coastal heathland; wetland fringes; sandy soils that are periodically waterlogged	Blond Bay Gippsland Lakes Coastal Park
Xerochrysum palustre (swamp everlasting)	V	Lowland freshwater wetlands and swamps	Blond Bay

*Conservation status as listed under the EPBC Act, where E=endangered, V=vulnerable.

Patterns in variability

Dwarf kerrawang (*Rulingia prostrata*) was the only nationally threatened flora species listed as present at the time of declaration of Gippsland Lakes as a Ramsar site. This species has been observed within the site as recently as 2006 (FIS database). However, it is not known whether populations within the site have declined, noting that the national conservation status of this species has been upgraded from vulnerable to endangered during this time period. Likewise, metallic sun-orchid (*Thelymitra epipactoides*) was only listed at the State-level at the time of Ramsar declaration and is now listed nationally as endangered.

Localities and population sizes have been determined for *R. prostrata* (see Carter and Walsh 2008), whereas this information is lacking for the other two species. As such, it is difficult to assess the levels of natural variability displayed by these species without the required long-term and/or detailed data.

A number of ecosystem processes underlie the natural variability of these species:

- freshwater wetland hydrologic processes in terms of surface water inflows/interaction and groundwater inflows/interaction
- freshwater wetland geomorphologic processes including topography and soil type
- climatic processes in terms of provision of a direct freshwater supply to wetlands by precipitation as well as loss of freshwater through evaporation
- freshwater wetland biological processes including population dynamic processes (reproduction, dispersal, recruitment) and species interactions (herbivory, competition).

Overall, there are no available data on water requirements of threatened plant species, nor are there suitable baseline (pre-1982) data describing water regimes/water levels at particular locations supporting the three threatened plant species.

3.5 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 critical components in the context of the considerations outlined in section 3.1.1 of this report. In this context:

- Some supporting components are already partially covered by other critical components, processes or services/benefits.
- The supporting components, while not critical, are important to wetland functioning and are noteworthy in this regard.

3.5.1 Other Wetland Habitats

As described in Section 2, a range of wetland habitat types are supported by the site. In addition to the wetland types that have been identified in the context of the critical component habitats (C1 to C5), other habitats types that support/contribute to the site’s wetland values include:

- Type E - Sand, shingle or pebble shores – along foreshores of the Gippsland Lakes Coastal Park
- Type F - Estuarine waters – within the larger lakes and at Lakes Entrance channel
- Type L - Permanent inland deltas – associated with the Mitchell Delta
- Type M - Permanent rivers, streams or creeks – associated with the lower parts of the Nicholson, Latrobe, Avon, and Perry Rivers that are within the boundaries of the site.

These wetland habitats contribute to the ecological character of the site but are do not support critical processes such as bird breeding, critical component species and groups or critical services/benefits to the extent of the other critical component habitats. For this reason, they are seen as supporting components.

3.5.2 Other Wetland Fauna

Fish

The fish community within the Gippsland Lakes Ramsar site is diverse, with approximately 179 species inhabiting all of the Lakes' wetland types except for the most hypersaline wetlands. The marine subtidal aquatic beds wetland type is particularly important to many species of fish as a nursery area.

Key fish species of commercial significance include: yellow eye mullet, black bream, tailor, river garfish, estuary perch, Australian anchovy, dusky flathead, luderick, Australian salmon, silver trevally, leatherjackets and sea mullet. Key species of recreational significance include dusky flathead and black bream, as well as snapper, whiting, squid and prawns.

The high diversity of fish assemblages reflects in part the 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 are also likely to maintain fish biodiversity values. It is suspected that the increased influence of saline waters due to permanent opening of the lakes system has dramatically altered fish communities, potentially resulting in an increase in diversity associated with greater usage by marine species. 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 (Ecos unpublished).

Fish (and to a lesser extent marine invertebrate species such as crabs, prawns, squid and similar animals) are important for their inherent value and, for some species, for their value as a fisheries resource. Fish also have a significant ecological role in the Gippsland Lakes as a food source for many water-birds and marine mammals. They are keenly sought after by recreational and professional fisherman linking to the site's importance in supporting tourism and recreation activities.

Fish populations within the site contribute to its ecological character but have been addressed as a critical service/benefit (refer Critical Service-S2), 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.

Aquatic invertebrates

The aquatic invertebrate fauna of the Gippsland Lakes has been little studied. The composition of invertebrate fauna is greatly influenced by the physical conditions in the local habitats in which the animals live. Within the lakes and fringing wetland areas, the key physical factors determining the types of invertebrate fauna present are most likely to be salinity, depth, sediment particle size, water velocity and habitat structure. Biological processes, most notably competition, predation and recruitment success, are also likely to exert a strong influence on patterns in community structure in space and time.

Invertebrates play an integral part in the function of aquatic ecosystems including supporting or forming the basis of food chains (including those supporting commercial fisheries), cycling of nutrients, the breakdown of plant matter and other detritus, provision of habitat for other species (for example, sessile colonial forms such as sponges and ascidians), regulating populations of other organisms by predation, parasitism, or grazing, and helping to maintain water quality by filtering water during feeding.

Aquatic invertebrates have been selected as a supporting component instead of a critical component on the basis of a lack of quantifiable information about the group across the range of wetland environments within the site.

3.6 Critical Processes

A broad range of ecosystem processes are occurring within the Gippsland Lakes. Within the Gippsland Lakes, many of these processes are highly interlinked such as, for example, the relationship between increased rainfall, catchment inflows and the resultant runoff affecting water quality and triggering of algal blooms. Those ecosystem processes that are considered to most strongly influence the ecological character of the site have been described below.

3.6.1 Critical Process 1 - Hydrological Regime

Reasons for selection as 'critical'

The Gippsland Lakes Ramsar site's hydrological regime can be separated into:

- surface freshwater inflows
- groundwater inflows and influences
- marine in-flows (from Bass Strait at Lakes Entrance).

Each of these aspects of the hydrological regime are considered to be critical 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

A description of each of the aspects of the hydrological regime and how they affect the ecology of the Gippsland Lakes are outlined in the following sub-sections.

3.6.1.1 Freshwater Inflows (surface hydrology)

The hydrological record demonstrates that riverine in-flows into the Gippsland Lakes demonstrate both high inter-annual and intra-annual variability. Each of the inflowing rivers contributes freshwater with different volumes, timing and duration and quality to different parts of the Gippsland Lakes system (Tilleard et al. 2009).

Stream flow exhibits significant seasonal trends, with higher flows in winter-spring (August-September-October) and lower flows occurring in late summer - autumn.

For the Gippsland Lakes Ramsar site, this high degree of variability means that the lower estuaries of the rivers and the lakes/lagoons receive a seasonal signature of freshwater inputs, which can provide important lifecycle triggers for various species.

In general the connections between the main rivers and the Gippsland Lakes are as follows:

- Tambo River (principally flows into Lake King)
- Mitchell River (principally flows into Lake King)
- Thomson River (principally flows into Lake Wellington)
- Latrobe River (principally flows into Lake Wellington)
- Merrimans Creek (can flow into the western end of Lake Reeve at times of high flow).

Superimposed over the background of the seasonal cycle of flows, the system experiences occasional large fresh and flooding flows. The high flow events can “flush” the estuarine sections of the rivers, making them completely fresh, and introduce large volumes of freshwater, sediment, nutrients and other pollutants into Gippsland Lakes. While these high flow and flood events have a moderate duration (a few days to one to two weeks), the poor flushing of Gippsland Lakes means there is significant opportunity for the pollutants associated with flood events to be retained in the Gippsland Lakes system for extended periods (several months to years).

In providing a historical context of hydrological processes since the time of site listing, Figure 3-6 shows the total annual discharge (in megalitres) from major rivers within the Gippsland Lakes catchment from 1976-2009. Figure 3-7 and Figure 3-8 show annual discharges from individual major western and eastern rivers, respectively.

When compared against rainfall records (refer Figure 3-9) over the same period (noting that two rainfall gauging sites have been used to provide a complete data set over that time period and do not include all the relevant catchment areas of the Lakes), there is a reasonable correlation between rainfall and inflows, particularly in major rainfall events such as that most recently experienced event in 2007-2008.

As shown by these graphs, the overall trend for inflows into the Gippsland Lakes are heavily influenced by rainfall, and in particular the overall declines in inflows over the past decade into the site corresponds with the prolonged period of below average rainfall over the past 13 years (State of Victoria 2010).

Notwithstanding, the anthropogenic influences on the hydrology and freshwater inflows into the Gippsland Lakes can also be significant in some rivers, notably the Latrobe and Thomson/Macalister

Rivers. Figure 3-10 (appended from Tilleard et al. 2009), shows the average annual discharge and surface water extraction from the major rivers entering the Gippsland Lakes system. The flow data is averaged for the period 1965 to 2003 noting the listing date for the Ramsar site would be in the middle of this data range in 1982.

Overall, at the current time, about 20 per cent of the available average annual riverine discharge to the Gippsland Lakes is extracted as surface water for agricultural, industrial and domestic purposes before it reaches the lakes. As identified above, river regulation and extraction of water is greatest for the western rivers Latrobe and Thomson (95 per cent of total extraction), while flows into the eastern rivers are largely unregulated and average annual extraction represents a significantly smaller proportion of flows.

Numerous environmental flow studies of the western tributaries of Gippsland Lakes were undertaken in the 1990s and early 2000s (refer Earthtech 2003; Gippel and Stewardson 1995). Reduced freshwater flows were also discussed as part of the Environment Audit for the Gippsland Lakes (refer CSIRO 1998), noting river regulation and water extraction in the major Gippsland catchments had changed the variability of water residence times in the Lakes by cutting down on the high flows and reducing flows during drier periods. The Audit noted that this effect has been exacerbated by longer term decline in rainfall since the 1950s leading to 'markedly reduced run-off entering the Lakes (CSIRO 1998).

The Victorian Government's White Paper (refer Victorian Government 2004) sought to respond to these issues by determining new procedures for setting the environmental water reserve (EWR) for the river systems. In particular, for the Thomson/Macalister and Latrobe systems, it noted that these river basins are fully allocated and the EWR needs to be enhanced as a high priority. The EWR would be set for these systems by capping consumption and a moratorium on new diversions was applied until the EWR was put in place.

At the time of preparation of this report, there has been a further response to achieving a balance between consumptive use and EWR through the Draft Gippsland Regional Sustainable Water Strategy (State of Victoria 2010). The Strategy aims to identify and understand potential challenges for water management and opportunities to secure water resources for the next 50 years. The draft Strategy indicates that the Government will protect Gippsland Lakes by:

- Managing the freshwater needs of the high value fringing wetlands, river estuaries and Jones Bay by:
    - placing precautionary caps on winter surface water diversions from the Mitchell, Tambo and Nicholson Rivers
    - identifying opportunities for improved environmental flows through the development of local management rules on these rivers
    - actively managing the environmental water needs of fringing wetlands along the lower Latrobe, including Sale Common, Dowd and the Heart Morass.
- Continuing to invest in catchment management activities that have a significant impact on water quality within the lakes system.

- Monitoring and undertaking further research on the condition of the lakes to ensure management activities continue to be effective in protecting the lakes' high environmental and social values.
- Implementing improved governance arrangements (State of Victoria 2010).

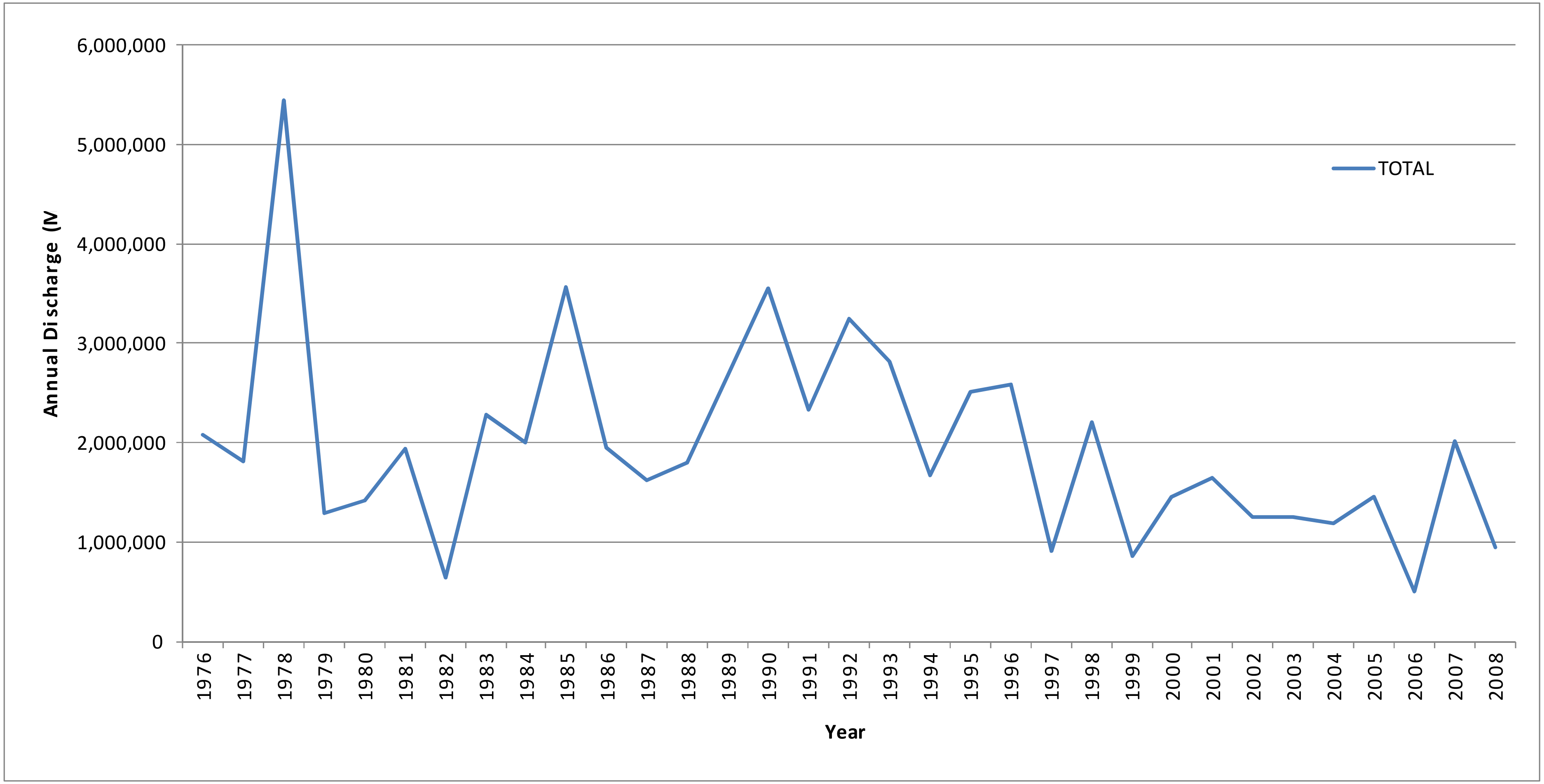


Figure 3-6 Annual total discharge from major rivers into Gippsland Lakes since 1976

Data taken from the Victorian Water Resources Data Warehouse – accessed 29th July 2009. http://www.vicwaterdata.net/vicwaterdata/home.aspx

Note that the time of listing of the Ramsar site is 1982.

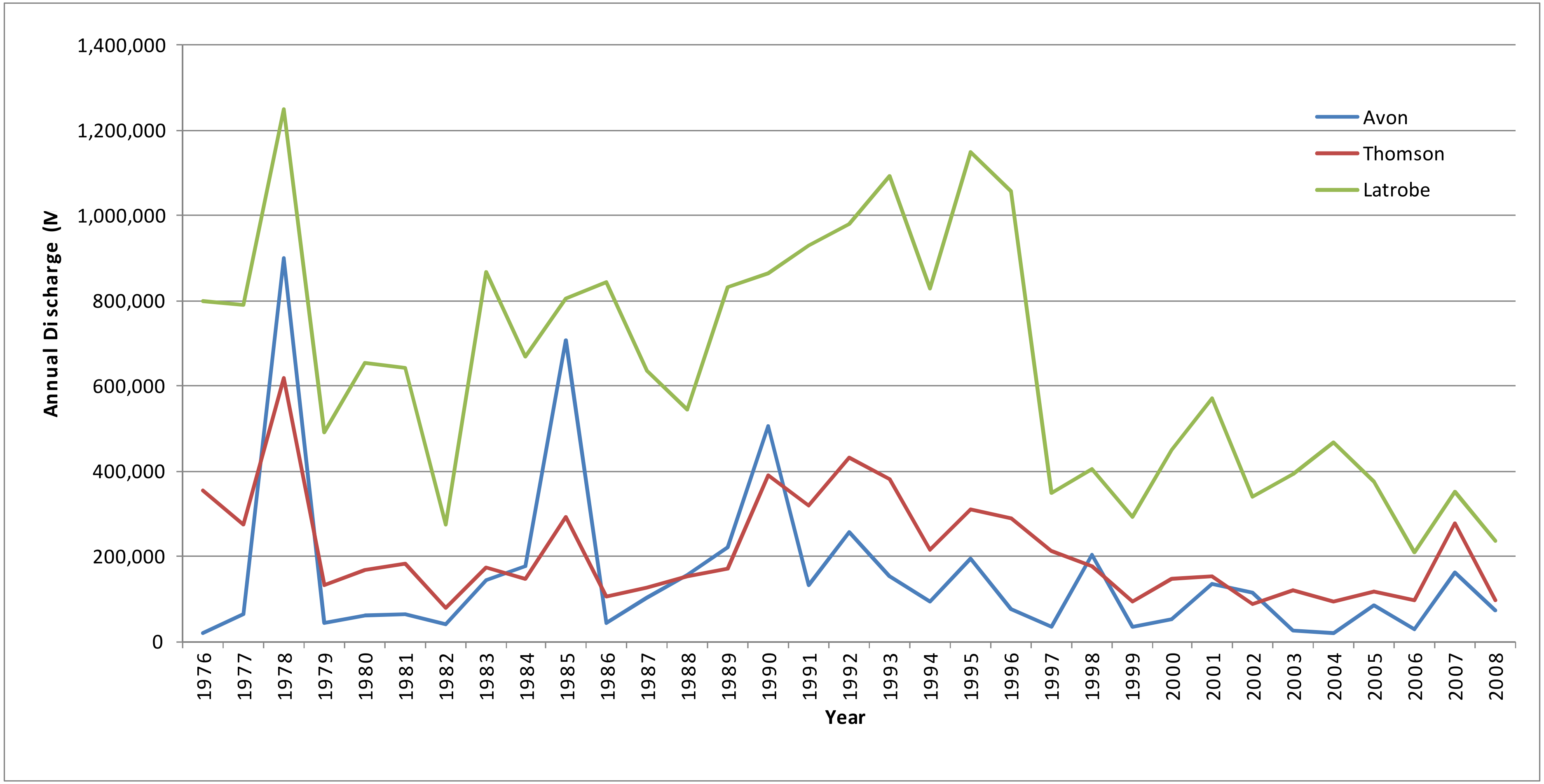


Figure 3-7 Annual discharge from major western rivers into Gippsland Lakes since 1976

Data taken from the Victorian Water Resources Data Warehouse – accessed 29th July 2009. http://www.vicwaterdata.net/vicwaterdata/home.aspx

Note that the time of listing of the Ramsar site is 1982.

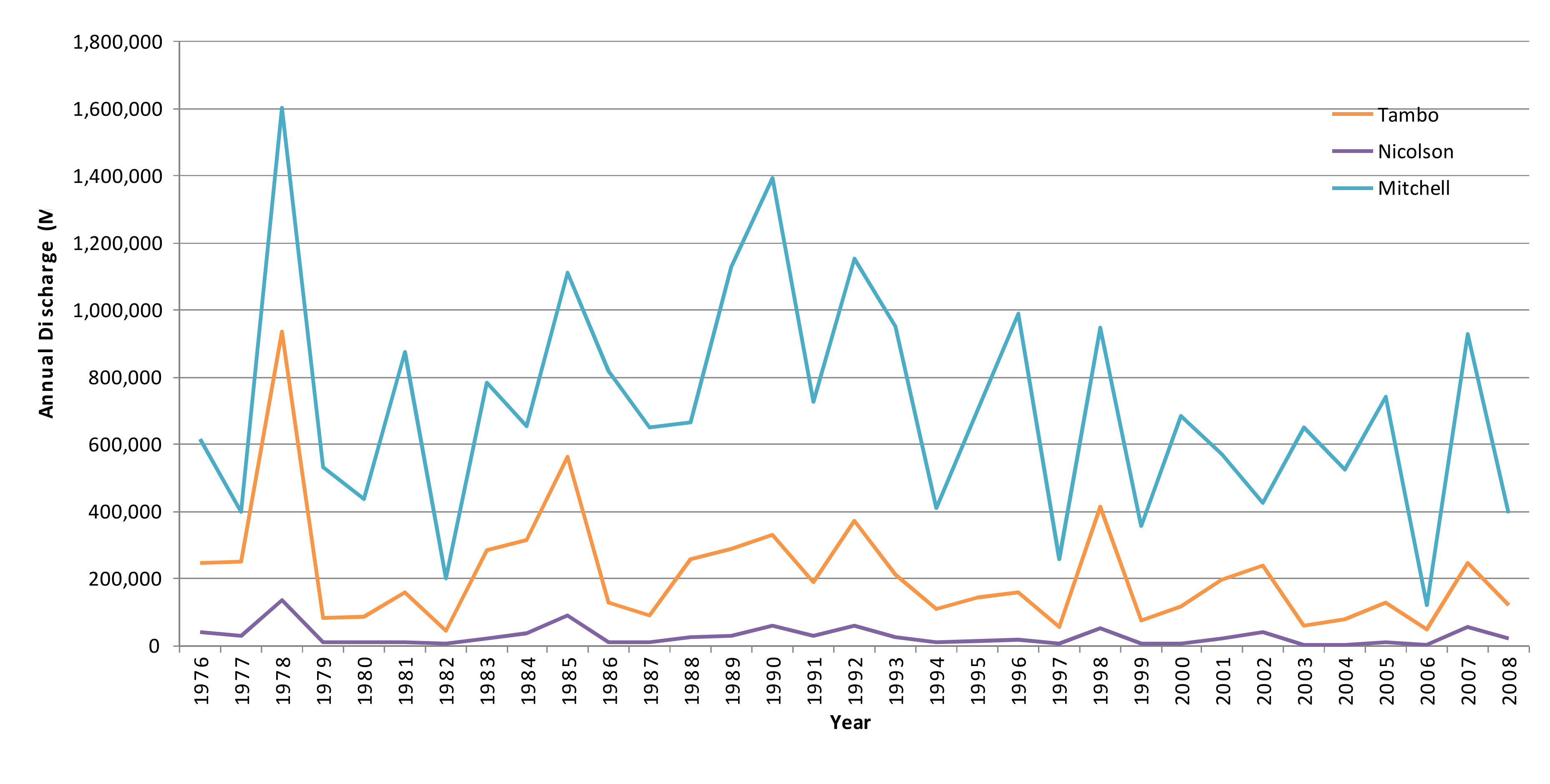


Figure 3-8 Annual discharge from major eastern rivers into Gippsland Lakes since 1976

Data taken from the Victorian Water Resources Data Warehouse – accessed 29th July 2009. http://www.vicwaterdata.net/vicwaterdata/home.aspx

Note that the time of listing of the Ramsar site is 1982.

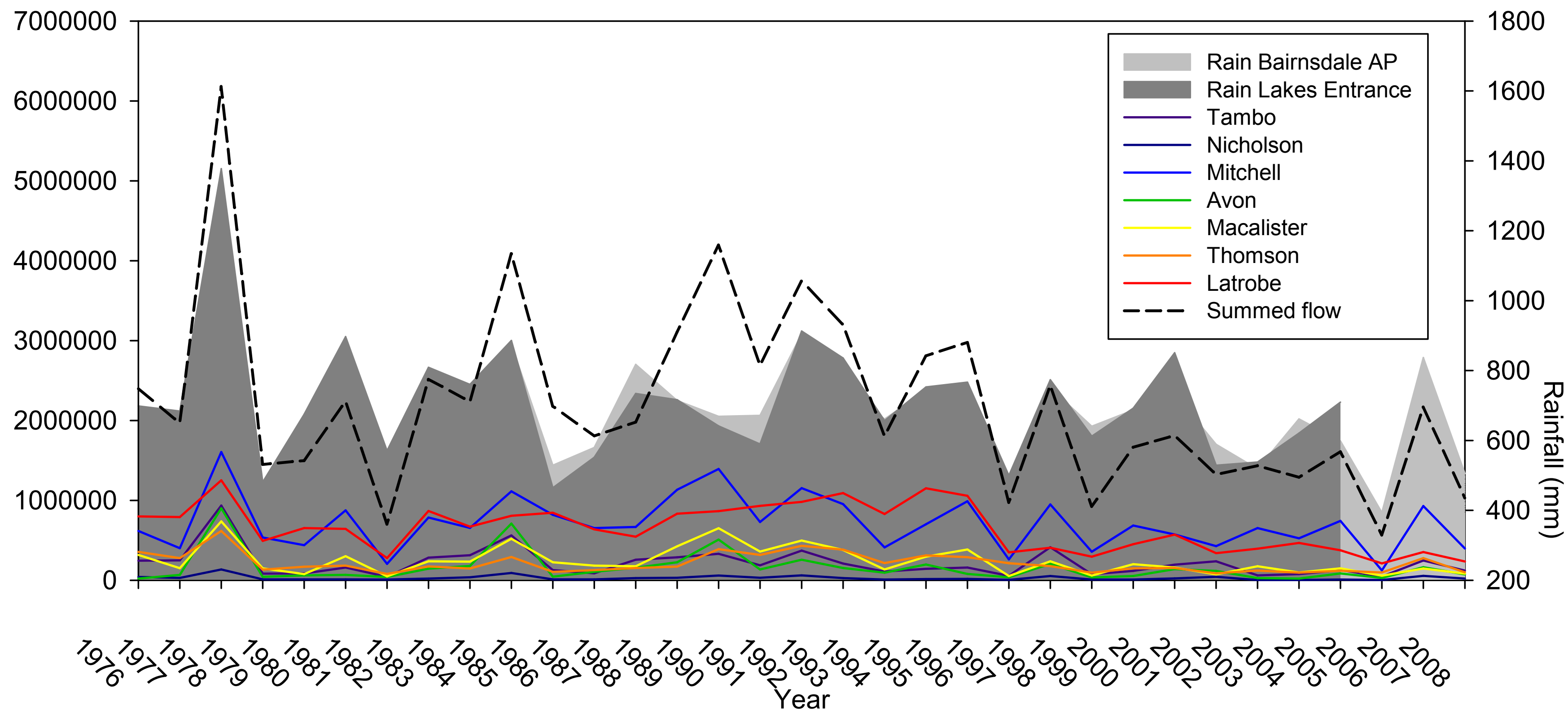


Figure 3-9 Annual discharge from major rivers into Gippsland Lakes since 1976 correlated against rainfall data

Notes:

- The time of listing of the Ramsar site is 1982.
- Data from rainfall gauges at Bairnsdale and Lakes Entrance may not be entirely representative of rainfall in the catchment areas of the Gippsland Lakes but demonstrates a reasonable correlation with inflows.

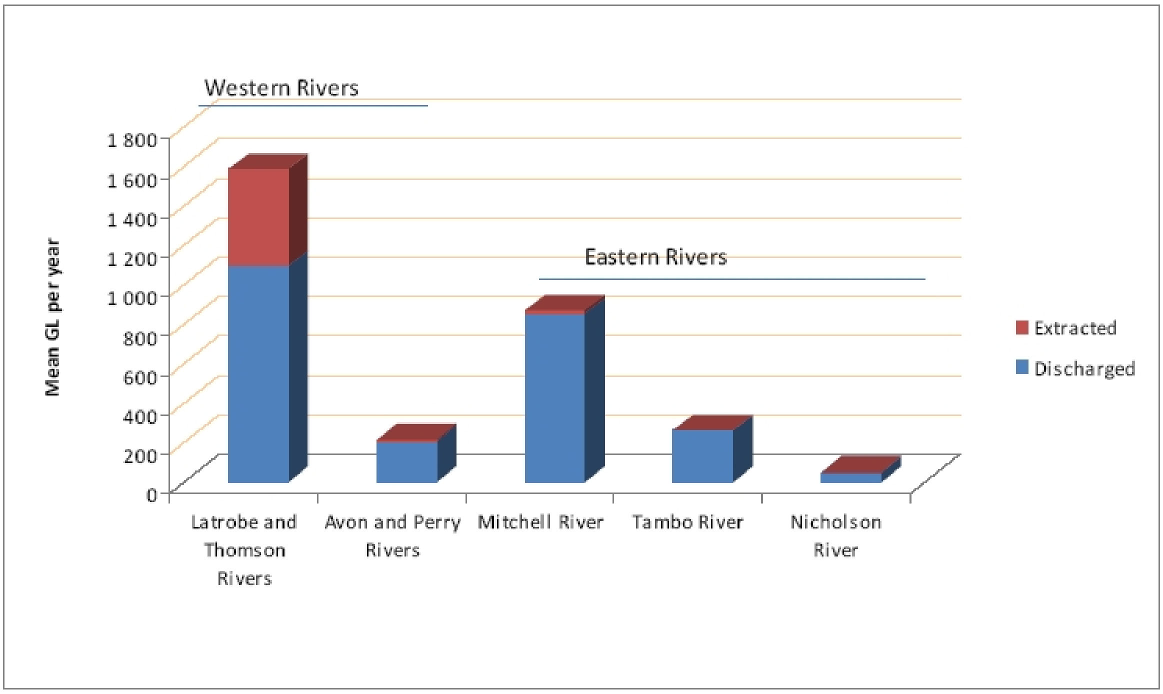


Figure 3-10 Average annual discharge and surface water extraction from the major rivers entering the Gippsland Lakes system. The flow data is for the period 1965 to 2003 (from Tilleard et al. 2009)

In the context of the draft Sustainable Water Strategy, a snapshot of the annual extent of water use (in terms of surface water extraction, groundwater extraction and recycled water use) compared to annual total water resource available for each of the five major rivers flowing into the Gippsland Lakes is provided in the Victorian Government's *State Water Reports*/*Accounts* (refer Victorian Government 2005, 2007 and 2010).

Data from these reports is presented in Figure 3-11 to Figure 3-14, and Table 3-4 below summarises all EWR that have been set for the Rivers (including updated provisions from the Gippsland section of the draft Water Strategy - see State of Victoria 2010).

Table 3-5 Environmental Water Reserves for river basins that influence the site (Victorian Government 2005, 2007 and 2010; State of Victoria 2010)

River name	Environmental Water Reserve (EWR)
Tambo	• Passing flows released as a condition of consumptive bulk entitlements held by East Gippsland Water • Water set aside for the environment through the operation of licensed diversions in passing flow conditions • Two gigalitre cap on new consumptive allocations (under review) • All other water in the basin not allocated for consumptive use
Mitchell	• Passing flows released as a condition of consumptive bulk entitlements held by East Gippsland Water • Water set aside for the environment through the operation of licensed diversions in passing flow conditions • Two gigalitre cap on new consumptive allocations (under review) • All other water in the basin not allocated for consumptive use
Thomson/ Macalister	• A bulk entitlement for the environment of 10 000 megalitres (gazetted in August 2005); an additional 8000 megalitres is proposed from water saving efficiencies by 2012 • 8100 megalitres of entitlement for the environment is proposed for the Macalister River (State of Victoria 2010) • Water set aside for the environment through the operation of passing flows released as a condition of consumptive bulk entitlements held by Melbourne Water and Southern Rural Water • Water set aside for the environment through the operation of licensed diversions in passing flow conditions • All other water in the basin not under entitlements
Latrobe	• Water set aside for the environment through the operation of passing flows released as a condition of consumptive bulk entitlements held by Gippsland Water, Southern Rural Water and Power Authorities • Water set aside for the environment through the operation of licensed diversions in passing flow conditions • All other water in the basin not under entitlements
Merrimans Creek	• Water set aside for the environment through the operation of passing flows released as a condition of consumptive bulk entitlements held by Gippsland Water • Water set aside for the environment through the operation of licensed diversions in passing flow conditions • All other water in the basin not under entitlements

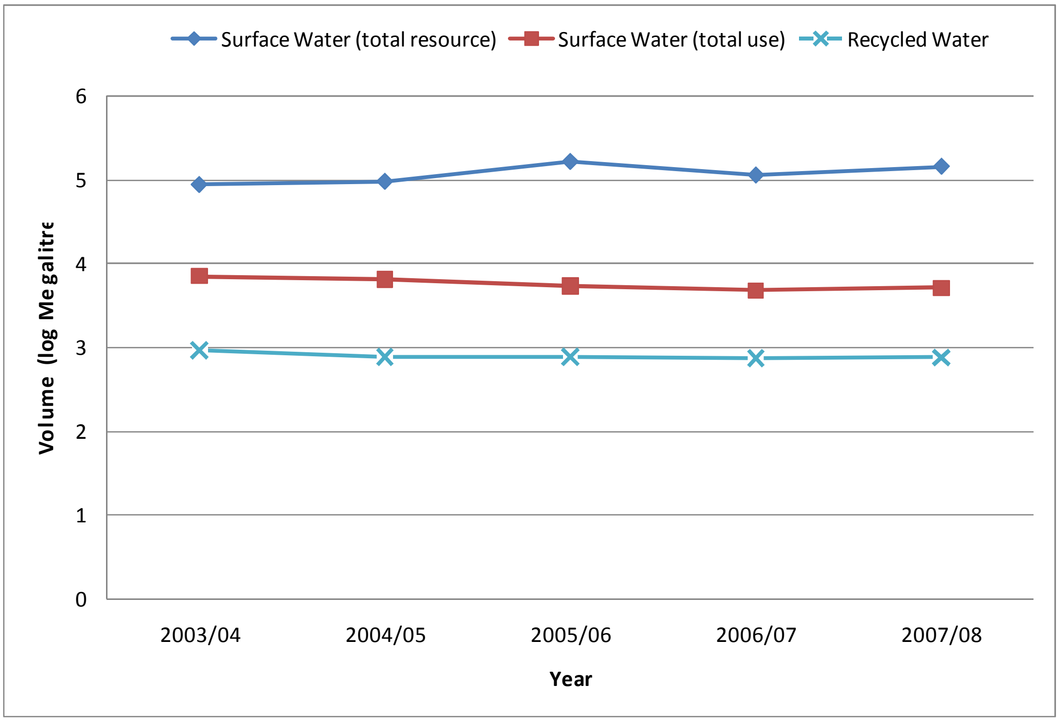


Figure 3-11 Water resource and water use within the Tambo basin over a five year period

Data obtained from Victorian Water Accounts, Our Water Our Future http://www.ourwater.vic.gov.au/monitoring/accounts

Notes: Recycled water total resource and total use were equal. There are no groundwater management areas or water supply protection areas within the Tambo basin.

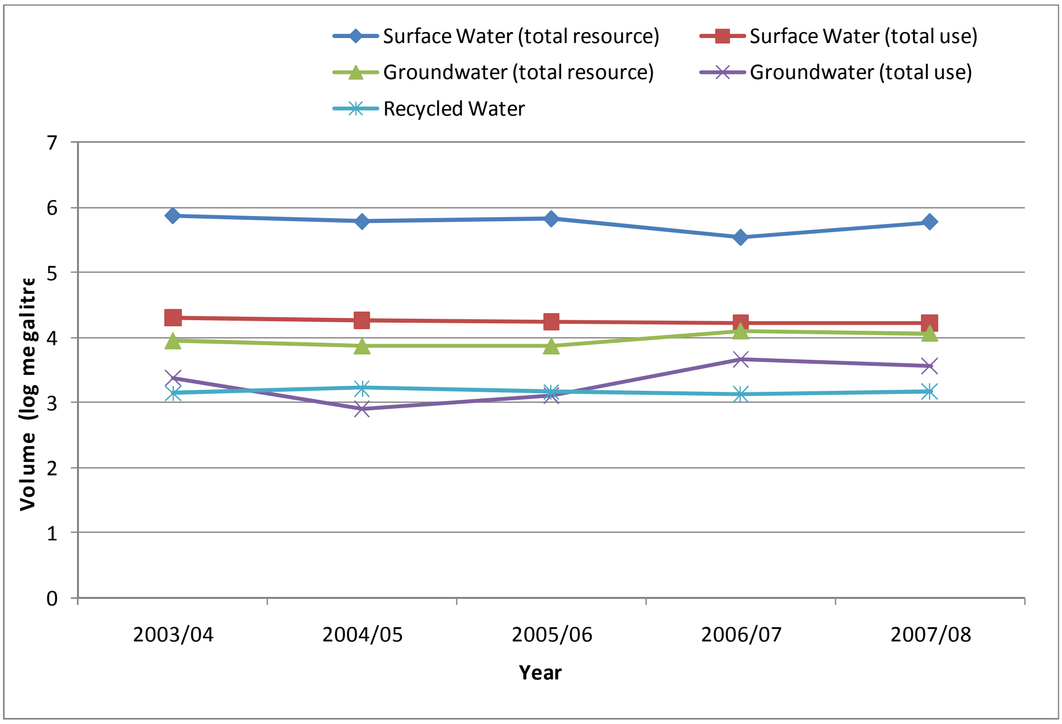


Figure 3-12 Water resource and water use within the Mitchell basin over a five year period

Data obtained from Victorian Water Accounts, Our Water Our Future http://www.ourwater.vic.gov.au/monitoring/accounts

Notes: Recycled water total resource and total use were equal.

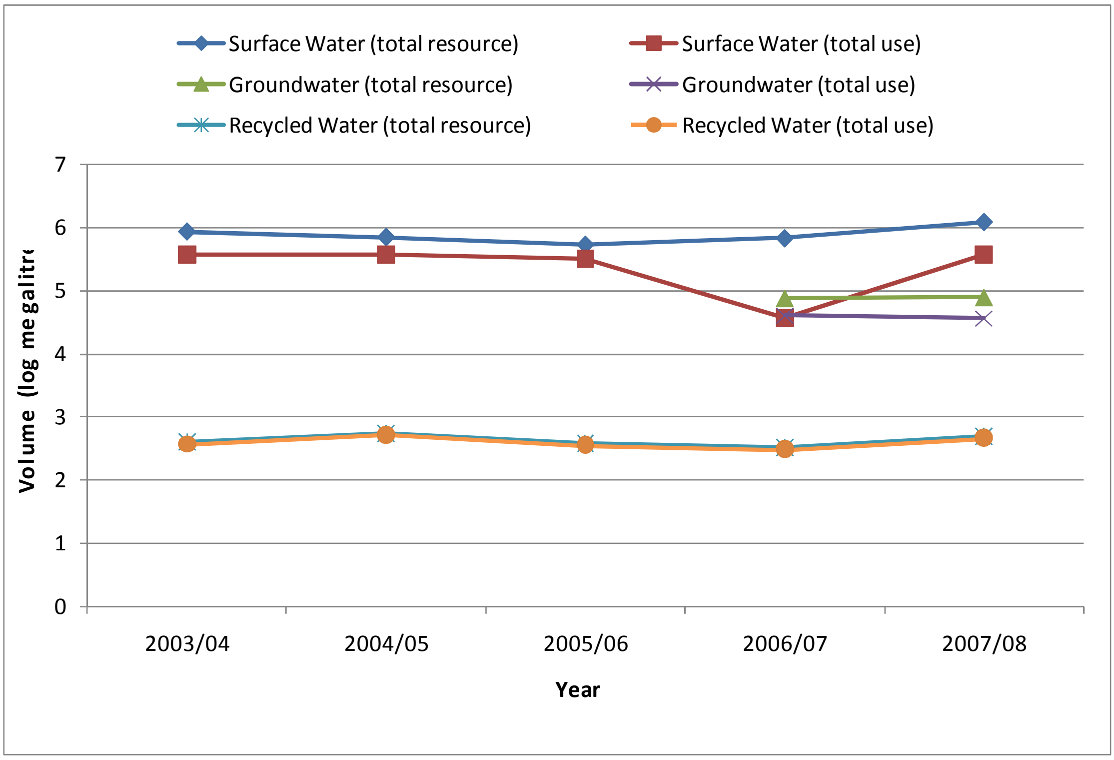


Figure 3-13 Water resource and water use within the Thomson basin over a five year period

Data obtained from Victorian Water Accounts, Our Water Our Future http://www.ourwater.vic.gov.au/monitoring/accounts

Notes: Data for groundwater total resource and total use were not available for the first three years.

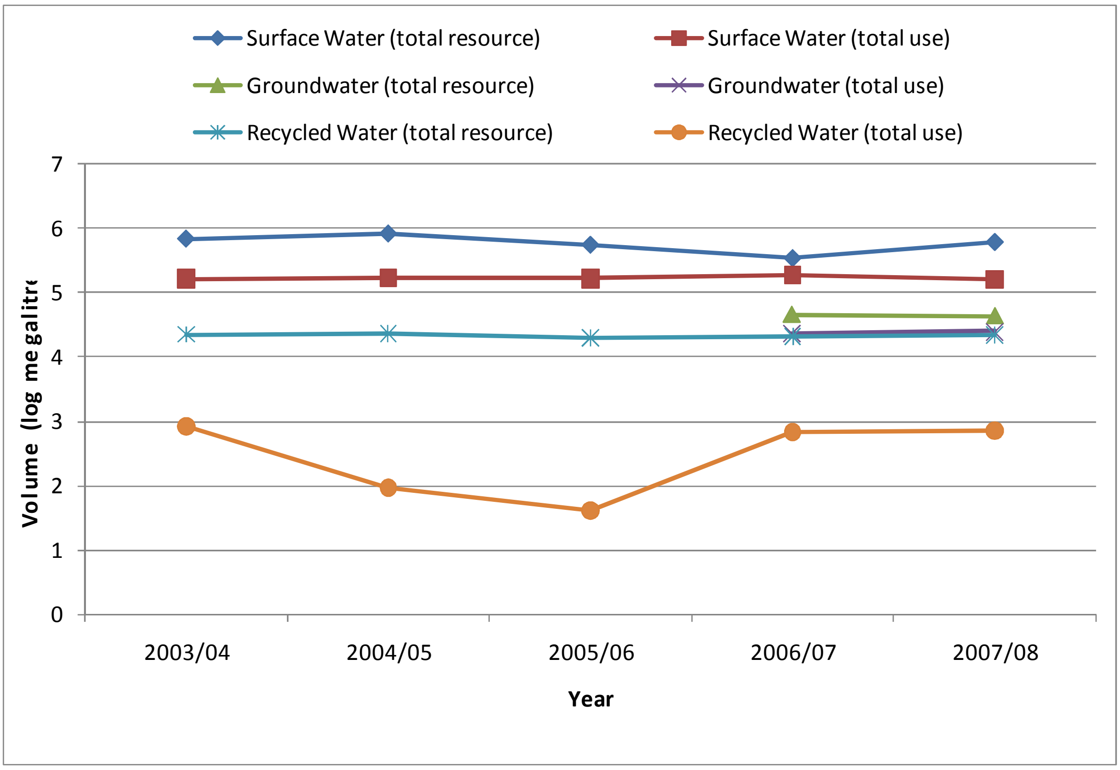


Figure 3-14 Water resource and water use within the Latrobe basin over a five year period

Data obtained from Victorian Water Accounts, Our Water Our Future http://www.ourwater.vic.gov.au/monitoring/accounts

Notes: Data for groundwater total resource and total use were not available for the first three years.

3.6.1.2 Groundwater

In terms of groundwater processes, it is difficult to quantify groundwater flows to and from the Gippsland Lakes lagoons and associated fringing wetlands due to the large uncertainty in aquifer permeability, aquifer thickness and groundwater gradient (SKM 2009). No direct calculation of groundwater/surface water interactions has been undertaken for the whole of the Gippsland Lakes. However, in some wetland areas within the site (Clydebank Morass, Dowd Morass) calculated groundwater inflows have been derived based on modelling studies.

The lower estuarine reaches of the rivers discharging into Gippsland Lakes are likely to be the predominant groundwater discharge features with the volume of groundwater discharge into the river dependent on the relative elevation of the river and nearby water table (SKM 2009).

The water table can become artificially elevated as a result of a combination of land clearing and irrigation resulting in land and wetland salination particularly in western catchments (SKM 2009). In particular, high groundwater salinity has been recorded in Clydebank, the Heart and Dowd Morasses. Rising saline groundwater tables can directly increase the salinity of wetlands through seepage and indirectly through run-off of salinised land. If salts entering a wetland via groundwater are not periodically leached from the soil, salts will accumulate over time. Leaching can occur laterally via surface flow or vertically via groundwater recharge. In groundwater discharge zones, the hydraulic gradient may not allow surface water to drain away as groundwater, hindering the leaching of salts into the groundwater table. Intermittently-flooded wetlands can be at particular risk from salinisation because of increasing salt concentration during drawdown (Boon *et. al*. 2008). Groundwater inflows with high nutrient loads may also be affecting the water quality of coastal lagoons of Gippsland Lakes in the context of the stimulation of algal blooms.

While there remains considerable uncertainty about the nature and effects of groundwater processes, the available studies on groundwater influences on the wetlands of the site have generally found that (SKM 2009):

- Inflows are small in comparison to the equivalent surface water inflows.
- The underlying aquifer is responsive to climate patterns with the water table rising and failing with rainfall.
- In periods of reduced rainfall and drought, there is lower groundwater discharge to the wetlands of the Gippsland Lakes.

3.6.1.3 Marine In-Flows

As already discussed, the Gippsland Lakes are connected to the ocean (Bass Strait) by a narrow, maintained man-made channel at Lakes Entrance. As a result, mean water level in Lake King and Lake Victoria correlates with the mean water level in Bass Strait on moderate time scales (one week or more). These variations are in response to the effect of longer period changes in atmospheric pressure or storm events on water level. The resulting longer term variation in water levels dominates the observed pattern of water level variation throughout the lakes and can result in mean water level variations within the lakes of ± 0.2 m about mean sea level.

Mean ocean levels in Bass Strait have a much greater influence of water levels in the lakes than ocean tidal variation. During large ocean surge events in Bass Strait the lakes respond with variations in mean water level up to 1.0 m. These variations in mean sea level typically occur over periods of a week or more. Additionally, wind setup across the lakes can also have a significant influence on local water levels, and is the main driver of internal circulation processes. In this context, the water level in the lakes can vary locally over a range greater than the observed tidal range which is strongly attenuated across the relatively narrow Lakes Entrance (McInnes et al. 2006).

3.6.1.4 Hydrological Regime Influence on Ecology

The ecological values of Gippsland Lakes are strongly influenced by the variable salinity regime that exists across the system. As described above, Lakes Entrance provides a permanent connection to the sea which, together with the variable freshwater flow regime, creates a highly dynamic salinity regime across the site and over time. This variable salinity regime controls a number of natural ecological patterns and processes including:

- The distribution, community structure and condition of vegetation communities associated with the fringing wetlands.
- The distribution, condition and community structure of submerged aquatic plants.
- Patterns in fish community structure and key processes controlling fish populations, including availability of suitable habitat, food supplies and the continued existence of life cycle cues for successful recruitment.
- The extent and strength of water column stratification in the main lakes and associated algal bloom production.
- The risk of invasion by exotic pest and animal species.

The ecology of the Gippsland Lakes is not just dependent on the annual volume of freshwater inflows but on the frequency, duration, timing and magnitude of inflows. The Environmental Water Requirements (EWR) study being undertaken for the Gippsland region (refer Tilleard et al. 2009 - Stage 1 report) outlines a summary of flow requirements, flow components and their functions for various habitats of the Lakes system. These can be summarised as:

- Main Lakes/Lagoons – Freshwater flows in to the lagoons stimulate ecological responses by providing organic material, nutrients and sediments. In-flows that reduce salinity will benefit fringing wetlands such as reed beds, and the variability will create a desirable environment for estuarine fish and limit the incursion of marine specialists in the lakes. Flows into the lagoons drive sediment and water column phytoplankton blooms as well as influence benthic algae, seagrasses and fundamental biological processes such as rates of primary production and decomposition. These are discussed further below in relation to water quality and biological processes.
- Fringing Wetlands – The ecological condition of these wetland areas is closely linked to influxes of freshwater, which under natural conditions predominantly occur in Spring. Both wetting and flushing flows are needed to maintain vegetation and habitat values with dry periods of several months desirable about every three to five years. Such dry periods are required to prevent tree

death from waterlogging and facilitate decomposition of accumulated organic matter, thereby making it available for uptake on re-wetting.

- Estuarine River Reaches - Annual flow in these areas drives the average extent and location of the salt wedge and has impacts on average lake salinity. This promotes breeding and recruitment of fish species such as black bream and is likely to have an impact on fringing plant communities, particularly freshwater species such as common reed. Likewise, flow pulses will drive variations in extent and position of the saltwedge within the waterways, also promoting breeding and recruitment by black bream and other estuarine fish species and the extent and distribution of fringing wetland plant communities.

In considering the relative sensitivity of different wetland habitat types to the hydrological regime, Tilleard et al. (2009) sought to identify priorities within the system. Table 3-6 (adopted from Table 10 of Tilleard et al. 2009) indicates that the ecology of predominantly freshwater and brackish fringing wetlands, the shallow lakes (such as Jones Bay) and the estuarine reaches of the rivers are critically affected by hydrological flows.

Table 3-6 Relative priority of wetland habitats when considering environmental flow requirements (appended in a modified form from Tilleard et al. 2009)

Wetland Habitat Type		Priority	Comment
Fringing wetlands	Freshwater wetlands	Very high	Wetting flows and flushes are known to be vital to wetland condition. Wetland condition is a crucial contributor to the overall value of the lakes system. Ecologically important flows are in the range that is significantly affected by river regulation.
	Variably saline (brackish) wetlands	Very high	
	Hypersaline wetlands	Moderate	Freshwater inflows are an important contributor to the condition of hypersaline wetlands but generally at a magnitude not significantly impacted by river regulation and diversion.
Main lakes/lagoons	Deep lakes	Moderate	Salinity from the entrance dominates environmental condition. Except for step climate change, deep lakes are likely to be relatively insensitive to likely changes in inflows.
	Shallow lakes: Jones Bay	High	The ecological condition of Jones Bay is vulnerable to changes in freshwater inflows. Jones Bay is in relatively good condition and is important to the value of the lakes system because it provides high quality fish and waterbird habitat.
	Shallow lakes: other	Moderate	Lake Wellington is important to the condition of its fringing wetlands however the lake has undergone a significant change in state which diminishes its value in the overall lakes system. The change is thought to be irreversible without dramatic intervention. Salinity from the entrance dominates the environmental condition of the remaining shallow lakes (North Arm and Cunninghame Arm). The median salinity of the Lake has also increased from about 4.6 to 8.1 ppt (~76per cent increase) as a result of reduced inflows as a result of existing river regulation and diversion.
Estuarine reaches of rivers		High	The length and location of the halocline is dominated by freshwater flows. Length and location of the halocline are thought to be important for fish breeding and for condition of bank vegetation and hence stability of estuarine reaches. The range of flows that are heavily impacted by river regulation and diversion have a strong physical and ecological influence on the estuarine river reaches.

The EWR study has also sought to define indicative thresholds for ecological conditions, which have been defined for:

- The fringing wetlands of Lake King and Lake Wellington (refer Table 4 within Tilleard et al. 2009).
- The estuarine river reaches of the major tributaries that flow into the site (refer Table 6 within Tilleard et al. 2009).
- The main lakes/lagoons (refer Table 8 within Tilleard et al. 2009).

Each of the threshold tables outline a range of quantifiable limits or flow objectives for maintaining ecological values of particular wetland features. While these form the basis for setting empirical limits of acceptable change (LAC), more detailed modelling and historical analysis at an individual waterway and/or wetland scale would be needed to assess the extent to which the required environmental flow objectives have been achieved or not achieved over time. This analysis is outside the scope of the current study but would be useful to consider as part of future studies that are currently being contemplated as part of further implementation of the EWR study.

Stage 2 of the EWR study (Tilleard and Ladson 2010) was completed as an addendum to the Stage 1 Scoping Study in 2010, with the selection of priority areas for investigation. These included: the Latrobe – estuarine river reach and freshwater and variably saline fringing wetlands including Sale Common, Dowd Morass and the Heart Morass; the estuarine reach of the Avon River and associated wetlands; the estuarine reach of the Mitchell River, Jones Bay and Macleod Morass; and the estuarine reaches of the Nicholson and Tambo Rivers and associated variably saline wetlands.

Outputs from the Stage 2 report have been considered as part of the ECD including the setting of LAC in Section 4.

3.6.2 Critical Process 2 - Waterbird Breeding Sites

Reasons for selection as 'critical'

The site supports habitat and conditions that are important for a variety of waterbird species at critical stages in their life cycles (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

Breeding habitat is identified within the site for a variety of waterbirds, including several species occurring in significant numbers.

Significant breeding sites within the Gippsland Lakes (based on NRE 1999a in Parks Victoria 2009; Peter Lawrence, Parks Victoria, *pers. comm*. 2010) include:

- Lake Coleman (east) and Tucker Swamp: Australian pelican (200 pairs); pied cormorants (numbers unknown but significant)
- Bunga Arm: little tern (25 pairs); fairy tern (three pairs); hooded plover (two pairs); Australian pelican (200 pairs)
- Macleod Morass: Australian white ibis (up to 300 pairs); straw-necked ibis (up to 300 pairs)
- Roseneath Wetlands: black-winged stilt (130 pairs)
- Sale Common: black swan (up to 500 pairs)
- Dowd Morass: large egret (50 pairs), little pied and little black cormorants (1000+ pairs), large black cormorants (two – 50 pairs), royal spoonbill (250 pairs); sacred ibis (1500 pairs); straw-necked ibis (1500 pairs); both rufous night heron and glossy ibis also breed in this wetland
- Lake Tyers: fairy tern (up to 40 pairs); little tern (up to 40 pairs).

Patterns in variability

There have been minimal studies to date that have sought to examine patterns and trends in waterbird breeding behaviour, frequency or success within the site. Notwithstanding, key controls on waterbird breeding usage of the site would include:

- Diversity of disturbance-free roosts and breeding sites that are spatially proximate to suitable feeding grounds (shorebirds, and terns mainly).
- Availability/quality of feeding sources such as the diversity and abundance of aquatic flora and invertebrate fauna (waterbirds generally).
- Densely vegetated permanent wetlands supporting submerged and emergent aquatic macrophytes, and fringing littoral vegetation (waterbird breeding habitat primarily, though also a key attribute for particular waterbirds as feeding habitat).

3.7 Supporting Processes

The supporting processes 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 processes. In this context:

- Supporting processes may operate over broad spatial scales and are not considered likely to be fundamentally altered by activities within the site.
- Some supporting processes are already partially covered by other critical components, processes or services/benefits.
- The supporting processes, while not critical, are important to wetland functioning and are noteworthy in this regard.

3.7.1 Climate

Reasons for selection

Key climatic processes that underpin the wetland values of the Gippsland Lakes 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

The climate of the Gippsland Lakes is temperate. In summer, the average maximum air temperature is about 24 degrees Celsius and the average minimum is 12 degrees Celsius. The average maximum temperature in winter is about 14 degrees Celsius and the minimum average ranges from three degrees to four degrees Celsius (obtained from the Bureau of Meteorology website: *www.bom.gov.au*).

Rainfall in the Gippsland Lakes catchment varies significantly from the coastal strip, where the lakes are located, to the upper catchment areas. This is due to the presence of the Great Dividing Ranges to the north, and the Strezlecki Ranges to the south of the Latrobe Valley. Rainfall across the site varies between 50 and 80 millimetres per month (around 700 millimetres annually) but with much higher rainfalls along the mountain ranges (situated north of the site) which affect hydrology and freshwater inflows into the site (Ecos unpublished). Rainfall is also naturally variable across the site along an east-west gradient, with more rainfall in the eastern lakes than in the western areas such as Sale Common (Paul Boon, *pers. comm*. 2009).

In general, Victoria has been subject to reduced rainfall over the past 13 years leading to drought conditions in many parts (State of Victoria 2010). Mean annual rainfall in Gippsland has also been somewhat reduced in recent years, leading to lower than normal base flows in the river systems. Murphy and Timbal (2007) undertook analysis of climate data for south-eastern Australia and conclude that during the last decade, the mean rainfall has been 14.1 per cent below the climatological (1961–1990) mean. While this should be considered part of the background variability in rainfall, the 1997-2006 drought was significant and affected flows to the Lakes.

As climate change occurs, 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.

3.7.2 Geomorphology

Reasons for selection

The geomorphology of the site underpins the diversity of wetlands types and waterbodies present. Geomorphological processes such as bathymetry and sediment transport are an important determinant of habitat structure and associated flora and fauna communities that use the site. Maintenance of these natural geomorphological processes are important for ensuring the biotic vales of the Ramsar site can be maintained over time.

Description

Gippsland Lakes is a system of coastal lagoons sheltering behind sandy barriers. The present coastal morphology has taken shape since the Late Pleistocene. Three barriers were recognised by Bird (1961). These include a 'prior' barrier that stands to the north of the Lakes beneath the former sea cliff, an 'inner' barrier that occurs north of Lake Reeve and an 'outer' barrier that lies to seaward (includes Ninety Mile Beach). Each barrier is surmounted by beach ridges and dunes. Development and maintenance of this landform is promoted by small tidal ranges, abundant sand supply, and very slow or no relative sea level change (Bird 1967).

The system is linked to the sea by an artificial entrance near the eastern end, opened in 1889, where the town of Lakes Entrance is now situated. Saline intrusion into the system has occurred as a consequence of the permanent entrance, with the freshwater systems replaced by marine, estuarine and brackish habitats (and in some areas hyper-saline environments). Today, saline intrusion in the lakes can extend throughout the system. During periods of drought or low freshwater inflows, ocean salinity can penetrate well up into the river reaches.

The geomorphology of the site provides for a broad range of wetland/waterbody forms. These include: periodically inundated palustrine marshes; permanently inundated palustrine marshes; shallow lacustrine (lake) features; deep lacustrine features; coastal lagoons with narrow inlets; and broad embayments. The site also includes the lower reaches of several riverine environments, including a large reach of the Nicholson River which feeds into Jones Bay.

The soils within the catchment to the Gippsland Lakes are diverse, reflecting the great variety of rock and unconsolidated sediments, landforms, climates and vegetation, as well as varied ages of soil development (Aldrick et al. 1984). The soils found in the Gippsland Lakes Ramsar site are mostly relatively young and associated with dunes and Holocene sediments (Ecos unpublished).

Specific aspects of the geomorphology include bathymetry and sediment transport processes which are discussed below.

3.7.2.1 Bathymetry

The bathymetry of Gippsland Lakes is highly varied and includes shallow mudflats and sand banks that can be exposed as water levels in the lakes drop due to ocean mean sea level influences. Figure 3-15 illustrates the bathymetry of the lakes, highlighting the significant variability in depth throughout the system. Lake Wellington is quite shallow areas (two to three metres deep), as are other areas in the lakes (Jones Bay in Lake King, the western end of Lake Victoria, and between Barrier Landing and Kelly Head). The deepest areas, down to 10 – 12 m deep, occur in the central sections of Lake Victoria and Lake King (south of the Silt Jetties), and in Reeve Channel. In these deeper areas (greater than five metres), saline stratification can develop, and is considered one of the major influences on the occurrence of bottom hypoxia (low dissolved oxygen conditions) in these areas (Grayson et al. 2001, Ecos unpublished).

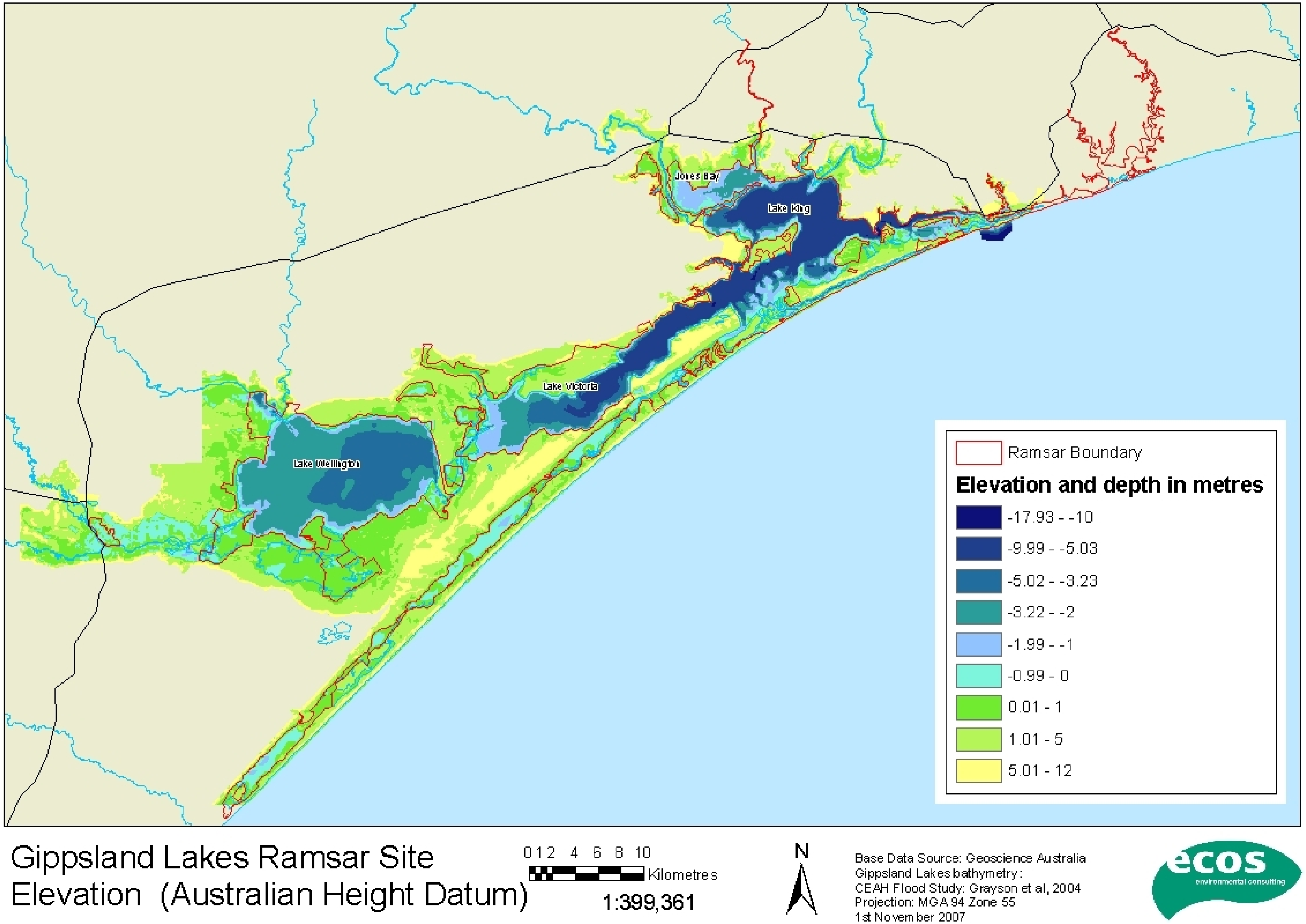


Figure 3-15 Gippsland Lakes bathymetry (after Grayson et al. 2001) reproduced from Ecos unpublished

3.7.2.2 Sediment Transport Processes

Marine sediment transport processes at Lakes Entrance and Lake Tyers

At Lakes Entrance sand is moved between the offshore bar and the internal channel and sand shoals of the site on a daily basis by the tide. Breaking waves cause seabed sediments to become suspended in the water and, if the tide is rising, then the tidal current will carry the water containing the suspended sediments into the lake system (Coastal Engineering Solutions 2003). On the ebbing tide a similar process occurs whereby sand is picked up from the channel between Bullock and Rigby Islands and transported out through the entrance channel. Entrainment of sand will depend on the tidal current velocities being high enough to initiate sediment motion (Coastal Engineering Solutions 2003).

Coastal Engineering Solutions (2003) estimated that the volume of sand that needs to be pumped off the bar channel system to maintain a navigable channel with a nominal depth of three metres is between 100 000 and 500 000 cubic metres per year. Based on advice from Lawson and Treloar, Jesz Flemming and Associates (2004) indicated that the mean accumulation rate was 130 000 cubic metres per year. However, the most recent estimate by Lawson and Treloar (2004) was that maintenance of the channel at a depth of three metres requires annual dredging of approximately 93 000 cubic metres during a moderate wave climate over a period of 75 days.

In Lake Tyers, deposits of fluvial sediment over time have resulted in the formation of mud banks near the mouth of the main lake, with the substrate covered by fine grained sands. Formations near the mouth of Lake Tyers also appear to have changed with deeper holes slowly disappearing and the main channel also becoming shallower (Fisheries Victoria 2007). The entrance to Lake Tyers is periodically closed by a sand bar, and may open naturally as a result of floods in the catchment.

Sediment transport processes within the Gippsland Lakes system

Sediment transport processes within the Gippsland Lakes system are not well understood, noting that landward bedload transport in the form of sand waves was observed by King (1981) in the inner channels from Lakes Entrance. Discussion in Ecos (unpublished) indicates that major flood events are likely to have sufficient power to significantly scour and redistribute coarse sediment in the channels. Wind is likely to be a key driver of sediment resuspension particularly in the more sheltered, shallow lakes.

The primary source of sediment input into the western lakes is from catchment sources. In the estuarine reaches of rivers/streams entering Gippsland Lakes, some infilling may occur following flood events but has not been identified as a major threat (Ecos unpublished).

Water quality data analysed by Grayson et al. (2001) indicate that sediment loads from the western catchments (discharging to Lake Wellington) deliver two to three times the nutrient and sediment loads than from the eastern catchments (Mitchell, Nicholson and Tambo Rivers). Total estimated loads of total suspended solids (TSS) to Lake Wellington are in the order of 165 000 tonnes per year whereas Lake King and Lake Victoria only receive 45 000 and 8500 tonnes per year respectively (Grayson et al. 2001). Lake Tyers whose estuary catchment is forested and lies within existing or proposed Forest Parks, State Forests or State Parks does not suffer the same degree of catchment erosion and sediment deposition as some other Gippsland lagoons (Fisheries Victoria 2007).

3.7.3 Shoreline and Coastal Processes

Reasons for selection

Shoreline and coastal processes influence habitat structure and vegetation communities that fringe the main lakes through natural processes of erosion of accretion. The shoreline and coastal processes of most significance to Gippsland Lakes are shoreline stability, erosion and accretion.

Description

Shoreline and coastal processes within the Gippsland Lakes have changed considerably since creation of the permanent opening at Lakes Entrance in the late 19th century. However, since listing of the site in 1982, the shorelines around the Gippsland Lakes have remained relatively stable (Sjerp et al. 2002).

Shorelines in Gippsland Lakes are influenced primarily by wave action. When the prevailing westerly winds are blowing, water levels in the eastern Gippsland Lakes will rise and in combination with wind-driven waves, will create erosion of the deltaic shoreline. By contrast, strong easterly winds will produce little shoreline erosion (Bird and Rosengren 1971). Scour of channels and the neighbouring coastline can occur during catchment flooding events as a result of current action. Floods and coastal storms also can have the effect raising water levels in the lakes, which as discussed above creates conditions favourable for shoreline wave erosion.

The presence of fringing vegetation along the margins of the lakes maintains shoreline stability as well as providing habitat for waterbirds and other wetland fauna. *Phragmites australis* once formed extensive fringing reedbeds around the Gippsland Lakes and was first noted to be in decline as early as 1922. By 1961 it became clear that die-back of *Phragmites* in Lake King, Lake Victoria and to a lesser extent in Lake Wellington was a response to the increased frequency and duration of higher salinity levels in the Lakes as a result of the permanent opening at Lakes Entrance. The initial loss of fringing *Phragmites australis* reedbeds was a marked event, giving the impression of a high erosion rate, but having receded to the backing *Melaleuca ericifolia* thickets, shoreline recession now appears less rapid, probably due to the sand/peat substrate being more robust (Sjerp et al. 2002).

Comparison of aerial photographs by Sjerp et al. 2002 (as discussed in Ecos unpublished) spanning 1935 to 1997 demonstrate that the vast majority of shorelines are eroding at an average of less than 0.1 metres per year. However, the deltas on the Latrobe, Avon, Mitchell and Tambo Rivers and on McLennan Strait all show evidence of continuing erosion as do particular locations such as Roseneath Point, Swell Point, Storm Point, Clydebank Morass and the northern shores of Jones Bay.

Evidence of shoreline accretion are reported as rare; the largest being several metres along the sandy eastern shores of Lake Wellington, north of McLennan Strait (Sjerp et al. 2002).

A range of structures including sea walls, rock rubble and timber groynes have been established to protect selected eroding areas, although the vast majority of the Gippsland Lakes shoreline remains in a natural state (Ecos unpublished).

3.7.4 Water Quality

Reasons for selection

Water quality within the wetlands of the Gippsland Lakes Ramsar site regulates the use of habitat by flora and fauna. The key parameter is salinity although dissolved oxygen, nutrients and pH are also important. Nutrients and sediments (total suspended solids and turbidity) in particular play a key role in the main lakes/lagoons in terms of production of algal blooms (see discussion on 'Nutrient Cycling' in next section).

Description

In characterising the water quality of the Ramsar site, water quality monitoring data was obtained from the EPA Victoria from five monitoring sites within Lakes Wellington, Victoria and King (Figure 3-16). The dataset consists of two main monitoring periods: (1) data from 1976 to 1980 from the Victoria State Rivers and Waters Commission (not longer existing) and (2) data from 1986 to present from the Victoria EPA fixed monitoring sites. No data exists from these five sites between 1980 and 1986. Data for catchment flow into the Gippsland Lakes was sourced from the Gippsland Catchment Management Authorities.

The periods 1976 to 1980 (pre-Ramsar listing) and 1986 to 2008 (Ramsar period) were analysed separately by calculating the minima and maxima values, and the 10th, 20th, 50th, 80th and 90th percentiles. The analysed parameters represent surface water measurements (0.5 metre water depth) and include salinity, pH, dissolved oxygen concentration, per cent saturation of dissolved oxygen, total suspended solids, total nitrogen, total phosphorus and chlorophyll *a*.

Where applicable, the calculated values were compared to the guideline values listed in Water of Victoria Schedule F3 (Gippsland Lakes and Catchment, No. S13, Gazette 26/2/1988). The guideline values listed in Schedule F3 differ between Lake Wellington and the eastern Gippsland Lakes. Schedule F3 uses minimum values, 50th and 90th percentiles as water quality objectives.

Total nitrogen, total phosphorus and chlorophyll *a* are not listed in Schedule F3 and therefore the ANZECC (2000) guideline values for southeast Australian estuarine systems were adopted for these parameters. The ANZECC guidelines use the 20th and 80th percentiles as lower and upper low-risk trigger values.

Water quality time series plots and the summed catchment flow discharging into the Gippsland Lakes is shown for Lake Wellington in Figure 3-17 and for the eastern Lake Victoria in Figure 3-18. Table 3-7 and Table 3-8 show the calculated percentiles and comparison to guideline values for Lake Wellington and the eastern Lake Victoria sites, respectively.

The patterns observed in the water quality time series for the remaining three monitoring sites were similar to the eastern Lake Victoria site and are provided in Appendix B.

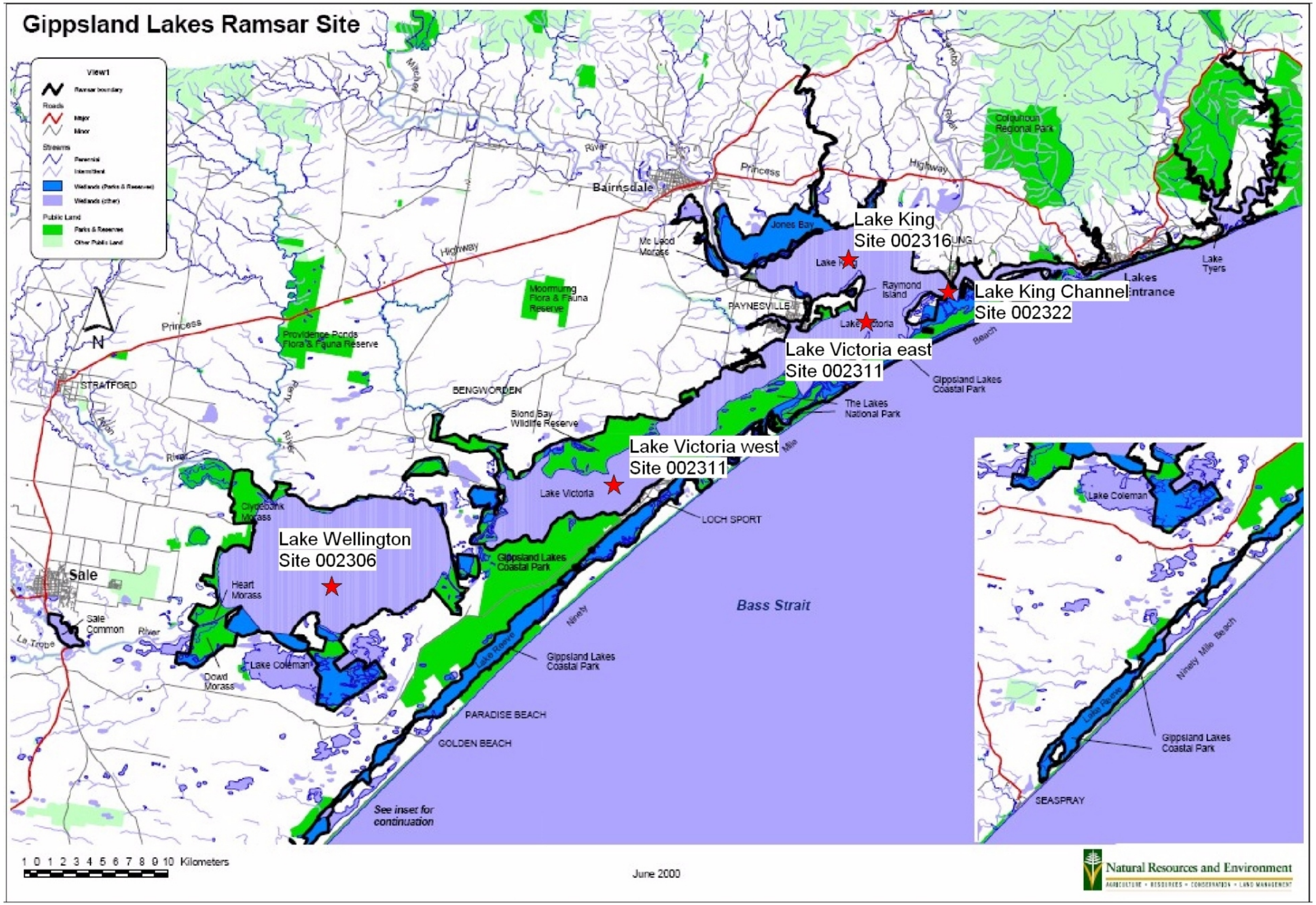


Figure 3-16 Locations of EPA water quality monitoring sites in the Gippsland Lakes (source: DSE)

3.7.4.1 Lake Wellington Water Quality

The water quality in Lake Wellington is strongly determined by flows entering the lake from the catchment (Figure 3-17). About one third of river flows in to the Gippsland Lakes and over half of the total nutrient load is supplied to Lake Wellington from the western rivers (mainly the Latrobe, Thomson and Avon Rivers. Due to these high catchment inflows and its distance from the Lakes Entrance in the east, Lake Wellington is less saline than the eastern lakes. Salinities are generally higher during years of low flow compared to lower salinities observed during high flow years (Figure 3-17). Correspondingly, increased input of sediments and nutrients during high flow years is reflected in higher concentrations of total suspended solids, total nitrogen and total phosphorus during these periods (Figure 3-17). As expected, the higher nutrient availability during high flow years ensues in higher chlorophyll *a* concentrations in the water column. Dissolved oxygen concentrations vary seasonally with higher concentrations during the cold winter months and lower concentrations during the warm summer months, most likely due to increased oxygen solubility with decreasing temperatures.

The comparison of ambient water quality against the relevant water quality guidelines from the SEPP in Table 3-7 show general conformance with the guideline values for the variables analysed noting exceedances have been observed for salinity, pH, nutrients and chlorophyll *a*. The increase in the median values of nutrients such as phosphorous over time are an indication of an increasingly eutrophied system. For further information refer Appendix B.

3.7.4.2 Eastern Lakes Water Quality

Time series of water quality parameters for eastern Lake Victoria and total catchment inflow are shown in Figure 3-18 (refer to Appendix B for time series of the other monitoring stations, including Lake King). Salinities are generally greater in the eastern lakes compared to Lake Wellington due to their proximity to the Lakes Entrance. As observed for Lake Wellington, salinities in the surface water of the eastern lakes are generally higher during years of low flow and lower during high flow years. Concentrations of suspended solids, total nitrogen and total phosphorus are not as clearly related to flow compared to observations from Lake Wellington. Dissolved oxygen concentrations generally follow a seasonal pattern with higher concentrations during the colder months due to increased oxygen solubility. Relatively low oxygen concentrations during some occasions may have been caused by mixing events with hypoxic bottom water, while particularly high oxygen concentrations may in part be attributable to high oxygen production during periods of algal blooms (Figure 3-18).

The comparison of ambient water quality against the relevant water quality guidelines in Table 3-8 show general conformance with the guideline values noting exceedances have been observed for pH, dissolved oxygen, nutrients and chlorophyll *a*. For further information refer Appendix B.

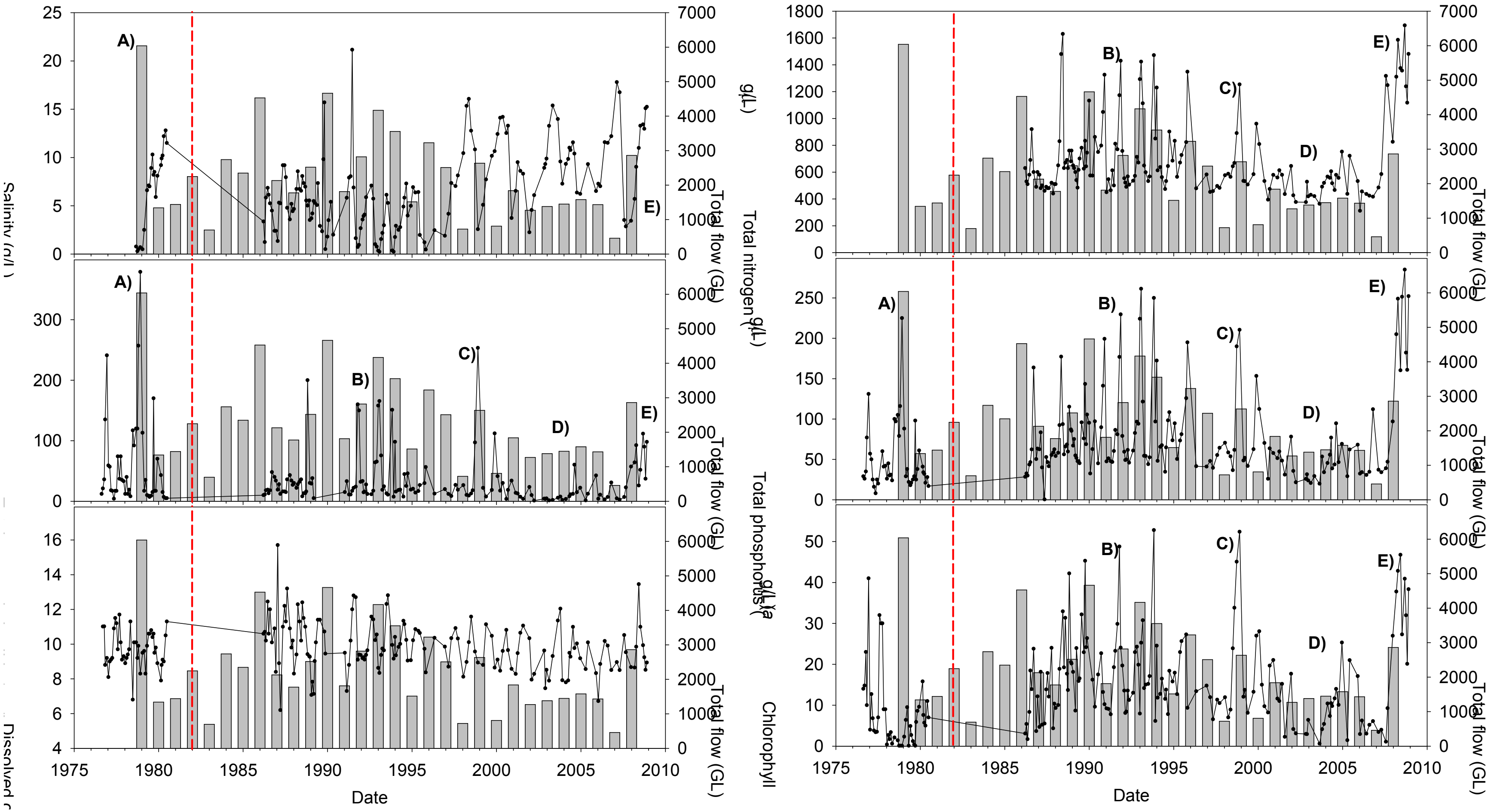


Figure 3-17 Lake Wellington surface water quality data (EPA monitoring site 002306)

Note: Total flow represents the summed flow recorded for all major catchment rivers and is given as hydrological year (June-May). Red dotted line denotes listing of Gippsland Lakes as Ramsar wetland in 1982. Refer to Appendix B for information on notable events A-E shown on the graphs.

Table 3-7 Lake Wellington surface water quality parameters and guideline values from EPA site 002306

Note: Orange and red colour represents slight and distinct exceedance of guideline trigger limits, respectively. Note that the ANZECC guideline values are representative of the broad southeast Australia estuaries and not specific to the Gippsland Lakes. It should be noted exceedance of the ANZECC Guidelines do not necessarily relate or otherwise equate to an Ecological Character Change – refer Limits of Acceptable Change in Section 4.

	Minimum		Maximum		10th percentile		20th percentile		50th percentile		80th percentile		90th percentile		Guideline	Source
	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008		
Salinity (g/L)	0.3	0.2	12.8	21.2	0.5	1.8	0.8	2.9	8.1	6.1	10.2	10.4	11.5	13.2	8	Waters of Victoria
pH	6.8	6.8	8.6	9.1	7.1	7.4	7.2	7.6	7.8	8.0	8.1	8.3	8.2	8.5	6-9	Waters of Victoria
Dissolved oxygen (mg/L)	6.8	6.2	11.7	15.7	8.5	8.3	9.0	8.7	9.6	9.7	10.6	11.0	11.1	11.6	6	Waters of Victoria
Dissolved oxygen (per cent saturation)		71.0		149.6		92.9		95.7		102.3		110.4		117.0	60	Waters of Victoria
Total suspended solids (mg/L)	4.0	0.9	379.0	253.3	7.4	4.6	11.6	10.0	21.0	18.7	96.2	39.6	129.0	74.5	25/80	Waters of Victoria
Total nitrogen (µg/L)		311.3		1693.9		451.6		490.0		587.1		830.0		1248.0	300	ANZECC
Total phosphorus (µg/L)	8.0	0.4	225.0	285.0	20.3	32.5	24.6	41.8	33.0	60.4	77.8	96.9	99.4	172.4	30	ANZECC
Chlorophyll a (µg/L)	0.1	0.6	41.0	52.8	0.2	4.2	1.4	7.8	5.7	13.8	11.3	24.0	20.1	31.2	4	ANZECC

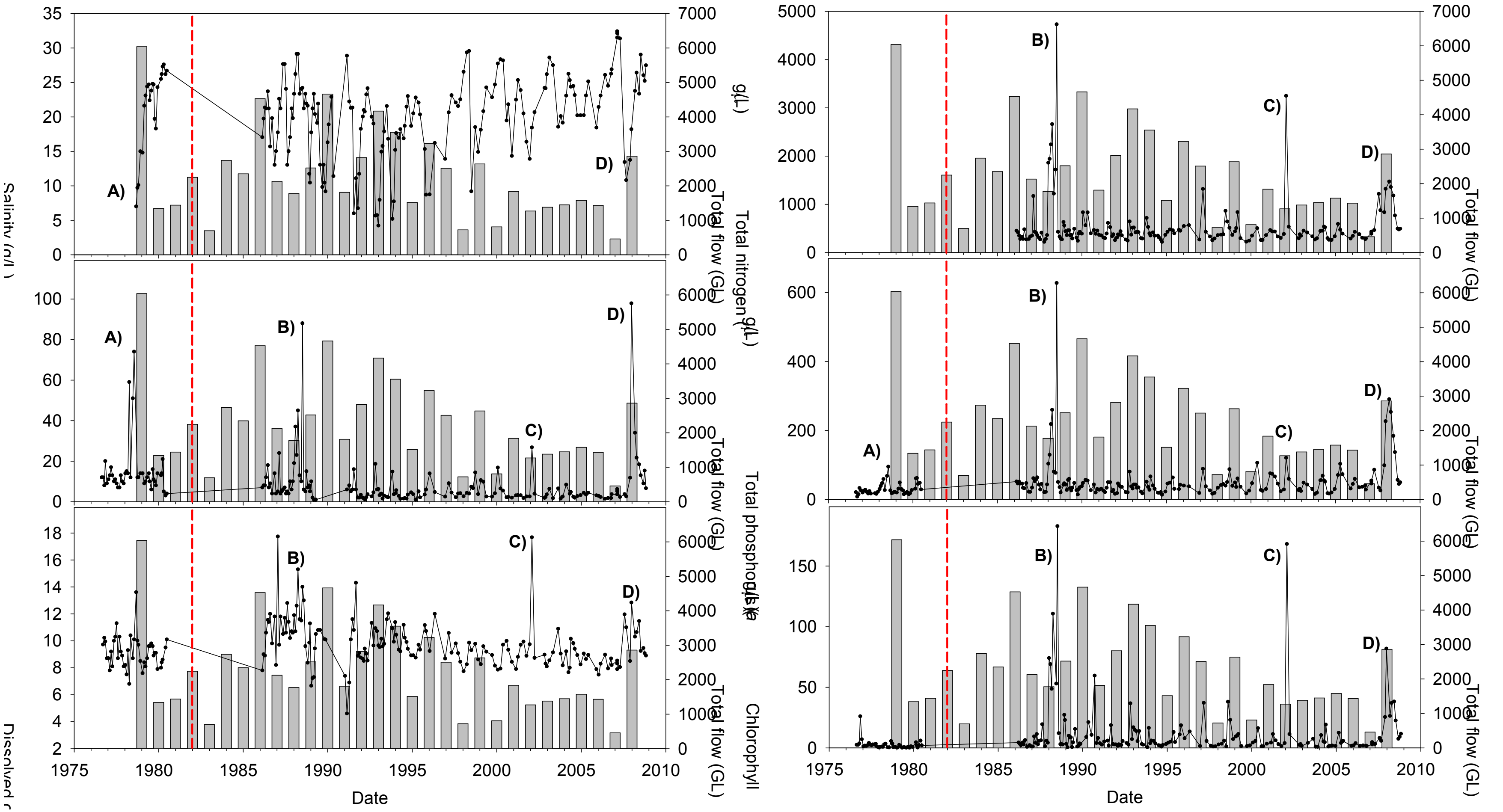


Figure 3-18 Eastern Lake Victoria surface water quality data (EPA monitoring site 002314)

Note: Total flow represents the summed flow recorded for all major catchment rivers and is given as hydrological year (June-May). Red dotted line denotes listing of Gippsland Lakes as Ramsar wetland in 1982. Refer to Appendix B for information on notable events A-D shown on the graphs.

Table 3-8 Eastern Lake Victoria surface water quality parameters and guideline values from EPA site 002314

Red colour represents exceedance of guideline trigger limits. Note that the ANZECC guideline values are representative of the broad southeast Australia estuaries and not specific to the Gippsland Lakes. It should be noted exceedance of the ANZECC Guidelines do not necessarily relate or otherwise equate to an Ecological Character Change – refer Limits of Acceptable Change in Section 4.

	Minimum		Maximum		10th percentile		20th percentile		50th percentile		80th percentile		90th percentile		Guideline	Source
	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008		
Salinity (g/L)	7.0	4.2	27.6	32.4	10.6	11.2	15.7	15.2	24.1	21.2	26.1	24.5	26.7	27.5	N/A	
pH	7.5	7.4	8.5	9.4	7.8	7.9	8.0	8.1	8.2	8.3	8.3	8.5	8.4	8.7	6.5-8.5	Waters of Victoria
Dissolved oxygen (mg/L)	6.8	4.6	13.6	17.7	7.9	8.0	8.2	8.5	9.1	9.4	10.0	10.9	10.3	11.6	6	Waters of Victoria
Dissolved oxygen (per cent saturation)		60.9		240.2		97.4		100.4		109.8		121.5		132.6	75	Waters of Victoria
Total suspended solids (mg/L)	3.0	1.0	74.0	97.8	7.0	1.8	9.0	2.3	12.0	4.2	14.0	9.2	18.8	15.2	25/80	Waters of Victoria
Total nitrogen (µg/L)		218.9		4730.0		270.0		295.7		393.7		526.7		834.4	300	ANZECC
Total phosphorus (µg/L)	8.0	13.8	95.0	627.2	16.3	20.5	18.0	26.0	25.5	40.0	41.4	57.7	56.0	80.5	30	ANZECC
Chlorophyll a (µg/L)	0.1	0.5	26.0	182.9	0.3	1.4	0.4	1.9	1.7	4.3	3.3	12.9	4.3	24.0	4	ANZECC

3.7.5 Nutrient Cycling, Sediments and Algal Blooms

Reasons for selection

As outlined above, the Gippsland Lakes are characterised by highly episodic delivery of nutrients to the system due to typically large year-to-year variation in rainfall and, hence, varying river discharge from the catchment. The residence time of water in the Gippsland lakes system is long and CSIRO (2001) estimated the average flushing time of the Gippsland lakes (defined as volume of the lakes divided by net freshwater input) to be an average of 206 days between 1975 and 1999. Tidal flushing is minimal due to the relatively low tidal amplitude of the region and the single, narrow lakes entrance.

Nutrient loads to the system from catchment flows are high enough to stimulate growth of phytoplankton blooms, which are regularly observed in the Gippsland Lakes. Aside from external supply of nutrients from the catchment, another important internal source of nutrients supporting phytoplankton growth is the sediments in the Gippsland Lakes.

Description

The description of this supporting process can be separated into: (i) the role of sediments; (ii) nutrient cycling; and (iii) algal blooms.

3.7.5.1 Role of Sediments

In shallow coastal systems such as the Gippsland Lakes, the relatively long residence time of the water (low flushing rates) and episodic input of nutrients mean that benthic recycling and exchanges between sediment and water column play a critical role for nutrient cycling (CSIRO 2001, Cook et al. 2008).

Most of the algae produced in the Gippsland Lakes are eventually mineralised (decomposed) in the sediments, which is typical for shallow aquatic systems. Microbial processes in the sediment decompose the organic matter that is sinking to the lake bottom and eventually mineralise the organic matter to CO_2 and inorganic nutrients, such as ammonium and phosphate. While oxygen is available to sediment bacteria, organic matter is preferentially mineralised aerobically and oxygen is consumed in the process. Aerobic mineralisation is the most effective and fastest way of breaking down organic matter. Furthermore, when oxygen is available to sediment bacteria, the ammonium produced by organic matter mineralisation can be rapidly oxidised to nitrate by the microbial process of nitrification, an integral part of the nitrogen cycle in aquatic systems.

Due to the consumption of oxygen in the sediment by aerobic mineralisation, oxygen is usually only available in the uppermost millimetres of the sediment and needs to be constantly replenished from the overlying water column. Bacteria living in deeper, anoxic layers of the sediment need to mineralise organic matter by anaerobic processes, using electron acceptors other than oxygen. The nitrate produced by nitrification is one of these alternative electron acceptors that can be used by bacteria living in the transition zone between oxic surface sediment and anoxic deeper sediment for mineralisation of organic matter. This anaerobic mineralisation process is known as denitrification and leads to a transformation of the nitrate to N_2 gas as an end-product (similar to gaseous CO_2 as an end product of aerobic mineralisation). The processes of nitrification and denitrification are often closely coupled in sediments. One of the most important consequences of this coupled nitrification/denitrification process is that nitrogen is effectively removed from the system through the production of N_2 gas, which is released from the system into the atmosphere. High denitrification rates are generally a good indicator of healthy ecosystem function of estuaries and lagoons such as the Gippsland Lakes and support the self-cleansing of the system by removal of excess nitrogen.

In contrast to nitrogen, there is no stable gaseous end-product of phosphate produced during aerobic and/or anaerobic organic matter mineralisation or other sedimentary processes. Phosphate is generally recycled internally within the ecosystem and the primary mechanism of its removal is by burial. When oxygen is present, a large fraction of the mineralised phosphate is readily adsorbed onto iron-oxides and iron-oxyhydroxides at the oxidised sediment surface and is therefore trapped as particles within the sediment (Howarth et al. 1995). However, this reaction is reversible and phosphate can be released from the sediment as soon as the sediment becomes anoxic. Phosphate release from the sediments may be exacerbated by sulfate reduction. Sulfate reduction is an anaerobic microbial process using sulfate instead of oxygen for the mineralisation of organic matter. This process is relevant in estuaries with marine influence, as seawater and sediment porewater have high concentrations of sulfate. Indeed, porewater profiles of sulfate/chloride ratios indicate that sulfate reduction occurs in sediments of the Gippsland Lakes (Longmore and Roberts 2006). The sulfide produced during sulfate reduction leads to the dissolution of iron-oxyhydroxides and ensuing release of phosphate from the sediment into the water column (Jensen et al. 1995, Howarth et al. 1995).

The important role of the Gippsland Lakes sediments for nutrient cycling is highlighted by the fact that sediments down to 20 centimetres hold very large stores of nitrogen and phosphorus, which can be more than 70 times the annual catchment loads (Longmore and Roberts 2006). The largest pools of ammonium and phosphate were found in Lake Victoria, comprising about 50 per cent of the total nutrient pool for the Gippsland Lakes. Monbet et al. (2007) demonstrated that about 85 per cent of the phosphorus in the sediment of Lake Wellington and Lake Victoria is stored in relatively labile fractions and is therefore immediately or potentially available for primary production. The immediately bioavailable forms of nutrients in the Gippsland Lakes sediments were estimated to be equivalent to four years (ammonium) and one and a half years (phosphate) of external catchment input (Longmore and Roberts 2006).

3.7.5.2 Nutrient Cycling in the Gippsland Lakes

In terms of nutrient cycling Lake Wellington differs markedly from Lakes King and Victoria (CSIRO 1998, CSIRO 2001), which is mainly caused by differences in circulation patterns and water column stratification. While Lake Wellington is very shallow with an average depth of 2.6 metres and is well mixed both vertically and horizontally, Lakes King (5.4 metres) and Victoria (4.8 metres) are deeper with maximum depths of up to 10 metres and are generally characterised by periodic salinity stratification (layering) of the water column (CSIRO 2001). This salinity stratification is particularly pronounced during wet years, when freshwater from river inflow overlays the denser, higher salinity bottom water of Lakes King and Victoria.

Lake Wellington

Inputs of dissolved nitrogen (ammonium, nitrate) from the catchment are usually rapidly assimilated by the phytoplankton resulting in very low dissolved nitrogen concentrations in the water column (CSIRO 2001). Due to the highly episodic input of nutrients from the catchment, phytoplankton growth is primarily supported by release of nutrients from the sediment during summer and drought periods with low base loads. Owing to the narrow McLennan's Strait, Lake Wellington is poorly flushed during periods of low flow. However, the well mixed water column of this shallow lake means that enough oxygen is supplied to the sediments. Coupled nitrification/denitrification rates are therefore expected to be high, constituting an important sink for nitrogen introduced from the catchment (CSIRO 2001).

The well oxygenated water column and surface sediments may result in the trapping of large amounts of phosphate within the sediment by adsorption to iron-oxides and iron-oxyhydroxides. Indeed, CSIRO (2001) found it necessary to include a 30 per cent burial term for the total phosphorus load in Lake Wellington to render the modelling consistent with observations. The rest of the total phosphorus load is exported to Lake Victoria.

Although CSIRO (1998) state that Lake Wellington appears to be phosphorus limited, nitrogen appears more likely to be the limiting nutrient for Lake Wellington. While the ratio of total nitrogen to total phosphorus (19:1 by atoms) suggests slight phosphorus limitation for phytoplankton, inorganic nitrogen is rapidly depleted in the water column of Lake Wellington, while measured phosphate concentrations in surface water are generally at levels not limiting phytoplankton growth (CSIRO 2001). Probably most importantly, coupled nitrification/denitrification in the well oxygenated surface sediments acts as an important sink for nitrogen, which likely outweighs the internal sinks for phosphorus (CSIRO 2001, WBM 2005).

Lake King and Lake Victoria

Nutrient cycling is more complex in Lakes King and Victoria, primarily due to the alternating stages of a mixed and stratified water column. The periods of water column stratification are characterised by limited exchange between bottom and surface water, which frequently leads to periodic hypoxia (low oxygen concentrations) and accumulation of high nutrient concentrations in the bottom water of the Lakes (Bek and Bruton 1979, CSIRO 2001). When freshwater inflows are reduced during summer, mixing events can break up the stratification and the built-up nutrients will be available for phytoplankton production in the surface water (CSIRO 1998).

During periods of water column stratification, the limited vertical exchange within the water column means that oxygen cannot be replenished in the bottom water layer. Ongoing mineralisation processes in the sediment eventually lead to bottom water hypoxia or anoxia, as is frequently observed in Lakes King and Victoria. This has major implications for the nutrient cycling in these lakes. During periods of hypoxia, the sediment may become anoxic up to the sediment surface. This leads to a breakdown of the coupled nitrification/denitrification process (nitrification requires oxygen) and ammonium is released from the sediment in high concentrations instead of being removed from the system (CSIRO 1998). Furthermore, large quantities of phosphate are released from the large semi-stable iron-oxyhydroxide stores in the sediment (CSIRO 2001). Ammonium and phosphate accumulate in the bottom water and are available for phytoplankton growth after mixing events.

The described cycling of nutrients in Lakes King and Victoria has major implications for the development of toxic blue green algae blooms (for example, cyanobacteria *Nodularia spumigena*), which are a recurring problem for the Gippsland Lakes (Stephens et al. 2004). In a study evaluating catchment flow and water quality data from the last 30 years, Cook et al. (2008) described the sequence of events leading to a typical *Nodularia* bloom:

- High river flow during winter (June-September) introduces high concentrations of dissolved inorganic nitrogen to the lakes, which can trigger blooms of diatoms and/or dinoflagellates. The total nitrogen (TN) to total phosphorus (TP) ratio from catchment inflow is typically around 20 (CSIRO 2001).

- The rapid depletion of nutrients in the water column and ensuing collapse of the bloom results in sedimentation of the dying algae to the lake sediment, where they are mineralised.

- Nutrients with a greatly reduced ratio of N:P are released from the sediment via two mechanisms: a) a substantial fraction of the released nitrogen is initially lost via coupled nitrification/denitrification in the sediment, and b) high mineralisation rates of the sediment eventually leads to low bottom water oxygen concentrations and ensuing release of stored phosphorus from the sediment.

- Loss of nitrogen via denitrification and release of high concentrations of phosphate from the sediment shifts the TN:TP ratio to about six. This ratio indicates strong nitrogen limitation, which highly favours growth of cyanobacteria like *Nodularia*. These algae are able to derive nitrogen for their growth from fixing N_2, which is dissolved within the water column. Cyanobacteria often dominate systems with N.P ratios of less than 15 (Paerl 2008).

- Strong stratification in high flow years results in accumulation of nutrients with low N:P ratio in the bottom water of Lakes King and Victoria throughout late spring and summer, when warm conditions favour *Nodularia* growth.

- The following mixing events during summer combined with low salinity surface waters (15-20 PSU) ultimately trigger the *Nodularia* bloom.

The described sequence in the nutrient cycling and associated lowering of the N:P ratio of nutrient input from the catchment supports previous observations that nitrogen is the limiting nutrient in Lakes King and Victoria (CSIRO 1998, CSIRO 2001, WBM 2005).

However, it should be noted that nutrient cycling processes differ between lagoons, and within lagoons over time. Ecos (unpublished) describes the following key differences between the main lagoons:

- **Lake Wellington** – Ecos (unpublished) argue that nitrogen (N) is probably more limiting than phosphorus due to competition for inorganic forms of nitrogen, and rapid depletion of available N via sediment nitrification – denitrification processes.

- **Lakes King and Victoria** – Ecos (unpublished) suggest that nitrogen is the predominant control of algae in these lakes. They argue that when the lakes (particularly Lake King) becomes stratified, bottom waters become more readily anoxic, leading to sediment nitrification – denitrification processes being less efficient. The anoxic sediments are likely to facilitate substantial fluxes of ammonium to the overlying water column, which can be taken up by dinoflagellates which can migrate through the water column (and into well lit upper waters).

Ecos (unpublished) also note that phytoplankton in Gippsland Lakes can also become phosphorus limited under some conditions.

Relevant to this point, between 2007 and through the winter of 2008, an unprecedented bloom of the cyanobacteria *Synechococcus* developed within the system. Cook et al. (2008) suggested that the bloom was caused by extremely high nutrient loads (particularly nitrate) entering the lakes in the 2007 flood, which followed the 2006-2007 fires. Cook et al. (2008) predicted that future blooms could be avoided providing catchment nitrogen inputs did not elevate to similar levels.

3.7.5.3 Algal Blooms

As mentioned above, algal blooms have historically been observed in several waterways throughout the Gippsland Lakes area over the past two centuries. Details of algal blooms recorded over the past several decades are presented in Table 3-9 below (after Stephens et al. 2004). More recent accounts of algal blooms include 2004 (Cook et al. 2008) and 2007-2008 (Beardall 2008) already discussed.

Table 3-9 Reports of algal blooms in the Gippsland Lakes (after Stephens et al. 2004)

Date	***Details of bloom***	***Previous flood***
July 1965	*Nodularia* bloom in Lake Wellington after bushfires and heavy rain	
March 1971	*Microcystis* bloom in Lake Wellington	January-February 1971, major
May 1971	Lake King, dinoflagellate dominated Lake Victoria diatom dominated, *Nodularia* present Lake Wellington *Nodularia*/diatom-dominated *Nodularia* dominant in Bunga Arm	
February 1974	*Nodularia* bloom Lakes King and Victoria	August 1973
October 1984	Minor non-specified bloom in Lakes Victoria and Wellington	July 1984, moderate
January 1986	*Anabaena* bloom in Lake King	December 1985
February 1987	*Nodularia* bloom in Lake King	October 1986
August 1987	Non-specified bloom in Lake Victoria	July 1987, minor
December 1987 to April 1988	*Nodularia* bloom in Lake Victoria	
December 1988	Dinoflagellate bloom in Lake Victoria	November 1988, moderate
July 1989	*Nodularia* bloom in lakes	
December 1989	*Nodularia* bloom in east Lake Victoria and south Lake King	July 1989, minor
July 1990	Unspecified bloom in Lake King North	April 1990, major
September 1990	Unspecified bloom in lakes King South and Victoria	
January 1993	*Microcystis* bloom in Jones Bay/Lake King	September and December 1992, major
January 1996	Unspecified bloom in Lake Victoria	October 1995, major
May 1996	*Nodularia* bloom in Lake King	
February 1997	*Nodularia* bloom in Lake King	July to October 1996, minor

3.7.6 Biological Processes

Reasons for selection

Biological processes describe any process occurring within, or being facilitated 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 within the Gippsland Lakes Ramsar site.

Description

The following is a brief overview of some of the key biological processes operating at a whole of site scale.

Energy and nutrient dynamics

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 an freshwater macrophytes (seagrass, mangroves, saltmarsh, freshwater marshes), which with few notable exceptions (for example, 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). Carbon flows in freshwater wetlands are not well known and require further investigation, although freshwater marshes are recognised as important sinks for carbon as they actively accumulate organic matter.

In the context of energy flows through the ecosystem, some energy is lost during microbial respiration, some is leached as dissolved organic material into the water, some is incorporated into microbial biomass, and some may be transformed to other organic compounds not incorporated in microbial cells. Of particular importance to higher trophic levels (that is, consumers) is the conversion of detrital material into bacterial biomass, which is then in a bio-available form for animals (Day et al. 1989). Microbes also affect energy flow by using dissolved organic matter, which is largely unavailable to other estuarine community components (Day 1967; Nybakken 1982; Day et al. 1989).

Biogeochemical processes that control nutrient cycles underpin both pelagic and benthic ecosystem components. Studies on algae bloom dynamics within the site suggest that there is strong benthic - pelagic coupling. As discussed in the previous section, Cook et al. (2008) found that catchment derived nutrient inputs, together with internal recycling of nutrients, ultimately control cyanobacteria (blue green algae) and other algae blooms within the system.

Productivity and foodwebs

The main primary producers within the site include phytoplankton, benthic microalgae (microphytobenthos), seagrass, saltmarsh, fringing reed beds and fringing *Melaleuca* forest. 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 freshwater marshes, seagrass and saltmarsh represent particularly productive communities (on a 'productivity per unit area' basis). It is also notable that phytoplankton can form major blooms within the estuary, as a result of the influx of excessive catchment derived nutrients (Cook et al. 2008). 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, or bottom-dwelling, fauna (meroplankton), including most species of direct fisheries significance. Little is known about the relationships between nutrient levels, phytoplankton dynamics, 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. 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 particularly likely to be the case in detritus-based foodwebs that characterise saltmarsh and freshwater wetland systems.

The relative importance of different primary producers in maintaining estuarine fisheries has not been investigated at the site to date. Recent studies in nearby 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).

Unlike Corner Inlet, Gippsland Lakes contains extensive areas of saltmarsh and brackish wetlands, and as discussed above, can have high phytoplankton biomass. Given the large area within Gippsland Lakes, seagrass is also likely to contribute significantly to foodwebs supporting commercially significant species, whereas the roles of marshlands and phytoplankton are unknown and warrant further investigation. Hindell (2008) predicts that a reduction in seagrass with Gippsland Lake would result in a comparatively greater contribution of other plants to the foodwebs supporting fish species (that is, a change in trophic structure), which we suggest may translate to a change in the growth and possibly relative abundance of some fish species.

The diet of wader bird species differs between species, and also within species, depending on food availability. While many shorebirds 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.

3.8 Critical Services/Benefits

Two critical services/benefits have been identified within the ECD. These critical services/benefits have been selected on the basis that they are unique determinants of the site's ecological character and underpin relevant Ramsar Nomination Criteria for the site.

3.8.1 Critical Service 1 – Maintaining 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.

The role of the site in maintaining threatened wetland fauna species underpins Ramsar Nomination Criterion 2.

In addition to the values of these species in terms of maintaining global biodiversity, some species are of great scientific research value and/or play a role in maintaining wetland ecosystems and foodwebs.

Description

DSE (2003) indicates that three flora and two fauna species recorded at the Gippsland Lakes Ramsar site are classified as nationally endangered under the EPBC Act, and four flora and ten fauna species as nationally vulnerable. More recent investigation of species lists have been undertaken as part of the current study and the following nationally or internationally threatened flora and fauna species are considered the key wetland dependent species of the site:

Threatened fauna species

- green and golden bell frog (*Litoria aurea)*
- growling grass frog (*Litoria raniformis*)
- Australian grayling (*Prototroctes maraena*)
- Australian painted snipe (*Rostratula australis*)
- Australasian bittern (*Botaurus poiciloptilus*)

Threatened flora species

- dwarf kerrawang (*Rulingia prostrata*)
- swamp everlasting (*Xerochrysum palustre*)
- metallic sun-orchid (*Thelymitra epipactoide*)

The majority of these species have already been discussed in the context of local populations that form critical components. The remaining species that are as yet undescribed include Australian grayling and the two cryptic wetland bird species, Australian painted snipe and Australasian bittern. These species have not been included as critical components on the basis that there are no or very minimal site records within the Ramsar site or otherwise there is poor information about the importance of the habitats within the site for these fauna.

Australian grayling

Australian grayling is listed as vulnerable under the EPBC Act and near threatened under the IUCN Red List (IUCN 2010), and is also listed as threatened under state legislation (Flora and Fauna Guarantee Act 1988). Confirmed records for these species exist for all major river basins that drain directly into the site, and given its apparent obligate estuarine juvenile life-history phase, it will need to use the site to complete its life-cycle. As identified above, there are records for Australian grayling for catchments that drain into the site. No information is available on the population dynamics and abundance of this species within these catchments or the Ramsar site.

The population status of Australian grayling in the river basins that drain into the site are highly likely to be dependent on the maintenance of suitable juvenile nursery habitat either within the estuarine sections of the site, or in the sea. It is thought that juveniles spend approximately six months of their life in estuarine/marine waters (approximately May to November), before migrating upstream into freshwaters, possibly in response to spring freshes (Backhouse et al. 2008). There are uncertainties regarding species habitat (structural and hydraulic) and water quality requirements during the juvenile stages.

There is no information on usage by the species within the site, although several drainages that flow into the site are considered to represent important habitats including Tambo, Mitchell, Avon and Thomson Rivers (Backhouse et al. 2008). Little is known about the population status of fish in these streams. Based on environmental flow assessments for the Thomson and Macalister Rivers, it was argued that abundances of this species were low and populations were unlikely to be self sustaining (Thomson Macalister Environmental Flows Task Force 2004), although it is uncertain how this conclusion was reached.

Painted snipe

Australian painted snipe (*Rostratula australis*) is listed as Vulnerable under the EPBC Act. This secretive, crepuscular species occurs on well vegetated shallow, permanent or seasonal wetlands (usually freshwater but occasionally brackish) (Geering et al. 2007). Occurrence is regarded as erratic and unpredictable (often in response to local rainfall), seldom remaining long in any locality and being absent from areas in some years and common in others (Marchant and Higgins 1993; Geering et al. 2007). This species requires dense vegetation cover for roosts (often tall grass) and forages on soft muds and in shallow water for seeds and invertebrates (Marchant and Higgins 1993; Geering et al. 2007).

The Birds Australia Atlas contains records of painted snipe in 1977 (three records), 1979 (one record) and 1980 (one record). The Birds Australia database (counts) and DSE Fauna databases do not contain any records of painted snipe at the site.

Australasian bittern

Australasian bittern (*Botaurus poiciloptilus*) – is listed as endangered under the IUCN Red List (IUCN 2010). This shy and cryptic bird roosts, feeds and breeds within dense vegetation cover of terrestrial and estuarine wetlands, though preferring permanent freshwater wetlands which support a combination of tall, dense vegetation (for example, bullrushes *Typha* spp. and spikerushes *Eleocharis* spp.) and short dense vegetation including sedges, rushes and reeds (Marchant and Higgins 1990;

Garnett and Crowley 2000). Garnett and Crowley (2000) consider that due to their comparatively specialised habitat requirements, this species may be more sensitive to overall habitat loss than are many wetland species.

The Birds Australia database contains one record of Australasian bittern at Lake Tyers in 1992, whereas the Birds Australia Atlas contains a record in 2006 at McLeod Morass (Birds Australia 2009). The DSE Fauna Database contains 15 records (years 1986, 1987, 1988, 1990, 1992, 1994, 1997, 1998), all of which were comprised of a single individual.

Natural variability

There are significant constraints to the assessment of Australasian bittern and Australian painted snipe due to their highly cryptic nature.

Nonetheless, maintaining the populations of these species (and the other threatened species) over time is most dependent on the following:

- Hydrology - Maintenance of natural patterns of freshwater inundation and prevention of increases in saline intrusion.
- Biological/Biophysical Processes - Maintenance of natural vegetation patterns, extent, condition, and habitat interconnectivity. Maintenance of key biological processes occurring at the site such as growth, reproduction, recruitment, feeding and predation.
- Water Quality - Maintenance of water quality in key habitats (nutrients, dissolved oxygen, salinity).

3.8.2 Critical Service 2 - Fishery Resource Values

Reasons for selection as 'critical'

Gippsland Lakes supports important fisheries resources in the form of fisheries habitats. These include 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.

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).

In the context of this service, black bream is considered a key indicator of the fisheries habitat values of the site. Selection of this species as a key indicator is based on the fact that recreational and commercial fishing focuses heavily on this species and there has been reasonable catch data collected over time for analysis.

Description

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.

Table 3-10 shows that important fisheries species (that is, those species listed in Table 3-11) 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 flexible 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 nearshore waters, particularly around seagrass and mangroves, whereas most species tend to spawn in inshore waters, particularly near the surf zone. Adults of most species tend to utilise a variety of habitats. There are exceptions to these general patterns; dusky flathead, river garfish and black bream spawn entirely in estuaries, with dusky flathead and river garfish typically spawn near seagrass and/or shoals, whereas black bream is thought to spawn in upper estuaries near the fresh and brackish water interface (Ramm 1986).

Table 3-10 Key fisheries species present in the Gippsland Lakes 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*	Inshore 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.			
river garfish	Juv., Ad	Juv., Ad., Spw.	Juv., Ad		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.			
estuary perch		Juv.		Juv. Ad.	Juv, Ad.	Spw (estuary mouth			
carp					Juv., Ad.				
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 (Hindell 2008); blue shading = habitats not represented in the site

Natural variability

Patterns in fish (and shellfish) community structure may vary across a range of spatial and temporal scales. Presently, there are no available data describing these life history functions for species within the site. As a decline in spawning or recruitment success would be expected to result in a reduction in relative abundance of juvenile and possibly adult fish, fish abundance data may provide a broad proxy indicator for this service.

Relative abundance data of high fisheries value species can be broadly determined based on commercial fish catch data (refer Table 3-11), which provides catch data for marketable fish. These data are strongly biased towards adults, are not based on systematic standardised catch methods and have limited spatial resolution. Furthermore, there are only four years of data for the period up to and including site declaration in 1982. There are also no suitable fisheries independent catch data to validate commercial catch data.

Notwithstanding these limitations, the commercial catch data presented in Figure 3-19 show:

- Black bream commercial catches displayed a marked decline, which was especially notable post-1986. This species does however remain one of the most abundant species in commercial catches within the Ramsar site. Overall declines were also observed for yelloweye mullet and tailor, although these species remained at a constant rank in terms of total catch within the site.
- European carp displayed a marked increase in numbers over time, particularly during the mid- to late-1990's.
- Overall, the post-1983 catch of other species was fairly similar to the pre-1983 catch, and the rank in terms of total catch within the site remained within one or two positions for most species.

Notwithstanding the above, Gippsland Lakes continues to represent an important habitat for black bream and other commercially significant species.

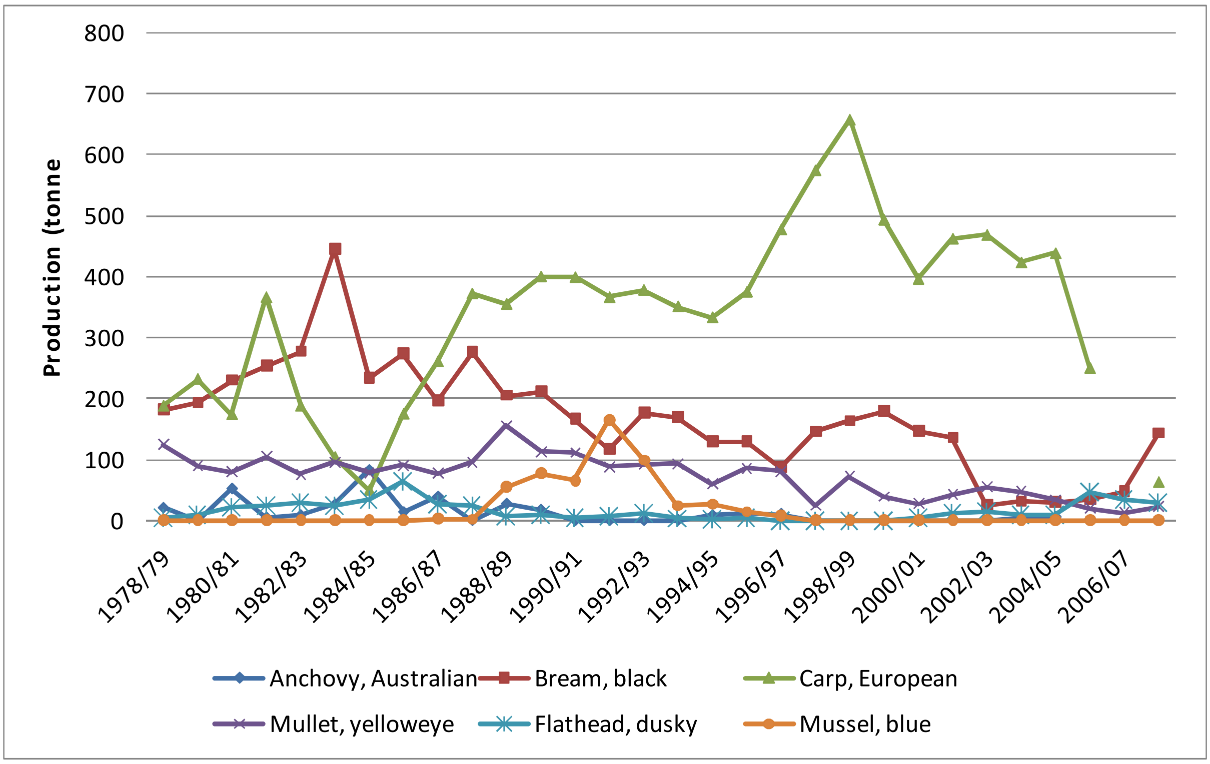
These above-described changes over time are likely to relate to a combination of changes in fishing effort and/or market demand, changes in actual abundance of these species and/or other factors controlling fishing effort (for example, fishing regulations, weather conditions, etc.). It is important to note, for example, there has been a reduction in number of license holders (and therefore fishing effort) due to Government buy-backs in the 2000's. Furthermore, it is noted that Lake Tyers was closed to commercial fishing in April 2003, coincident with a major reduction in black bream catches. However, even excluding data from the period when the Lake Tyers fishery was closed, the median black bream catch for the period 1982-83 to 2001-02 (174 tonnes) was still less than the 20th percentile catch for the period 1978-79 to 1981-82 (190 tonnes). Analysis by Ecos (unpublished) shows that fish effort has also declined since listing (Figure 4.1; Section 4.1.2), however there was a period in the mid 1980's to 1990's where catch declined but effort was equivalent to pre-1982 levels.

Catch per unit effort data were unavailable to the study team, hence it is not possible to make a definitive determination of whether changes in fishing effort or other factors were responsible for changes in commercial catch over time. Based on catch per unit effort data presented in Ecos (unpublished) for black bream catch (Figure 3-20), it is apparent that commercial catch has tended to decline in time in the period 1978 to 2003. Based on these data, the baseline catch per unit effort (tonnes/number of vessels) for the period 1978 to 1982 was 7.9 (median), and the 10^{th} percentile baseline catch per unit effort was 6.1.

Table 3-11 Commercial production (tonnes) for Gippsland Lakes summary statistics (20^{th}, 50^{th} and 80^{th} percentile values)

Species	Pre-listing (*n* = 4)			Post 1982 (*n* = 26)
	20^{th}	50^{th}	80^{th}	50^{th}
Australian anchovy	3	13	33.8	3.5
Australian salmon	3	3.5	4	13
black bream	189.6	212.5	240.6	156
European carp	183.4	211	286.6	376
dusky flathead	9.6	17.5	24.2	11.5
river garfish	0.6	4	24.6	2
leatherjacket	0.6	2.5	5.6	1
luderick	13	17	23.8	20.5
sea mullet	5.4	9.5	22	10.5
yelloweye mullet	87	98.5	114	78
blue Mussel	0	0	0	1
estuary perch	0	0	0	1
tailor	41.8	48	52.6	23
silver trevally	11.8	13.5	15.2	16
other	19	27.5	35.6	27.5

(Data source: DPI 2008). Red = 20^{th} percentile 'baseline' greater than median post-1982 value



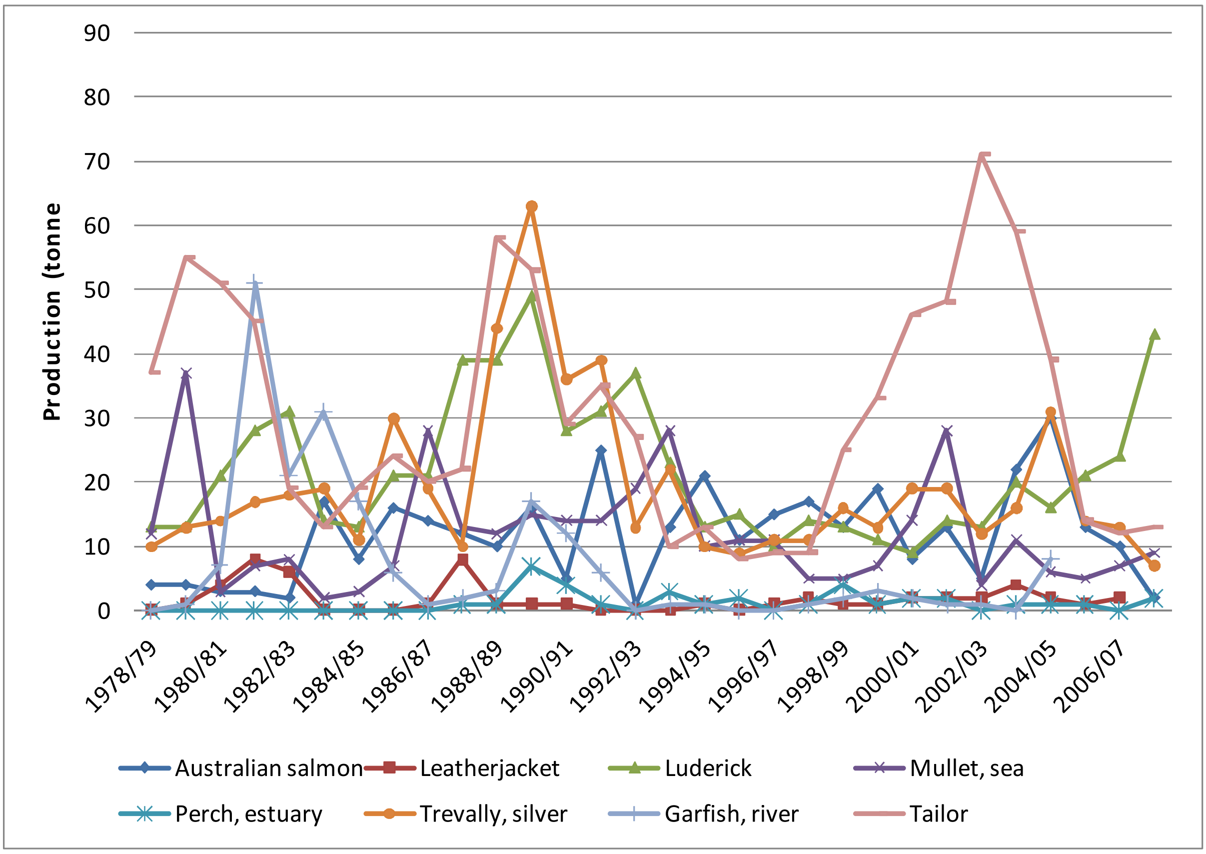
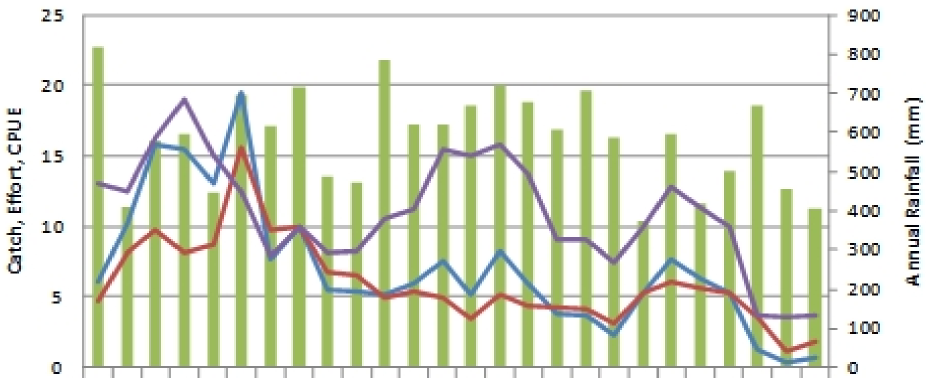


Figure 3-19 Commercial fisheries catch data between 1978-2008 (Source: DPI 2008)



Year	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	0	1	2	3
Rainfall	81	40	58	59	44	69	61	71	49	47	78	62	61	67	72	68	60	70	58	37	59	41	50	67	45	40
Catch tonnes (/10)	6	10	16	16	13	20	8	10	6	5	5	6	8	5	8	6	4	4	2	5	8	6	5	1	0	1
CPUE	5	8	10	8	9	16	10	10	7	7	5	5	5	3	5	4	4	4	3	5	6	6	5	4	1	2
No. boats (/100)	13	13	16	19	15	13	8	10	8	8	11	11	16	15	16	14	9	9	8	10	13	11	10	4	4	4

Figure 3-20 Black bream commercial catch, effort (number of boats) and catch per unit effort (catch divided by number of vessels) at Gippsland Lakes (Data source: Ecos unpublished)

3.9 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.

3.9.1 Recreation and Tourism Values

Description

Tourism and recreation are among the most important uses of the Gippsland Lakes, and have a major impact on employment and the economic wealth of the region. In this context, a supporting service/benefit of the site is its tourism and recreational use including recreational fishing.

Tourism and recreational use

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 Main 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).

Visitors undertake a wide range of recreational activities on and around the Lakes including bushwalking, boating and sailing, fishing, swimming, camping, hunting, bird watching, horse riding, picnicking and sight-seeing. Boating and fishing are, however, the main recreational activities with most visitors attracted to the Lakes for angling and boating opportunities (DSE 2003).

Coastal towns in the Gippsland region are subject to large seasonal population fluctuations usually in summer which are directly related to tourist influx into the region's motels, hotels, caravan parks and holiday homes for holidays. Maintenance of coastal environmental values (that make the Gippsland Lakes region attractive to visitors) is therefore a key to economic sustainability of many of these areas.

The visual attraction of the area is underpinned by the fact that the National Trust of Australia has classified the Gippsland Lakes area as being of special regional landscape significance. Of prime visual importance is the contrast of land and water, particularly due to the sandy barrier system which formed the coastal lagoons comprising the Gippsland Lakes and several geomorphic sites of international, national and state significance already discussed (DSE 2003).

Commercial tour operators run tours and make use of Gippsland Lakes and its parks, particularly Gippsland Lakes Coastal Park and The Lakes National Park (DSE 2003). National Parks, Coastal Parks and reserves in the Gippsland Lakes contain about 300 campsites, 150 picnic and other visitor areas, boating facilities (including private jetties that provide some 300 – 400 berths) and more than 60 toilet blocks (DSE 2003).

Based on the region's market profile prepared by Tourism Victoria, 84 per cent of overnight visitors to Gippsland were sourced from the intrastate market, followed by 12 per cent from interstate and three per cent from the international market (Tourism Victoria 2007). The region has 13 per cent market share of all domestic visitors to regional Victoria.

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.

Recreational fishing

Approximately 43 per cent of Victorian recreational fishing in 2000-2001 occurred in bays, inlets and estuaries such as the Gippsland Lakes (Fisheries Victoria 2007). Recreational fisheries are an important aspect of the Gippsland Lakes region, contributing significantly to regional economy and tourism. Recreational fishing supports the tourism and recreational industries in the region which surrounds the Ramsar site which has a major impact on the economic health of the region (DSE 2003). Approximately 1.3 million hours per year are spent by recreational fishers (DCNR 1995) with similar fish being targeted as the commercial fishery, including black bream, flathead, snapper, whiting and squid. There is interdependence between the commercial and the recreational sectors with the recreational sector relying on bait collected by commercial operators. Lake Tyers was declared a recreational fisheries reserve in 2004 to improve recreational fishing opportunities in the region.

3.9.2 Scientific Research

Description

Scientific investigations of the Gippsland Lakes in the past have focussed on water quality monitoring as a result of major algal outbreaks, which have occurred about every ten years but have intensified following the recent flood and fire events. State agencies also carry out regular water quality monitoring, data of which has been considered as part of the current study (see Appendix B). Other studies include long term assessment of seagrass assemblages (by Roob and Ball 1997; and more recently by Hindell 2008) and fisheries monitoring (Fisheries Victoria 2007). Extensive research into the loss of *Phragmites* and succession of *Melaleuca* vegetation communities in Dowd Morass have been undertaken by Boon et al. (2008) but the same level of study has not been undertaken for the other fringing wetlands of Lake Wellington. The Strategic Management Plan also notes that the Victorian Wader Study Group is active on the site monitoring the success and numbers of breeding little tern (DSE 2003).

Based on the literature reviewed as part of this study, the site is seen as an important site for expanding scientific knowledge with respect to several key features including the various sites of geomorphic significance, the zoological significance of Lake Reeve, the long term study of algal blooms in Lake Wellington.

Sites of geomorphological significance

The sites of geologic and geomorphological significance on the site range from sites of national, state and regional significance. These sites are well documented by Rosengren (1984). Of particular note is the Mitchell River Delta which is deemed as a site of international geomorphological significance as it is one of the finest examples of a classic digitate delta in the world (DSE 2003). The other sites of significance (as mapped by DPI) include:

- Rotomah Island (National Significance)
- Boole Boole Peninsula (National Significance)
- Sperm Whale Head (National Significance)
- Cunninghame Arm (National Significance)
- Red Bluff (State Significance)
- Barrier Dunes – Ninety Mile Beach (State Significance)
- Lake Reeve and Outer Barrier - Paradise Beach (State Significance)
- Outer Barrier near Seaspray (State Significance)
- Cuspate Forelands at Lakes Entrance (State Significance)
- Tambo River Delta (State Significance)
- Macleod Morass (State Significance)

- Point Turner - Banksia Peninsula (State Significance)
- McLennan Isthmus and McLennan Strait (State Significance)
- Latrobe Delta (State Significance)

Zoological/botanical significance of Lake Reeve

The Lakes National Park and Gippsland Lakes Coastal Park Management Plan (1998) (Parks Victoria 1998), identifies Lake Reeve being of ‘international significance and is a site of special scientific interest’ based on the site’s unique geomorphology, remnant vegetation communities that have been disturbed elsewhere throughout most of their range, species diversity and extensive waterbird usage as breeding, roosting and feeding habitat.

Long term study of water quality and algal blooms

There have been a number of significant studies into the water quality of Gippsland Lakes including most notably the Gippsland Lakes Environmental Audit (CSIRO 1998), the Gippsland Lakes Environmental Study (CSIRO 2001) and more recent work by the Water Studies Centre (Cook et al. 2008). Long term monitoring of water quality has also been undertaken by the Victorian EPA.

Through these studies, a sound understanding has been developed of the triggers for different algal blooms and nutrient flux issues within the Lakes. A major knowledge gap recognised in the studies is how these algal blooms affect the ecology of the Lakes which are currently being explored at least in part by continuing baseline seagrass and fish surveys by the Arthur Rylah Institute (Chris Barry (GCB) p*ers. comm.* 2009).

As discussed previously, it should be noted that water quality is not degraded in all parts of the Gippsland Lakes Ramsar site. Lake Tyers in particular provides a useful reference site for measuring water quality at a regional scale given its predominantly undeveloped catchment and near-pristine water quality conditions.

3.10 Conceptual Models

The broad interaction of critical and supporting components, process and services/benefits at a whole-of-site level is shown in Figure 3-21. As shown in the figure, there are three broad processes identified (climate, geomorphology and regional-scale hydrodynamic and hydrological processes) that together have shaped the local 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 3-21).

The interaction of the critical ecosystem components, processes and services/benefits are shown in conceptual models for the site in Figure 3-23, Figure 3-24 and Figure 3-25. The models are based on the three broad wetland habitat groupings identified previously and utilise the numbering system for the critical components (C1 to C8), processes (P1 and P2) and services/benefits (S1 and S2) already presented.

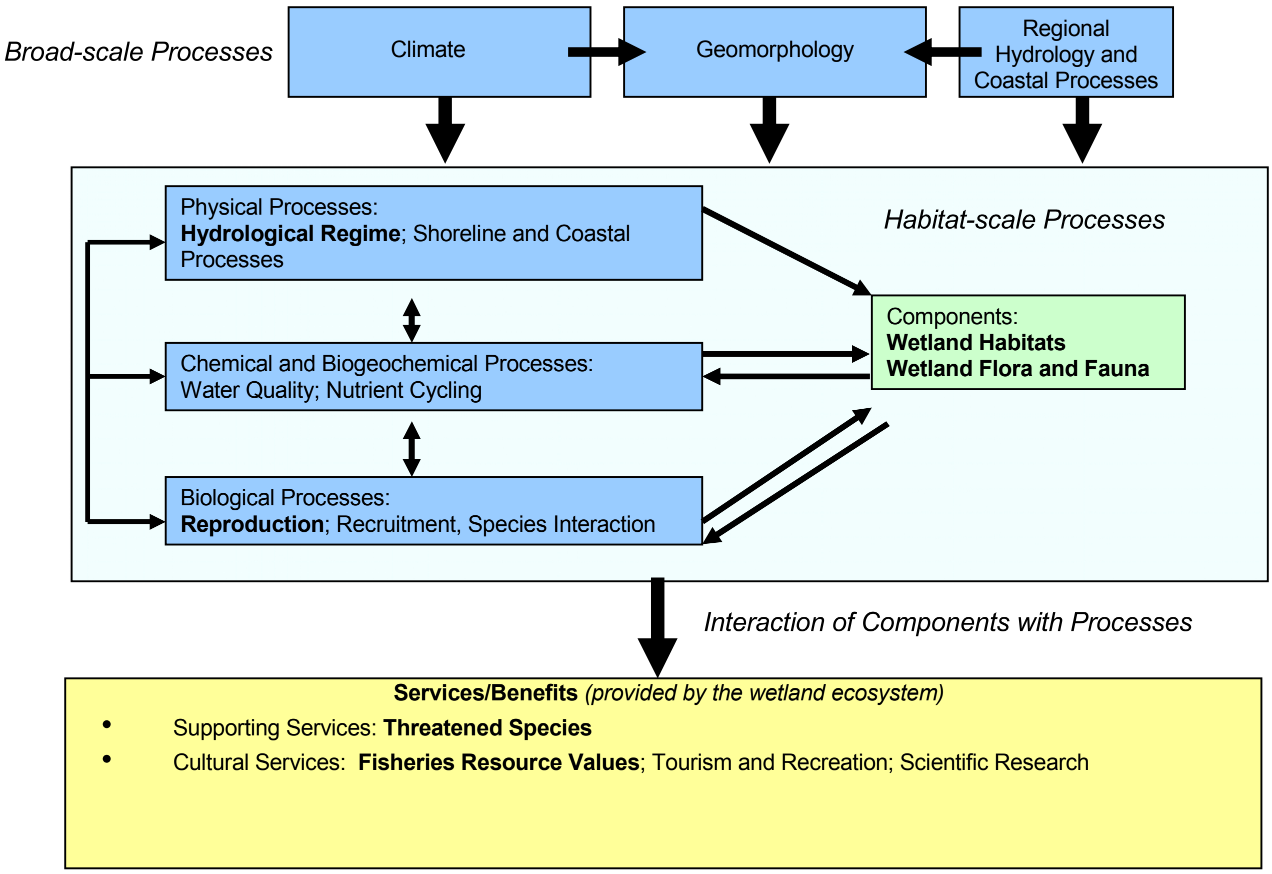


Figure 3-21 Conceptual model showing interaction of ecosystem components, processes and services/benefits (bold font indicates critical element)

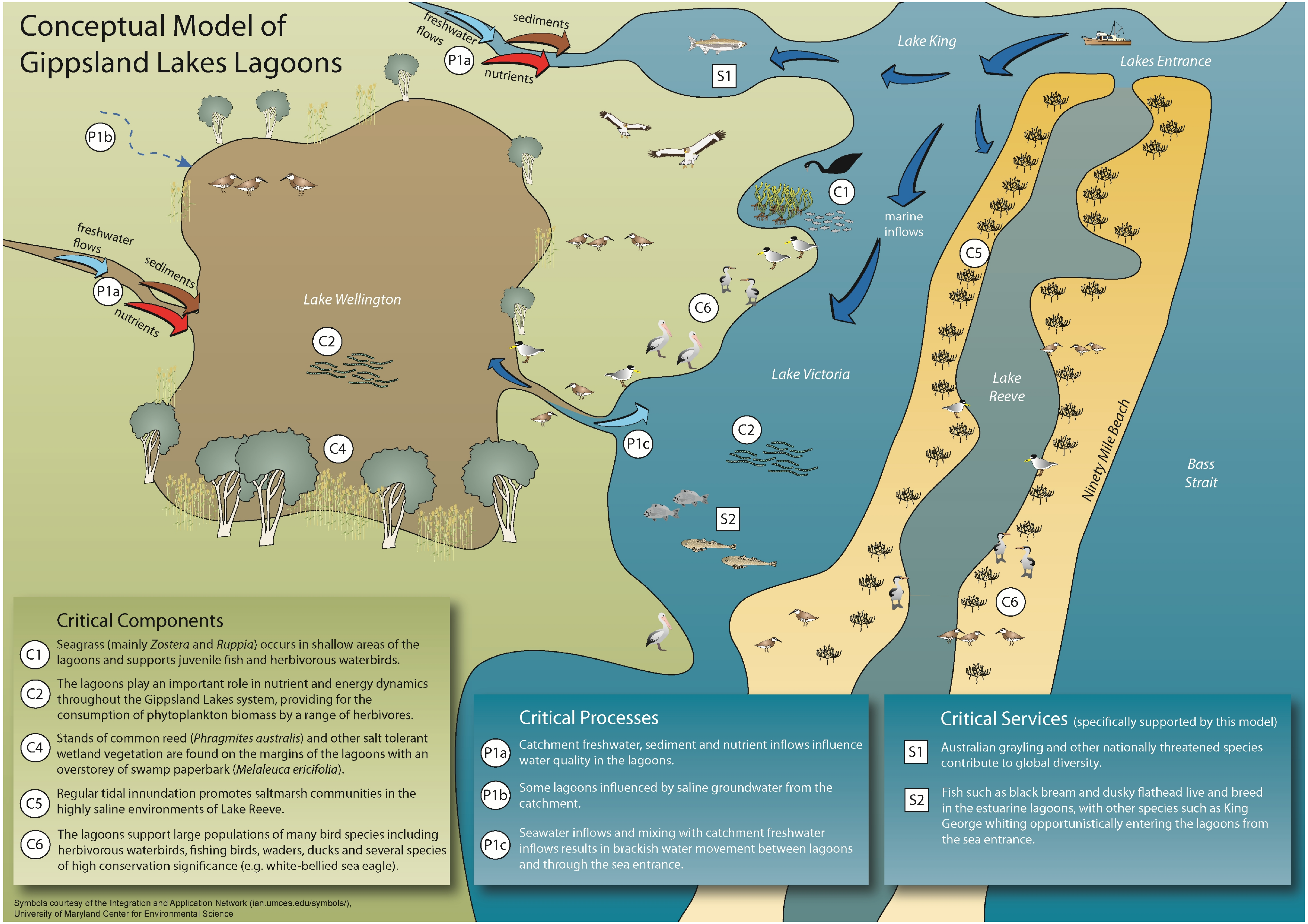


Figure 3-22 Conceptual model of Gippsland Lakes lagoons

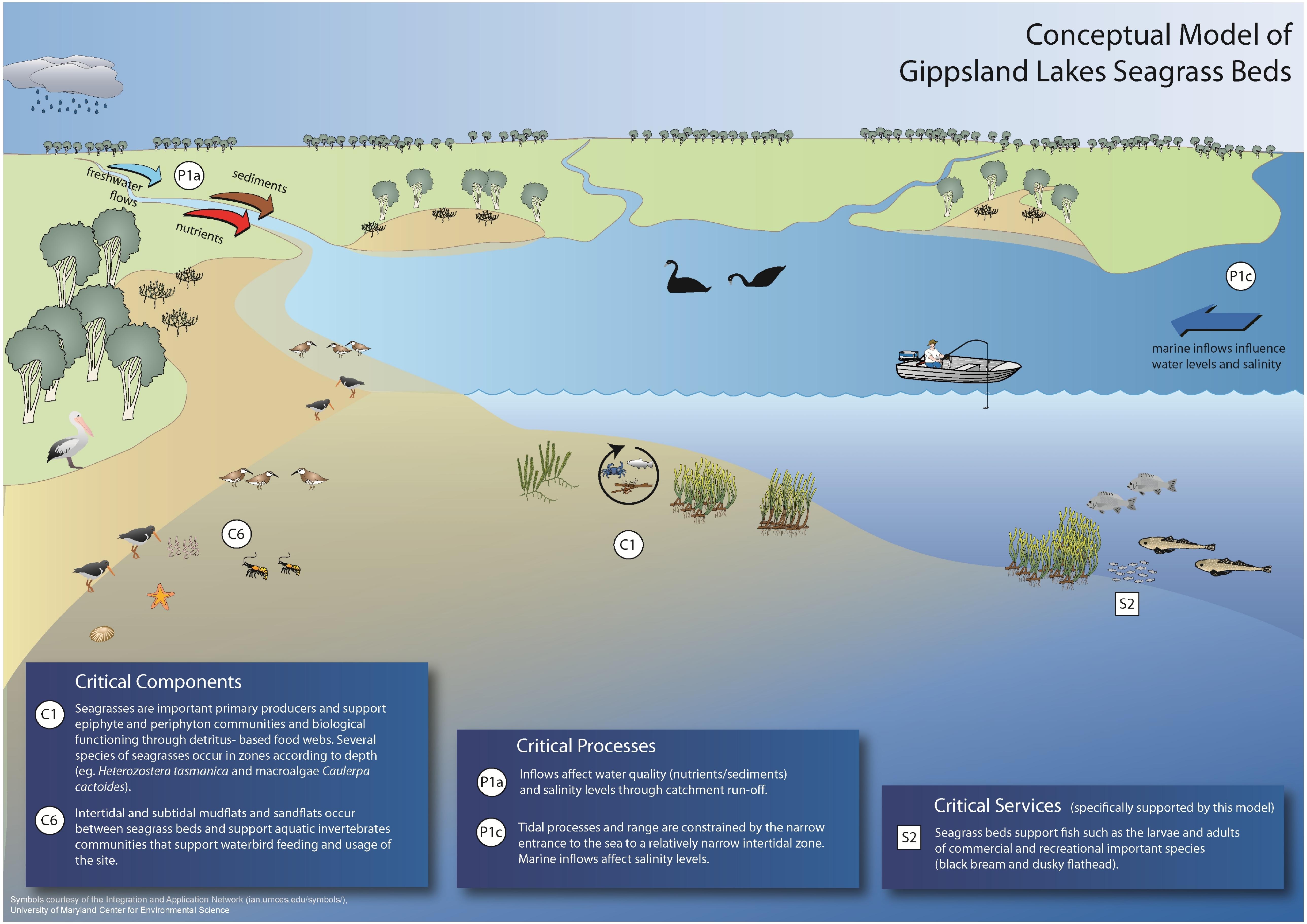


Figure 3-23 Conceptual model of Gippsland Lakes seagrass beds

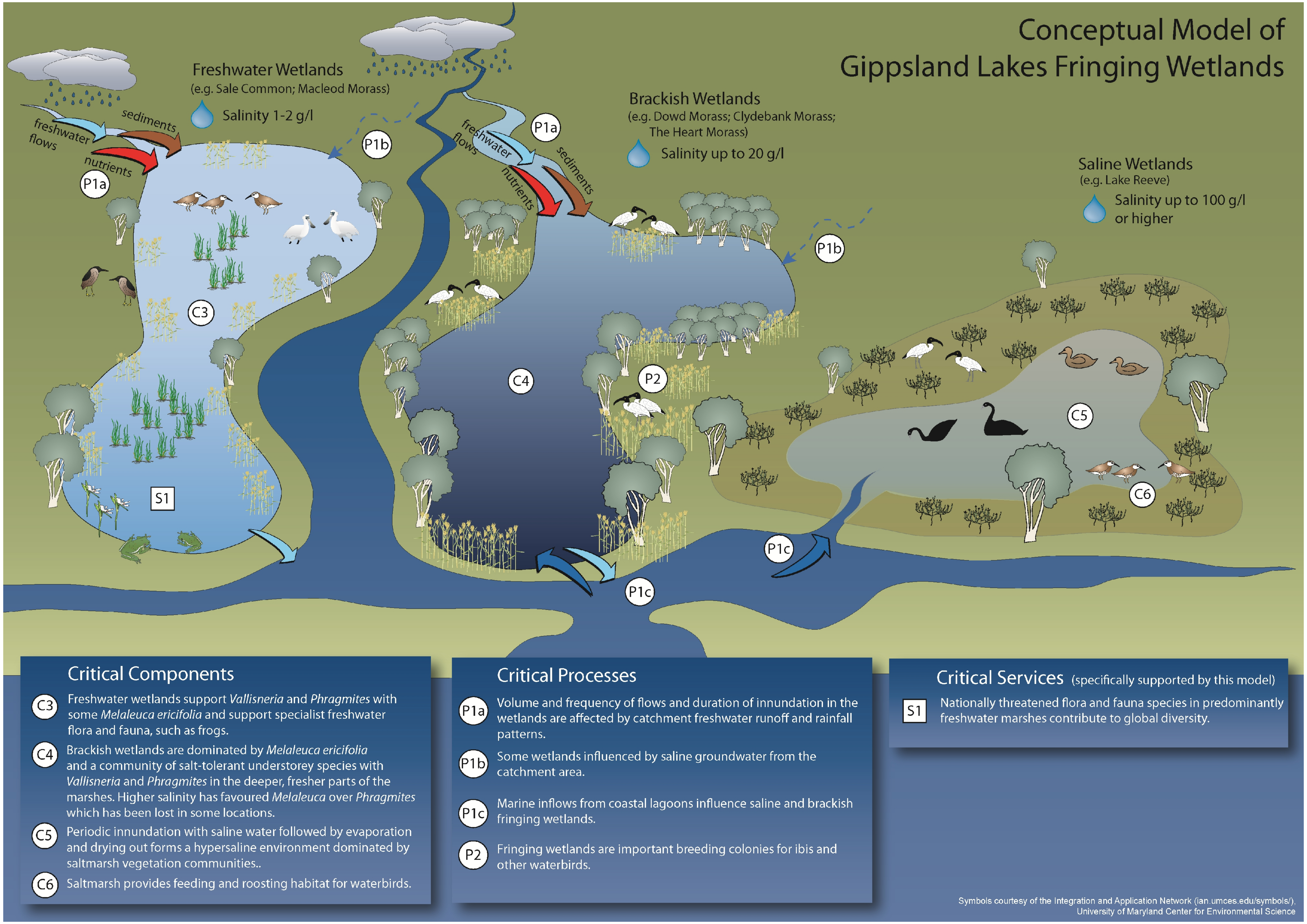


Figure 3-24 Conceptual model of Gippsland Lakes fringing wetlands

4 LIMITS OF ACCEPTABLE CHANGE

4.1 Background and Interpretation

A key requirement of the ECD is to define the limits of acceptable change (LAC) 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. 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. In most cases, 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.

Exceedance of a LAC may indicate a potential change to the ecological character of a Ramsar site. In most cases this will need to be determined through monitoring of the extent and condition of key wetland parameters (refer Section 7 on 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 LAC 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 LAC 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 LAC 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, LAC 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 LAC 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, LAC as part of the current study have also been based on a statistical measure of baseline data for a particular parameter. These LAC 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), LAC 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 LAC 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 LAC 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 LAC set out in other ECD studies (prepared by BMT WBM and other authors) have also been reviewed for their applicability to the Gippsland Lakes ECD.

Additional Limits of Acceptable Change explanatory notes

Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.

Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.

While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.

Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.

Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

4.3 Characterising Baseline Information

In characterising the baseline information used in deriving LAC, 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 LAC 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 LAC 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 2.3.

(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 LAC 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 (LAC)

Number	Indicator for critical component / process/service for the LAC	Relevant timescale[9]	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	Marine sub-tidal aquatic beds (for example, within Lake King, Lake Victoria, Lake Tyers, Bunga Arm and Lake Bunga)	Long Term	• Total seagrass extent will not decline by greater than 50 per cent of the baseline value of Roob and Ball 1997 (that is, 50 per cent of 4330 hectares = 2165 hectares) in two successive decades at a whole of site scale. • Total mapped extent of dense and moderate *Zostera* will not decline by greater than 80 per cent of the baseline values determined by Roob and Ball (1997) in two successive decades at any of the following locations: o Fraser Island o Point Fullerton, Lake King o Point King, Raymond Island, Lake King o Gorcrow Point – Steel Bay, Lake Victoria o Waddy Island, Lake Victoria	Sampling to occur at least twice within the decade under consideration. Baseline mapping against which this LAC can be tested is within Roob and Ball 1997. Note that the seagrass assessment by Hindell (2008) did not produce mapping but did use similar sampling sites to Roob and Ball.	Level B - Recent quantitative data describes seagrass condition at various sites but over a limited timeframe. There is no available seagrass condition data prior to listing.	P1
C2	Coastal brackish or saline lagoons (for example, Lake King, Lake Victoria, Lake Wellington, Lake Tyers)	Long Term Long Term Short Term	• No change in wetland typology from the 1980 classification of Corrick and Norman (1980), as presented in Figure 2-3. • A long-term change in ecosystem state at Lake King, Lake Victoria or Lake Tyers from relatively clear, seagrass-dominated estuarine lagoons to turbid, algae dominated system (characteristic of Lake Wellington) will represent a change in ecological character. • No single cyanobacteria algal bloom event will cover greater than 10 per cent of the combined area of coastal brackish/saline lagoons (that is, Lake King, Victoria, Wellington and Tyers) in two successive years.	To be determined based on expert review. To be determined based on expert review. Algal bloom extent (per cent lakes area and location) and number should be reported annually, but assessed on an ongoing basis.	Level B - VMCS mapping data describes wetland extent. This is coarse scale mapping and should be considered as indicative only. Level A - The occurrence of cyanobacteria algal blooms are well documented. The extent of algal blooms historically has not been assessed, including at the time of site declaration.	P1, S2

[9] Short Term – measured in years; Medium Term – 5 to 10 year intervals; Long term – 10+ year intervals.

Number	Indicator for critical component / process/service for the LAC	Relevant timescale[9]	Limit(s) of acceptable change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
C3	Fringing wetlands – predominantly freshwater marsh at Macleod Morass and Sale Common	Long Term	• No change in wetland typology from the 1980 classification (Corrick and Norman 1980; See Figure 2-3). In this regard, the conversion of vegetation communities at Sale Common and Macleod Morass from a predominantly freshwater character (for example, giant rush, common reed, cumbungi) to those of a brackish water character (brackish or swamp scrub/saltmarsh species) will represent a change in ecological character.	To be determined based on expert review.	Level B - VMCS mapping data describes wetland extent during 1980. This is coarse scale mapping and should be considered as indicative only. There is no available community data prior to listing.	P1, P2, C6, C7, C8
			• The total mapped area of freshwater marshes (shrubs and reed wetland types) at Sale Common and Macleod Morass will not decline by greater than 50 per cent of the baseline value outlined in VMCS for 1980 (that is, 50 per cent of 402 hectares = 201 hectares) in two successive decades.	Sampling to occur at least twice within the decade under consideration.		
		Short Term	• In existing freshwater wetland areas, the annual median salinity should not be greater than one gram per litre in two successive years. *Note that where ambient water quality characteristics fall outside the range of these baseline levels, and ecosystem health indicators shows no signs of impairment, the LAC may need to be adjusted accordingly.*	Annual median based on at least eight sampling periods per year, encompassing wet and dry periods.	Level C - No available baseline data. Value based on species salinity tolerances.	
C4	Fringing wetlands – brackish marsh (for example, Dowd Morass; The Heart Morass; Clydebank Morass, Lake Coleman {Tucker Swamp})	Long Term	For all fringing brackish wetlands: • No change in wetland typology from the 1980 classification (Corrick and Norman 1980).	To be determined based on expert review.	As for C3.	P1, P2, C6, C7, C8
		Medium Term	For Dowd Morass and the Heart Morass: • The annual median salinity will be less than four grams per litre in five successive years. *Note that where ambient water quality characteristics fall outside the range of these baseline levels, and ecosystem health indicators shows no signs of impairment, LAC may need to be adjusted accordingly.*	Annual median based on at least eight sampling periods per year, encompassing wet and dry periods.	Level C - No available baseline data. This value is based on species tolerances and requirement for salinity to be less than four grams per litre to allow reproduction (refer Tilleard and Ladson 2010).	
		Long Term	• The total area of common reed at Dowd Morass will not decline by greater than 50 per cent of the 1982 baseline value (that is, 50 per cent of 480 hectares = 245 hectares) outlined in Boon et al. (2007) in two successive decades.	Sampling to occur at least twice within the decade under consideration.	Level A - Boon et al. (2007) provides good quality mapping data relevant to time of listing.	

Number	Indicator for critical component / process/service for the LAC	Relevant timescale[9]	Limit(s) of acceptable change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
C5	Fringing wetlands – saltmarsh/hypersaline marsh (for example, Lake Reeve)	Medium Term	• No change in wetland typology from the 1980 classification (Corrick and Norman 1980). • The total mapped area of salt flat, saltpan and salt meadow habitat at Lake Reeve Reserve will not decline by greater than 50 per cent of the baseline value outlined in VMCS for 1980 (that is, 50 per cent of 5035 hectares = 2517 hectares) in two successive decades.	To be determined based on expert review. Sampling to occur at least twice within the decade under consideration.	As for C3.	P1, C6
C6	Abundance and diversity of waterbirds	Medium Term	• The number of standard 20 minute searches (within any ten year period) where waterbird abundance is less than 50 individuals will not fall below 50 per cent of the 'baseline' value (based on Birds Australia count data – 1987-2010), for the following species: ○ black swan = 15 per cent of surveys ○ chestnut teal = 10 per cent of surveys ○ Eurasian coot = 11 per cent surveys. • The absence of records in any of the following species in five successive years will represent a change in character: red-necked stint, sharp-tailed sandpiper, black swan, chestnut teal, fairy tern, little tern, musk duck, Australasian grebe, grey teal, Eurasian coot, great cormorant, red knot, curlew sandpiper. • Median abundance (derived from at least three annual surveys {summer counts} over a 10-year period) falls below the 20th percentile baseline value. *Note: An adequate baseline will need to be established to assess this LAC (for example, at least three annual surveys (summer counts) over a 10-year period).*	Sampling to be undertaken at least twice a year over any 10 year period at stations containing favourable habitat for these species (see Table E8 for locations). Surveys should consist of standardised 20 minute counts. Sampling to be undertaken at least twice a year (during summer) at stations containing favourable habitat for these species (see section 3.4.1 for important locations). Recommended baseline monitoring program should include: • A combination of aerial and ground surveys. • Representative coverage of primary habitats within the site.	Level A - Birds Australia data, while standardised in terms of sampling effort per site, is not standardised in terms of frequency of sampling events at any given sampling location. Data should be considered indicative only. Level A - Records for these species are reliable. Birds Australia and DSE data can be used to assess this qualitative LAC. There are no baseline data available for this LAC.	P1, P2

Number	Indicator for critical component / process/service for the LAC	Relevant timescale[9]	Limit(s) of acceptable change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
C7	Presence of threatened frogs	Medium Term	• The site will continue to support suitable habitat for growling grass frog and green and golden bell frog. In this regard, the LAC for Component 3 applies. • There is insufficient data to develop a LAC relating directly to site usage by these species, which represents a critical information gap. Should baseline data become available in the future, the following LAC will apply: a significant reduction (greater than 25 per cent over a period of 5 years) in the local adult population within the site, especially for important local populations (for example, within Macleod Morass, Sale Common, Ewings Marsh, Roseneath wetlands (Morley Swamp and Victoria Lagoon), the Heart Morass and freshwater pools on Rotamah Island).	Refer to C3. Recommended baseline monitoring program should comprise a minimum two annual sampling periods separated bat least one year (and within a 5 year period).	Level C - Surveys for these species have been opportunistic. The most recent record for growling grass frog is 2007, whereas the green and golden bell frog was recorded at the site in 1998. There are no empirical data describing abundances at the site.	P1
C8	Presence of threatened wetland flora species	Long Term	• The three threatened flora species (*Rulingia prostrata*, *Thelymitra epipactoides* and *Xerochrysum palustre*) continue to be supported within the boundaries of the Gippsland Lakes Ramsar site.	Based on opportunistic searches.	Level C - Setting of empirical limits of acceptable change is not possible at present, given the absence of quantitative estimates of population size of threatened species within the site, and more importantly the viability of populations (and their key controls) within the site.	P1

<table>
<tr><th>Number</th><th>Indicator for critical component / process/service for the LAC</th><th>Relevant timescale[9]</th><th>Limit(s) of acceptable change</th><th>Spatial scale/temporal scale of measurements</th><th>Underpinning baseline data</th><th>Secondary critical C,P,S addressed through LAC</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Critical Processes</td></tr>
<tr><td>P1</td><td>Hydrological regime</td><td>Short Term – Medium Term</td><td>Wetland wetting frequency, flushing frequency and flushing volume are maintained as follows:
<table>
<tr><th>Wetland</th><th>Wetting Frequency</th><th>Flushing Frequency</th><th>Required Flushing Volume</th></tr>
<tr><td>Sale Common</td><td>Annual with 100 per cent reliability</td><td>2-3 times/decade</td><td>4 GL</td></tr>
<tr><td>Dowd Morass</td><td>5-7 times/decade</td><td>2-3 times/decade</td><td>15GL</td></tr>
<tr><td>The Heart Morass</td><td>5-7 times/decade</td><td>2-3 times/decade</td><td>15GL</td></tr>
</table>
From Tilleard and Ladson (2010); note that larger flushing volumes (~20GL) are identified as being needed for Dowd and the Heart Morasses following saline flood events in the Lake Wellington system (for example, when the wetlands are filled with saline water from Lake Wellington and this corresponds with low flows in the Latrobe River).</td><td>Refer to LAC for details. Values measured at existing gauging stations in the lower reaches of the Rivers or otherwise in the wetlands themselves.</td><td>LAC have been identified for these wetlands on the basis that they are the best indicators of freshwater flows into the broader Gippsland Lakes system.

Level C - LAC based on Tilleard and Ladson (2010) ‘Hydrological Analyses to Support Determination of Environmental Water Requirements in the Gippsland Lakes’. This is a threshold-based LAC that is based on modeling and ecological assessments. Note that these values should be considered as indicative only at this stage, and should be constantly reviewed.
Tilleard and Ladson (2010) indicate no work has been done for wetlands on the Mitchell (Macleod Morass); McLennan Straits (Morley Swamp, Lake Betsy); or Jones Bay.</td><td>C1 – C8
S1, S2</td></tr>
<tr><td>P2</td><td>Waterbird breeding</td><td>Short Term</td><td>Abandonment or significant decline (greater than 50 per cent) in the productivity of two or more representative breeding sites (based on two sampling episodes over a five year period) within any of the following site groupings:
• Lake Coleman, Tucker Swamp and Albifrons Island - Australian pelican.
• Bunga Arm and Lake Tyers – little tern and fairy tern.
• Macleod Morass, Sale Common and Dowd Morass – black swan, Australian white ibis, straw-necked ibis, and little black cormorant.</td><td>Recommended baseline monitoring program should comprise a minimum two annual sampling periods separated by at least one year (and within a 5 year period).</td><td>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.</td><td>C6</td></tr>
</table>

Number	Indicator for critical component / process/service for the LAC	Relevant timescale[9]	Limit(s) of acceptable change	Spatial scale/temporal scale of measurements	Underpinning baseline data	Secondary critical C,P,S addressed through LAC
Critical Services/Benefits						
S1	Threatened species	N/A	No LAC are proposed for painted snipe and Australasian bittern at the current time until greater information is available about patterns of usage and populations in the Ramsar site. Other threatened species are dealt with in the critical components above.	N/A	Level C - Site records are not recent, uncommon and the location within the Ramsar boundary not known.	P1, C3
		Long Term	Australian grayling continues to be supported in one or more of the catchments draining into the Gippsland Lakes.	Setting of more empirical limits of acceptable change not possible at present, given the absence of quantitative population data for this species for any of the rivers and creeks that drain into the site.	Level C - This species has been recorded in the major drainages that drain into the site. Juveniles have an apparent obligate estuarine phase, and therefore must use the site in order for this species to persist in these drainages. There are no data describing the population status of this species in these drainages.	P1, C1, C2
S2	Fisheries resource values	Medium Term	• Total annual black bream commercial fishing catch per unit effort will not fall below the 10th percentile historical baseline value of 6.1 (see Section 3.8.2) in a five successive year period. • Sub-optimal black bream spawning conditions should not occur in any successive five year period within key spawning grounds (that is, mid-lower estuaries and adjacent waters of main lakes) during the peak spawning period (October to December). Based on Tilleard (2009), optimal conditions are as follows: • Water column salinity is maintained in brackish condition (for example, between 17-21 grams per litre median value) in the middle of the water column in the mid-lower estuaries and adjacent waters of the main lakes • The salt wedge is located within the mid-lower section of the estuarine river reaches or just out into the main lakes as opposed to far upstream or well-out into the Lakes.	Median measured over 5 years. Annual median value for the period October to December. As above	Level B - While some commercial fish data has been accessed and reviewed as part of the current study, the abundance and usage of the Gippsland Lakes by key fish species of commercial and recreational significance is not well quantified. The baseline data used in this LAC has limited duration (5 years), and is unlikely to be representative of patterns in abundance over longer timeframes. This LAC will need to reviewed and refined. Level C – based on conditions outlined in Tilleard (2009).	C1, C2, C3, C4, C5

5 THREATS TO ECOLOGICAL CHARACTER

5.1 Overview

Given the size and diversity of wetland habitats present, the actual or likely threats to the ecological character of the Gippsland Lakes Ramsar site vary greatly across multiple spatial and temporal scales and in terms of their potential severity.

Major threats to the Ramsar site are identified in the Strategic Management Plan (DSE 2003), and are summarised in Table 5-1 and discussed below. Two additional threats, algal blooms and climate change have been added to the list of threats presented in DSE 2003, as more current and contemporary threats to the ecological character of the site. In characterising the key threats identified in Table 5-1, the likelihood of individual threats was assessed based on categories presented in Table 5-2.

Table 5-1 Summary of major threats to the Gippsland Lakes Ramsar site

Threat	Potential impacts to wetlands	Likelihood of impact	Timing*
Altered water regimes	Impact on water quantity and quality in downstream marshes and lagoons	Medium	Short to long term
Salinity	Catchment driven salinity caused by rising groundwater levels	Medium	Long term
Pollution	Accumulation of nutrients (leading to algal blooms)	Medium to high	Short to long term
Pest plants and animals	Reduced regeneration of native flora and predation on native fauna	Medium	Short to long term
Natural resource utilisation	Grazing and overfishing	Low	Medium to long term
Dredging	Dredging of sand from entrance channel; occasional use in beach nourishment	Medium	Short to medium term
Activation of acid sulfate soils	Reduced pH; fish kills	Low to medium	Medium to long term
Recreation and tourism	Disturbance to flora and fauna; litter and water pollution	Medium	Medium to long term
Fire	Loss of protective vegetation cover; increased stream sediment and turbidity	Medium	Short to long term
Erosion	Increased sediment and turbidity	Medium	Short to long term
Algal blooms	Growth of phytoplankton blooms	High	Short to long term
Climate change	Sea level rise, increased rate of erosion, increased drought	Medium to high	Long term

*Timing: short term 1–5 years; medium term 5-10 years; long term ~ decades

Table 5-2 Threat likelihood categories

Threat Likelihood Category	Interpretation
High	• Irreversible Impacts at the Broad Scale or Regional Scale • Medium Term Impact at the Broad Scale
Medium	• Irreversible Impact at a Local Scale • Medium Term Impacts at the Regional Scale • Short Term impact at a Broad Scale
Low	• Irreversible Impact at the Individual Scale • Medium Term Impact at a Local scale • Short Term impact at a Regional Scale

5.2 Discussion of Threats

Each of the major threats identified in Table 5-1 are briefly discussed below:

Altered water regimes

In particular, annual water extraction and the impoundment of water from the major rivers flowing into the Ramsar site affect water quantity and quality in the downstream marshes and lagoons, and estuarine reaches of the rivers themselves. The lower reaches of the larger rivers flowing into the lakes (for example, Latrobe River, Thomson River, Mitchell River) have extensive floodplains in which there are large wetlands, often separated by natural levees from the main river channels. As discussed throughout this document, these transitional marsh areas are highly significant waterbird and wetland plant habitats and represent the last remaining freshwater wetlands around the lakes. They are now subject to significantly altered hydrological regimes due to a combination of factors including:

- Water control structures connecting the river at these sites allow for artificial water regulation. Water regimes are not always managed, if managed at all, in line with natural regimes.
- Erosion of the riverbanks separating these wetlands from the Lakes leads to saltwater inundation and more stable water levels (for example, Clydebank Morass).
- Influxes of saline water from the Lakes enter these wetlands during periods of flooding (for example, Heart Morass, Dowd Morass).

The failure to establish appropriate water level and salinity management of these remaining freshwater wetlands represents a high risk to the diversity and environmental values of the Lakes. As part of the *Our Water, Our Future* Initiative and as reported in the 2008 Victorian State of the Environment Report, the Victorian Government has made significant commitments to improve the EWR in 100 high priority reaches of rivers that includes the Latrobe, Thomson and Macalister Rivers in the relation to the Gippsland Lakes Ramsar site catchment. This is planned to be achieved through recovering water for the environment, implementing water recovery projects, adjusting water entitlements and management of the enhanced EWR (State of Victoria 2008 and State of Victoria 2010).

Salinity

In addition to the long term marine influence on the site from the opening of Lakes Entrance other salinity threats occur from catchment driven salinity caused by rising groundwater levels. This groundwater salinity principally occurs as a result of past native vegetation clearing, followed by replacement of the deep-rooted native vegetation with shallow rooted pasture species (leading to rising water tables and associated salinity). Salinity problems have been identified around Lake Wellington (where at least 10 000 hectares are affected) and the associated marsh/morass wetlands (for example, Dowd, Heart, Clydebank and Lake Coleman/Tucker Swamp) (DSE 2003).

Increases in salinity of the groundwater may change the ecology of the streams, wetlands and the Lakes, ultimately affecting the patterns of distribution of key species and the broad value of the Lakes for the conservation of native flora and fauna, the value for commercial activities such as fishing, and community enjoyment of the natural environment (DSE 2003).

Pollution

Pollutants from point and diffuse sources within the catchment tend to accumulate and concentrate in Gippsland Lakes (DSE 2003). Nutrients constitute the most significant pollutant in the Lakes, particularly given the propensity for algal blooms. In addition to background inputs of nutrients from natural processes occurring in the catchment, urban run-off (including sewage treatment effluent), run-off from agricultural and forestry activities and septic tank leachate from unsewered areas (for example, around Loch Sport) have been identified as sources of nutrients (DSE 2003). The main contemporary source of the nutrients is from run-off from agricultural land, particularly from dairy farming in the Maffra-Warragul area.

Sedimentation principally from agricultural and forestry uses in the catchment also contribute to the pollutant load in the Lakes. Many factors contribute to the vulnerability of soil to erosion in the Gippsland catchment area including a lack of suitable vegetation cover (coinciding with high rainfall events); soil exposed by fire, roads and tracks, pest animals, stock movement or tillage; and farming management decisions that inadequately address the risk factors of different practices. The Strategic Management Plan quotes that about 100 000 tonnes of suspended solids (excluding bottom sediments) are estimated to enter the Gippsland Lakes each year from the catchments of the Mitchell, Tambo and Nicholson Rivers alone (DSE 2003).

Site-specific pollution issues discussed in the Management Plan and other sources include historic pollution of Lake Coleman from paper mill and sewage treatment plant discharge and sewage treatment plant discharge into the Macleod Morass. Other pollution threats listed in the Strategic Management Plan include sediment toxicity, litter and oil spills though none of these appear to be at significant levels.

Pest plants and animals

Pest plants of the Gippsland Lakes include exotic and indigenous agricultural weeds, and environmental weeds. Pest plants have the potential to reduce opportunities for regeneration of indigenous flora through competitive growth, and by changing soil conditions required for successful germination and development of native flora. A number of introduced animals have also been recorded in the Gippsland Lakes, including the fox, feral and domestic cat, dog, rabbit, feral goat, feral pig, and carp (Parks Victoria 1998). In updating this information, Ecos (unpublished) and other marine pest sources (refer www.epa.vic.gov.au) identify the following key invasive plants and animals as current or potential threats to the Gippsland Lakes Ramsar site:

- Brazilian milfoil (*Myriophyllum aquaticum*) – an introduced freshwater macrophyte which has been recorded in Sale Common and Lake Wellington complexes.
- Green macroalgae or 'broccoli weed' (*Codium fragile* ssp. *tomentosoides*) – a marine macroalgae detected in Corner Inlet, Western Port and Port Philip Bay in the mid-1990s that has the potential to spread to Gippsland Lakes.
- Japanese kelp (*Undaria pininatifida*) and aquarium weed (*Caulerpa taxifolia*) – marine weeds that may be introduced from infested ports such as Port Phillip or by boats such as dredging vessels and recreational watercraft.
- Northern pacific seastar (*Asterias amurensis*) – already present at Port Phillip that may be a future risk to Gippsland Lakes due to the species broad salinity tolerance.
- Mediterranean fanworm (*Sabella spallanzanni*) – a marine polychaete found within temperate harbours and embayments in the region elsewhere along the Victorian coast.
- European shore crab (*Carcinus maenas*) - an extremely tolerable and hardy species, showing few limitations of the type of habitat it prefers. It is found in both the intertidal and shallow subtidal zones of bays and estuaries.
- Carp (*Cyprinus carpio*) – a declared noxious species that was established in Gippsland Lakes prior to listing but has since reached large biomass due to their ability to inhabit a variety of habitats and salinity states.
- Eastern gambusia (*Gambusia holbrooki*) - the potential threat posed by Eastern gambusia is unknown and requires further investigation. This species is known to occur in three of the catchments that drain into Gippsland Lakes. Elsewhere this species is a known threat to native fish and frogs.

Natural resource utilisation

In particular, 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 recreational fishing effort that occurs in the wetland are identified as threats. For instance, under the Strategic Management Plan, preliminary results of a survey of recreational catches in the Gippsland Lakes indicated that there had been a 53 per cent decline in the seasonally adjusted mean catch rates over the period 1990 - 2003 (DSE 2003). Bait digging for worms and callianassid shrimps (ghost nippers) also represents a locally important fishery though its impact on values is unknown.

Dredging

Dredging can cause direct loss of habitat in the dredge footprint and cause indirect changes to hydrodynamics and sediment transport processes that can impact on neighbouring wetland environments. Key threatening processes include sedimentation and smothering of seagrasses and other benthic habitats, reduction in water clarity and physical changes to the nature and quality of bottom substrate as a result of changes to hydrodynamic processes. Dredging continues to occur in relation to maintaining a navigable entrance to Bass Strait at Lakes Entrance and maintaining channels and infrastructure for boating access within the Lakes system. An estimated 300 000 cubic metres per annum is dredged at Lakes Entrance to maintain navigability of the ocean entrance and other areas with Gippsland Ports responsible for all dredging both inside and outside the Ramsar site (DSE 2003). While it is understood that most dredge material is disposed of offshore, sand has also in the past been dredged for replenishment of beaches and eroding shorelines.

Activation of acid sulfate soils

Like most low-lying coastal wetland areas, the Gippsland Lakes region has a high incidence of potential acid sulfate soils (ASS) that when oxidised will release sulfuric acid into the environment. ASS are easily activated (for example, oxidised) by altered water regimes leading to significant reductions in pH and associated impacts to aquatic species such as fish kills and other sub-lethal stresses.

Recreation and tourism

Recreation and tourism is a critical service of the wetland, but high visitor numbers and associated recreational activities can pose a threat to wetland values. Particular issues include:

- Disturbance to fauna species, particularly waterbirds, at feeding and nesting sites or during the breeding season.
- Boating activities that can damage foreshore flora, disturb fauna and introduce a range of pollutants through boat sewage, in terms of the siting of pump-out stations and installation of boat holding tanks at key boating localities, boat wash and subsequent erosion, leaching of anti-fouling compounds, fuel spills etc.
- Camping and recreational fishing leading to problems associated with litter, water pollution, fire, removal and damage to native vegetation, and associated soil erosion and soil compaction (Parks Victoria 1997).
- Hunting for hog deer and waterbirds, which can create both physical and noise disturbance to fauna and result in the accidental shooting of protected and threatened fauna species and contamination of wetlands from long term accumulation of lead shot (DSE 2003). The use of lead shot for duck hunting in Victoria has been prohibited for more than a decade.

Projected population growth in urban areas in Victoria will continue to place pressure on Gippsland Lakes as a recreation and tourism resource.

Fire

Wildfires can cause, indirectly, significant losses to wetland values. In one case, a lightning-started wild fire in Dowd Morass within the past approximately five years also caused localised direct impacts. Major wildfires in the Gippsland Lakes catchment occurred in 1939, 1965, 1978, and 1983, burning areas of up to 100 000 hectares in a single fire season (DSE 2003). More recently, there have been major fires within the Gippsland Lakes catchment in 2006 and 2007, burning up to 600 000 hectares of land.

Stream sedimentation and turbidity, due to the loss of protective vegetation cover, are likely to significantly increase immediately following such fires. Flooding following significant fires in the western catchments in 2006-2007 transported large amounts of nitrogen during runoff leading to major algal blooms in the Lakes. The principal causes of wildfires are lightning strikes, deliberate lighting by arsonists, barbeques, campfires, mismanaged burns on private property and inappropriate fuel reduction burning. It is noted that drought and high temperatures associated with climate change, combined with an expected increase in the incidence of storms, are expected to exacerbate fire risk in the region in the future. Suppression of fire can also have a significant impact on the environmental values of some wetland ecosystems, by adversely affecting the diversity of flora and its dependent fauna (DSE 2003). Heathland communities require prescribed burning to produce mosaics of different aged heaths in order to maintain species diversity. The endangered metallic sun-orchid (refer critical service 2) for example also requires sensitive management of fire regimes in its habitat (DSE 2003).

Erosion

The foreshores of the Gippsland Lakes Ramsar Site have been subject to periodic as well as long-term erosion in large part due to loss of fringing reed beds as a result of increased salinity (Sjerp et al. 2001). Climate change induced sea level rise (refer discussion below) and increased intensity of tidal storm surge has the potential to significantly increase foreshore/shoreline erosion and inundation processes.

Algal blooms

The nutrient loads to the system from catchment flows are high enough to stimulate growth of phytoplankton blooms, which are regularly observed in the Gippsland Lakes. Aside from external supply of nutrients from the catchment, the sediments in the Gippsland Lakes provide another important internal source of nutrients supporting phytoplankton growth.

While efforts to reduce catchment nutrients continue to be a priority (with projects funded by the Gippsland Lakes Taskforce and WGCMA on-going), it is highlighted in Cook et al. (2008) that there may be a need to also examine options to temporarily reduce stored phosphorous from the bottom waters and sediments. A range of measures are discussed including application of a clay product, *Phoslock* that removes phosphorous from the water column and traps it within the sediment as well as adding additional nitrogen to the lakes to achieve a more favourable N:P ratio. However, neither of these options presents optimal solutions in terms of cost and possible environmental side effects (Cook et al. 2008).

Related to the discussion below on climate change, increased saline intrusion into the Gippsland Lakes system through a breach in the Boole Boole Peninsula as a result of sea level rise may have the unexpected positive impact of reducing the frequency of *Nodularia* algal blooms, which are sensitive to salinity but would favour more salt-tolerant phytoplankton species including *Synechococcus* (Cook et al. 2008).

While considerable work has been undertaken to describe the biogeochemical triggers for algal blooms, how these algal blooms affect the ecology of the Lakes in terms of habitat values (for example, seagrass assemblages), critical species and life history functions (spawning, breeding, recruitment) remains a significant information gap across the site, except for a few specific studies (refer Hindell 2008 for example).

Based on the above, the frequency and severity of algal blooms remains a key threat to ecological character and continued research and monitoring is a priority in the Gippsland Lakes.

Climate change

As outlined in the Gippsland Estuaries Action Plan (GCB 2006), a sea level rise of seven to 55 centimetres is predicted across Western Port and the Western and Eastern coastal regions of Gippsland Lakes (0.8 to 8.0 centimetres/decade) by 2070. The Gippsland coast contains large areas of dunes that are vulnerable to erosion, which will be exacerbated by increases to sea level rise, more severe storm surges and high wave actions predicted under various climate change scenarios.

For the Gippsland Lakes, there is the potential for increasing sea levels to increase rates of erosion along the Ninety Mile Beach, which could eventually lead to breaches in the coastal barrier system that separates the Lakes from the sea.

CSIRO modelled the effect of climate change on extreme sea levels in Corner Inlet and Gippsland Lakes in 2006 (refer McInnes et al. 2006) using a set of high resolution hydrodynamic simulations. Through these analyses, areas likely to experience inundation during a one in 100 year storm tide event under current conditions are largely confined to several locations such as Baines Swamp, Big Swamp and Rigby Island (all of which are located near Lakes Entrance). However, under the high mean sea level rise climate change scenarios for 2030 and 2070, potential inundation from a similar one in 100 year storm tide event reveals much more extensive inundation especially around Big Swamp where inundation extends across Boole Boole Peninsula and Lake Reeve.

The conclusion of the study that Lake Reeve and the low lying saltmarsh along the inner edge of the coastal barrier are likely to be the first places to experience extensive inundation (as a result of increasing sea levels) is significant given the current values and ecosystem services that are provided by that part of the Ramsar site. The current ecology of the area as a non-tidal, predominantly hypersaline saltmarsh that has a low incidence of inundation would be significantly affected by such a change.

Accordingly, as outlined in McInnes et al. (2006), further investigation have been recommended in the context of the contribution of waves to extreme sea levels and long term shoreline responses due to the combination of land subsidence, increasing sea levels and wave climate through use of morphological models.

While attention to date in terms of climate change in the Gippsland Lakes 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
- 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
- increased temperatures and reduced flows/evaporation rates will increase fire risk, noting large scale fires followed by flooding are a significant trigger for algal blooms in the lakes

- changes in the patterns or intensity of agricultural use in catchment areas which may lead to increased water extraction requirements.

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.

6 CHANGES TO ECOLOGICAL CHARACTER

6.1 Timescales Used in the Assessment

In assessing changes to ecological character for Gippsland Lakes, the ECD examines:

1) matters affecting ecological character that pre-date listing as Ramsar site (principally long term salinity and hydrology changes through the permanent opening of Lakes Entrance)

2) changes that have been observed or documented since listing of the site as a Wetland of International Importance in 1982 up to the present time (as required by the National ECD Framework).

Item 1 has been included as part of this ECD to recognise and discuss the long term trends that affect the ecological character of the site, many of which were occurring prior to listing of the site in 1982 and have continued to influence the site's character in the intervening period to the present time.

6.2 Matters Affecting Ecological Character Prior to Listing

Up until the late 19th century, the Gippsland Lakes was an intermittently closed and open lagoon system, separated from the Southern Ocean by a series of low sand dunes. Riverine discharge meant that fresh water would accumulate in the lagoons and wetlands until high water levels eventually breached the dune system; a temporary opening was then created that allowed a connection with the ocean until sand transport down the Ninety Mile Beach closed the breach and freshwater conditions slowly re-established. The permanent opening of Lakes Entrance in 1889 (and subsequent dredging to maintain the Entrance for shipping) set into motion a long-term change in the character of the site from this intermittently closing and opening estuarine system, with significant freshwater lacustrine (lake) and palustrine (marsh/morass) features, to a more open marine-estuarine system that is regularly influenced by coastal tides, currents and storm surges. Thus the Gippsland Lakes system now shows a salinity gradient from east to west, with the easterly sections almost totally marine and the most westerly sections largely freshwater. Moreover, the creation of the permanent entrance allowed average water levels in the lagoons (and therefore also in the fringing wetlands) to drop by approximately 0.5 metres, as fresh waters no longer built up behind the closed dune system, instead being able to discharge quickly to the sea. As a result of these long term changes in salinity and water-level regimes, the only remaining 'permanent' freshwater features are Macleod Morass (due partly to storm-water discharge and inputs of treated sewage) and Sale Common, although most of the morasses and swamps along Lake Wellington may exhibit freshwater conditions after very large floods.

The current brackish-water conditions existing within Lake Wellington (which ceased to be a freshwater system in the mid-1960s, following severe drought and bushfires, resulting in saline intrusions from the easterly lagoons) have resulted from long-term estuarine processes, highlighted recently by several large floods events in the eastern lakes that caused the overflow and spillage of large quantities of salty water through McLennan Strait into Lake Wellington (Chris Barry, GCB, *pers. comm*. 2009). This process is a direct consequence of the large size of the Gippsland Lakes, as river discharge from the westerly rivers (for example, Latrobe, Thomson, Macalister) may be out-of-sync with that of the easterly rivers (for example, Nicholson, Mitchell and Tambo). The salinity shift that has taken place in Lake Wellington has seen major shifts in floristics, fish populations and human amenity.

The long-term transition of the western Gippsland Lakes system from a predominantly freshwater system at the time of European settlement into a more estuarine system has led to corresponding changes in the ecological structure and function of site over time (DSE 2003). In general it would be expected that freshwater-dependent flora and fauna species and communities, while still able to preferentially inhabit or use the site during periods of high freshwater flow, are under increasing stress and are likely to be gradually replaced by those species and communities better adapted to more marine and estuarine conditions, or otherwise to the more variable estuarine and brackish conditions in Lake Wellington and the western lake and marshes.

This general hypothesis is substantiated as part of various studies documented in Ecos (unpublished) about wetland habitat and fauna populations over time which are summarised below:

- **Freshwater macrophytes in Lake Wellington:** Freshwater taxa, such as *Vallisneria*, seem to have disappeared after the drought-bushfire-flood-saline intrusion cycle of the late 1960s and not regrown. Lake Wellington is now dominated by phytoplankton, including periodic outbreaks of cyanobacteria (that is, algal blooms). As a result, Lake Wellington has experienced a change in state, and has switched from a macrophyte-dominated system to an algal-dominated system.

- **Seagrass:** There is long term variability in seagrass cover and density in the main lakes (King and Victoria). Roob and Ball (1997) showed clearly that there has been a continual fluctuation in seagrass cover at five sites within the Gippsland Lakes Ramsar site over their study period 1959 to 1997. This variability matches the long-term (decadal) variability observed for seagrass beds in south-eastern Australia since the 1970s. A near-complete loss of seagrasses was reported for the Gippsland Lakes between the 1920s and the 1950s (Coles et al. 2003).

- **Phytoplankton blooms:** Long term salinity changes to the lagoons within the site, in connection with long term nutrient loading from the catchments have made it more prone to cyanobacteria blooms, specifically *Nodularia* as discussed previously in this report.

- **Fringing reedbeds and wetlands vegetation:** The study by Boon et al. (2008) for shifts in vegetation from 1964 to 2003 in Dowd Morass showed the very clear decline in area of common reed (*Phragmites australis*) and increase in area of swamp paperbark (*Melaleuca ericifolia*). There were 467 hectares of common reed community in Dowd Morass in 1982, a decrease of 10 hectares from 1973. The area of swamp paperbark in 1982 was 515 hectares, an increase of 394 hectares over that recorded for 1973. These results indicate clear and substantial changes were occurring in the relative (and absolute) areas of common reed and swamp paperbark in this wetland over time around the time of listing, and it is likely that they reflect changes that have occurred in many other parts of the Gippsland Lakes (for example, see Bird 1986; Crossco 2002).

- **Carp:** Carp represent both a threat (through its role in habitat disturbance particularly in the less saline waterbodies of the site) and also represents a freshwater commercial fishing resource. Carp was introduced into the Gippsland Region in the 1960s for the purpose of farm dam stocking. They have been abundant in the lower Latrobe and Lake Wellington since the 1970s, prior to Ramsar listing, and now reach very high abundances in the Mitchell and Tambo Rivers, particularly during low flow periods.

- **Drainage works:** Corrick and Norman (1980) reported that drainage works had eliminated 27 wetlands (of 5625 hectares) and reduced the surface area of another 18 (by 1913 hectares) within the Gippsland Lakes system. These works pre-date the listing of the site in 1982, but continue to affect the hydrological regimes of wetlands such as Dowd Morass, the Heart Morass, and Lake Coleman

- **Native freshwater fish:** The regional conservation status of several species has changed over time, due to changes in habitat (triggered by the permanent mouth opening and subsequent changes), water regime (resulting from upstream water regulation and extraction) and catchment condition (resulting in poor water quality in some of the streams and lakes of the Gippsland Ramsar site). The gradual and persistent changes towards a more marine system have seen the extent of habitat for freshwater fish significantly reduced (due to the twin effects of the permanent mouth opening and reduced upstream inflows), and significant reductions in the populations of these fish. A key species for the site, dwarf galaxias (*Galaxiella pusilla*), is a freshwater fish requiring highly vegetated aquatic systems, and shallow temporary wetlands such has Macleod Morass. However, dwarf galaxias is thought to have declined in extent significantly since settlement due to habitat modification (Corrick and Norman 1980) and was likely experiencing decline prior to Ramsar listing.

While the conversion of areas of the Gippsland Lakes to more estuarine conditions represents a change from what the Lakes were in pre-European times, not all changes to ecological character can be viewed as being adverse in the context of the now broader criteria of the Ramsar Convention. The site now supports large populations of migratory and resident waterbirds that prefer estuarine and nearby marine habitats for important life cycle activities (such as feeding and roosting). Estuarisation has promoted growth of seagrass assemblages in the main lakes, and through the maintenance of the permanent opening at Lakes Entrance a high diversity of marine/estuarine fish and invertebrate species and fish habitats now exist (relevant to Criterion 8).

6.3 Assessment of Ecological Character Changes Since Listing

When considering changes in ecological character of the site, the National ECD Framework requires the ECD to examine any changes to character that have occurred since the listing of the site in 1982.

The nomination documentation for the site (see Victorian Ministry for Conservation 1980) is brief (one typed page). As discussed in Section 2 of this document, it summarises environmental values to waterbird at the time of listing, as well as providing estimated extents of specific wetland features within the site (Macleod Morass, Lake King and so on).

As a result, a range of other information sources have been reviewed in an attempt to identify/characterise the baseline conditions of the site at the time of listing and to assess any anecdotal or documented changes to ecological character since listing. Key points are as follows:

- **Salinity from estuarine and marine inflows:** The ‘estuarisation’ of the site was well progressed at the time of listing and there is some evidence that floristic changes (for example, loss of reed beds along Lake Wellington) had already occurred within 20 years of the entrance being opened. Nevertheless, it may take centuries for the full impact of the artificial opening to become apparent.

- **Increased river regulation and diversion:** Over the past 25 years there has been a documented reduction in the diversity and volume of surface water flows into the Gippsland Lakes system from the construction of significant water infrastructure (Thomson Dam) to supply water to Melbourne in the late 1970s, from water extraction for irrigation purposes and from increased taking of water for industrial use. This in turn has been exacerbated by increased salinity from a combination of marine inflows, groundwater interaction which has developed predominantly from poor catchment management practices (clearing of vegetation and evapotranspiration) and fires (as a major contributor to vegetation loss and increased evaporation rates) (Boon et al. 2008; SKM 2009). While most of the eastern rivers that flow into water bodies such as Lake Victoria and Lake King largely retain their natural flow regime, the western river catchments that flow into Lake Wellington and its fringing wetlands, such as the Latrobe-Thomson-Macalister system and Avon River are heavily regulated with only large flows reaching the lakes. It has been observed that the absence of smaller, more variable freshwater flows events (that previously occurred in these catchments on a seasonal basis prior to increased water regulation and extraction) have had an impact on the fringing wetlands which, as natural sinks, support important wetland biological processes such as reproduction and recruitment of *Melaleuca* communities that are critical for colonial bird breeding.

- **Water quality and algal blooms:** The larger lakes (particularly Lake Wellington) have been heavily affected by catchment inputs (CSIRO 1998 and 2001) and the increased incidence of algal blooms brought about mostly by the flux of nutrients into the system. Fine sediments and higher turbidity from catchment runoff have also become more permanent features of shallow water bodies like Lake Wellington, contributing to poor water quality and conditions that preclude submerged macrophytes from re-establishing in the lake substrate.

Algal bloom in the Gippsland Lakes in 2008 (source: Paul Boon)

While these physico-chemical changes to water quantity and quality in the Ramsar site continue to be observed and studied, there is little information available to quantify the associated ecological impact of the changes, particularly in the context of critical components and processes such as waterbird abundance and usage and impacts to key life-cycle functions such as breeding.

Table 6-2 (which appears at the end of this section) has been prepared to summarise information about the various wetland and waterbodies within the site at a local scale, in order to qualitatively describe impacts/changes to those values that have been documented in various literature since 1982.

Some of the key conclusions that can be drawn from Table 6-2 are as follows:

- There is poor baseline data and understanding of the conditions of each of the wetlands at the time of listing. The information contained in the Table is highly qualitative and based on information from plans, strategies and scientific papers about the wetland/waterbody areas as opposed to empirical studies.
- There is little information or data available that has been systematically collected over the intervening period since listing from which to quantitatively assess whether the values of each waterbody/wetland continues to exist or function since listing. This is a major information gap in assessing changes to ecological character of the site. As a result it is difficult to provide definitive advice about whether the values of the wetlands have been retained or the extent or reversibility of any adverse impact.
- Notwithstanding the above, even in the absence of quantitative data, the ecological character of several waterbodies/wetlands (for example, Lake Tyers) is unlikely to have changed since listing

based on the conservation-based management regime in place for the area and the relative absence of threatening processes.

- An improvement in ecological condition since listing could be argued in some locations based on documented investment in restoration and rehabilitation measures (see Parks Victoria 2003 for Macleod Morass; Parks Victoria 2008 for the Heart/Dowd Morass) but again a lack of baseline condition data and information prevents quantification of any net environmental gain.
- For other wetlands in the system, aspects of ecological character have likely declined as a result of changes in hydrology and water quality (nutrients, suspended solids and salinity). This is most prominent in the marshes/morasses in the western portion of the site and in Lake Wellington (noting some of these impacts had or were already occurring at the time of listing). This is discussed further in the context of the assessment of ecological character against LAC (see section 6.4), noting the reasons for the changes are likely to be a combination of natural and anthropogenic causes.

Based on the information that is available, some specific examples of aspects of ecological character (related to critical components of this ECD) that have reduced or declined are discussed below:

Waterbird usage and abundance

A general decline in the site's waterbird population has been noted by Ecos (unpublished), though the body of count data is identified in that source as being insufficient to confidently detect trends in waterbird abundance since 1982. Table 6-1 shows the trends in species/group usage of the site (at various locations) based on information about flock sizes and annual average counts presented in the technical appendix to Ecos (unpublished).

While these reductions could be the result of factors outside of the site boundaries in terms of broader migratory waterbird usage patterns, Ecos (unpublished) asserts that trends in abundance for both "declining" and "increasing" species within the site are linked to changes in salinity (as a result of reduced freshwater catchment inflows from a combination of drought and/or anthropogenic impacts, subsequent saline intrusion, and concomitant effects on aquatic flora and fauna, and fringing vegetation).

Salinity may cause profound changes in aquatic fauna and flora on which waterbirds are dependent (Hart et al. 1990 and Froend et al. 1987 in Kingsford and Norman 2002, Halse 1987) and many waterbirds are considered to be intolerant of salinity above about 5000 micrograms per litre (Loyn et al. 2006).

For Gippsland Lakes, Ecos (unpublished) noted a pattern of increasing abundance in the mid-1990s (a period of high rainfall and flooding) was found for almost all of the site's waterbirds, with the exception of those considered tolerant of highly saline conditions (for example, Black-wing Stilt) or marine species (for example, crested tern) which showed an opposite trend. This contrasts with generally suppressed levels of waterbird abundance during the 1980s and since 2000 (concomitant with evidence of lower levels of freshwater inputs and higher ambient salinity levels in wetlands and waterbodies).

Table 6-1 Trends in the populations of important waterbirds (adopted from Ecos unpublished)

Common Name	Trend	Comments (summarised from text presented in Ecos)
Australasian bittern	Declining	Probably lost as a breeding species due to loss of *Phragmites* habitat
Australasian glebe	Declining	Appears to have been rapidly lost from breeding sites in recent years
Australasian shoveller	Declining	May be continuing to decline as a breeding species below 1980s levels although large flocks have been reported in the 2000s
Australian pelican	Increasing	Breeding population appears to be increasing based on average annual count size
Australian shelduck	Possibly Declining	No substantial variation reported but recent declines
Australian white ibis	Possibly Declining	No substantial variation reported but recent declines
Australian wood duck	Increasing	Substantial increase since the 1980s
Banded stilt	Increasing	More local usage possibly in relation to refugia values of the site and lack of suitable inland habitat
Black swan	Declining	Somewhat stable but average annual count sizes have been declining in recent years
Black-winged stilt	Increasing	Some evidence of increase since 1980s – Roseneath wetlands are a key breeding site
Blue-billed duck	Increasing	Some evidence of increase in Macleod Morass since 1980s
Caspian tern	Stable	Large increases in the 1990s have since stabilised
Chestnut teal	Stable	Stable noting slight decrease in reporting rates but substantial increases in flock size since the 1980s
Common greenshank	Stable	No substantial variation reported since 1980s
Common tern	Stable	Stable despite high degree of natural variability observed since the 1970s
Curlew sandpiper	Stable	No substantial variation reported since 1980s
Dusky moorhen	Substantial Decline	Substantial declines across Gippsland Lakes since the 1970s. Largely absent from eastern end of the Lakes, occurring in predominantly freshwater habitats of Sale Common, Macleod Morass and fringing wetlands of Lake Wellington
Eurasian coot	Substantial Decline	Very substantial decline in flock size and reporting rate since the 1980s. Key habitats include Roseneath and western Lake Victoria, Dowd Morass and Silt Jetties
Fairy tern	Stable	No substantial variation reported since 1980s
Great cormorant	Stable	No substantial variation reported since 1980s
Great crested grebe	Substantial Decline	Very substantial decline in flock size and reporting rate since the 1980s. Key habitats include *Vallisneria* eel grass habitats as well as Jones Bay and Roseneath Peninsula
Great egret	Declining	Reporting rate has declined by about 50 per cent since the early 1980s. Common in the fringing brackish and freshwater morasses (Dowd, Heart, etc.)
Grey teal	Possibly Declining	High degree of variability – recent reduction in reporting rate
Hardhead	Stable	Reduction in numbers between 1980 and 1999 but have now recovered
Hoary-headed grebe	Substantial Decline	Substantial decline in both reporting rate and average flock size compared to 1980s. Victoria Lagoon in the Roseneath Wetlands is a key habitat area along with other freshwater wetlands areas and Lake Reeve. Link to *Vallisneria* eel grass habitats which have been lost from Lake Wellington prior to listing of the site
Hooded plover	Stable	No substantial variation reported since 1980s
Latham's snipe	Stable	No substantial variation reported since 1980s
Little black cormorant	Increasing	Increase in annual count size suggesting it may be occurring more commonly
Little pied cormorant	Stable	Decline since 1990s but numbers now appear similar to 1970s and 1980s
Little tern	Stable	May have increased since the 1980s
Musk duck	Substantial Decline	Substantial decline since the 1970s – some rebound in the 1990s but trending downward
Nankeen night heron	Substantial Decline	Average annual counts sizes declining since the 1980s
Pacific black duck	Possibly Declining	May be experiencing reduction in the number of breeding birds using the site
Pacific golden plover	Stable	No substantial variation reported since 1980s

Common Name	Trend	Comments (summarised from text presented in Ecos)
Pied oystercatcher	Stable	Stable with some increases shown since 1990s
Pink-eared duck	Stable	No substantial variation reported since 1980s
Purple swamphen	Substantial Decline	Very substantial decline since the 1990s likely due to loss of suitable habitat at Heart Morass
Red-kneed dotterel	Substantial Decline	Key habitat is Macleod Morass – low occurrence of this species in the past decade
Red-necked avocet	Increasing	Substantial increase since the 1980s
Red-necked stint	Possibly Declining	Substantial decline in the 1980s but recovery in the 1990s
Royal spoonbill	Increasing	Notable increase in reporting rate since 1980s
Sharp-tailed sandpiper	Stable	No substantial variation reported since 1980s
Straw-necked ibis	Stable	Increased in 1990s but has since declined. Still reported in higher levels than 1980s
Whiskered tern	Stable	No substantial variation reported since 1980s
White-bellied sea eagle	Increasing	Notable increase in reporting rate since 1980s
White-fronted tern	Stable	No substantial variation reported since 1980s
Yellow-billed spoonbill	Possibly Declining	Stable but evidence of recent decline

Note: Colour key is as follows: Red = substantial decline; Orange = declining numbers possible below early 1980's level; Yellow = recent decline but numbers do not appear to be below early 1980s level; and Green = stable or increasing since the early 1980s. Source: Ecos (unpublished).

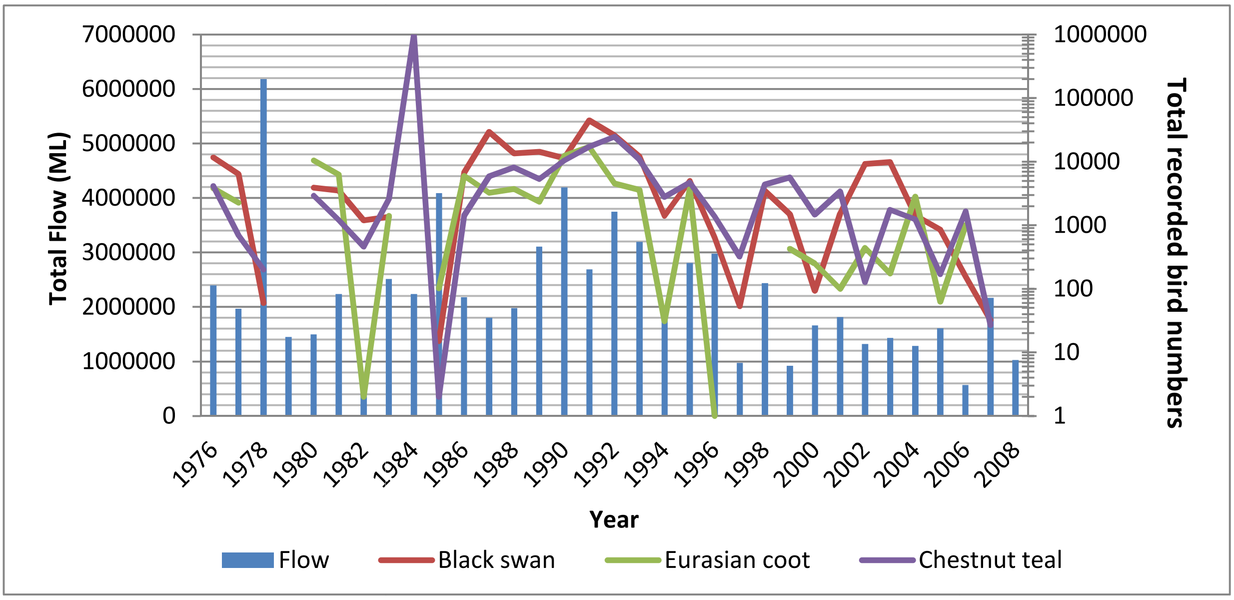
In addition to the information presented in Ecos, BMT WBM undertook additional analyses of waterbird count data provided as part of the current study which is presented in Appendix C. This data analysis relied on data provided from the Victorian Government DSE database as well as Birds Australia count data.

Several key species were selected for analysis as they have been identified in this ECD as significant species in the context of meeting the one per cent of the total population criterion.

Figure 6-1 shows that there is great year to year variability in bird counts. In summary, the analysis of DSE and Birds Australia data for the key species (see Appendix C) indicated the following:

- Little tern – DSE data indicate that average annual counts were greater in the 2000's than in previous years. This could reflect actual increases in abundance or higher sampling effort for this species. There was insufficient data in the Birds Australia database to determine trends.
- Fairy tern – DSE data indicate that highest counts of fairy tern were recorded during two years in the 1990's. However, it is noted that records/counts were very patchy over time and may reflect increased sampling effort rather than actual increased numbers. There was insufficient data in the Birds Australia database to determine trends.
- Musk duck – DSE data indicates that average annual counts have been consistently low since the late-1990s. In previous decades, numbers were relatively high (approximately 100 individuals counted), but variable between years. There was insufficient data in the Birds Australia database to determine trends.
- Black swan – DSE data does not reveal any clear long term temporal trend, reflecting due to inconsistencies in sampling effort. The standardised Birds Australia count data indicate a low reporting rate (and low average annual abundance) since 1990.
- Eurasian coot – Analysis of DSE data indicate that average annual counts were highly variable over time with a peak in 1990. However, no apparent long term trend could be discerned from the DSE data. Similar to black swan, the standardised Birds Australia count data indicate a low reporting rate (and low average annual abundance) since 1999.

- Chestnut teal – DSE data indicate that numbers appear to have been relatively stable over time, the exception being a peak in 1984. The standardised Birds Australia count data indicate that most surveys containing 20 minute count data occurred in the period 1988 through the 1990's, but there were was a low reporting rate post 2000.



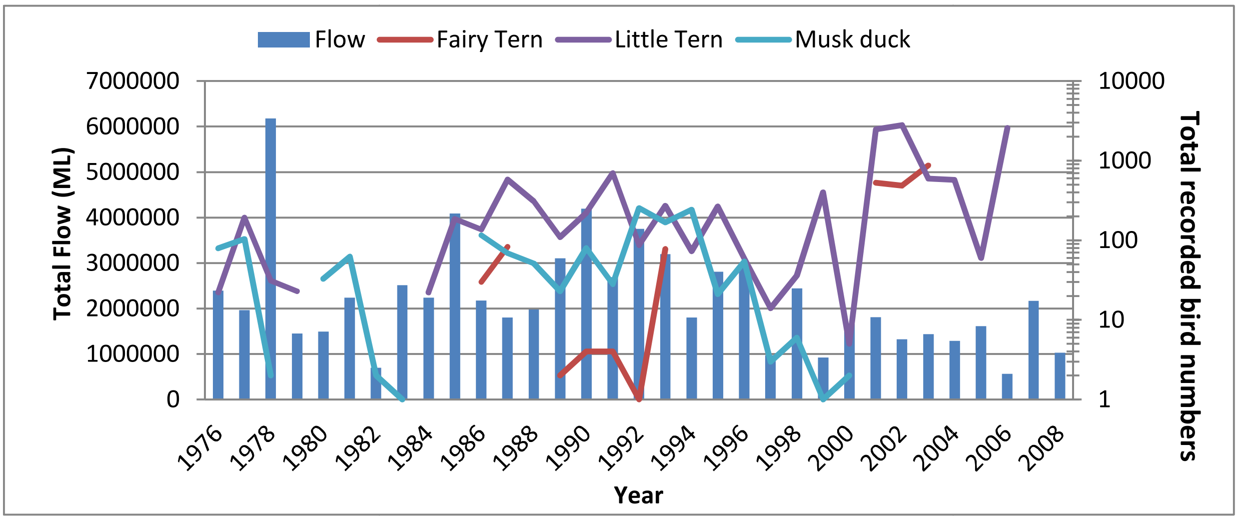


Figure 6-1 Total number of individuals recorded in each year for black swan, Eurasian coot, chestnut teal, fairy tern, little tern and musk duck, together with total annual river inflows into the site (DSE Database)

With some exceptions, this data review generally agreed with the findings of Ecos; namely that waterbird usage of the site since listing in 1982 generally shows that predominantly freshwater-dependent birds (for example, musk duck) are now occurring in lower numbers. However, in considering these trends it is important to note the following:

- Count data were not standardised in terms of survey methods, survey locations and survey effort. These can severely bias data, and therefore results should be considered as indicative only. Refer to Appendix C for discussion.
- The extent to which these patterns relate to drought conditions over most of this period, anthropogenic impacts from increased abstraction of water from contributing catchments, increased salinity impacts in traditional freshwater water habitats from the long term estuarisation of the Lakes, natural variation or a combination of these factors cannot be definitively determined based on the absence of comprehensive sampling data over time.

Wetland habitat condition

While there has not been a comprehensive assessment of habitat extent and condition across the Ramsar site, specific studies of particular wetlands and waterbodies within the Gippsland Lakes have shown more demonstrable changes to ecosystem condition than to extent. Two specific examples of observed changes to habitat condition include changes to the vegetation community structure at Dowd Morass (refer Boon et al. 2008) and changes to seagrass assemblages in the main lagoon system (refer Hindell 2008).

Long term studies of Dowd Morass discussed in Boon et al. (2008) show clear evidence of the conversion of *P. australis* reed-dominated systems to one that is dominated by *M. ericifolia* and swamp scrub over the period from 1964 to 2003, with the greatest rate of change during the period of 1982 to 1991. This change in the vegetation community structure is attributed within Boon et al. (2008) to changes in the hydrological regime (site drainage works undertaken in the 1970s caused more regular inundation of the morass) as well as persistent increasing salinity levels and microtopological relief within the system which impacts on plant reproduction patterns. As a management response, Dowd Morass was partially dried by Parks Victoria in 1995 and completely dried in 1998 with a more active management regime instigated through use of gated culverts since that time (Parks Victoria 2008). While each of the fringing wetlands within the Gippsland Lakes are somewhat unique, it has been postulated that similar changes to wetland vegetation communities have occurred in the other fringing wetlands of Lake Wellington, particularly at Clydebank Morass and Lake Coleman (which have even greater levels of salinity than Dowd Morass). However, there have not been historical studies of the vegetation communities at these wetlands to the same level of detail as Dowd Morass.

In studies of seagrass in the Gippsland Lakes, Hindell (2008) found that seagrass had lower densities than previous recordings by Roob and Ball (1997) with declines noted at 23 of the 30 sites sampled. The studies were undertaken principally to assess changes to seagrass assemblages in response to the persistent algal blooms within the Lakes in 2007, and it was noted by Hindell that the declines could reflect 'natural cycles in productivity or changes in environmental conditions that could be independent of the current phytoplankton blooms'. Recommendations were made for further studies using the 2008 study as a baseline. Based on the findings of the study, there have been reductions in the extent and condition of seagrasses at several locations in the main lakes, although the permanence of the change (and ability of the habitat to recover) remains a knowledge gap.

Black bream populations

Black bream catch has shown a marked decline since listing which is especially noticeable post-1986 (refer Figure 3-20). The cause/s of this change in catch are not fully known but likely relate to a combination of threats including reduced freshwater inflows, water quality and associated algal blooms, over-harvesting, and incremental habitat loss. Notwithstanding, the decline in catch (particularly during the period from the mid 1980s to 1990s when effort was equivalent to pre-1982 levels) could represent a decline in the overall abundance of this species. However, more detailed investigations are required to determine the key drivers of the observed changes.

Table 6-2 Waterbody/Wetland level assessment

NOTES:
[A] Information sourced from the Strategic Management Plan for the Gippsland Lakes Ramsar site (DSE 2003), previous Ramsar Information Sheets, nomination documentation as well as other sources listed in the References Section.

Waterbody/ wetland name	Habitat types and wetland values supported at time of listing (1982) ([A])	Description of trends/ impacts to wetland values during the period since listing (1982 – 2010)	Likely reason/source of impact(s)	Key indicators for assessing future impacts (links to Monitoring Needs)	Source of Information
Sale Common	Deep freshwater marsh Supports: • Waterbirds of significance such as little bittern, Australasian bittern, painted snipe and great egret • Example of a wetland type (freshwater marsh) now rare in the Gippsland Lakes region	Generally stable; values at time of listing are likely to continue to be supported Changes to flow regime and the seasonality of flow have been observed leading to loss of wetland connectivity and altered wetting and drying cycles Highly dependent on maintenance of flows from the Latrobe system Infestation of invasive weed Brazilian milfoil	Increased allocation of water for consumptive purposes from the Latrobe River system Reduced variability of flows from the catchment (more regular inundation) Long term hydrology changes from construction of Sale Canal Recreation usage possibly increasing weed impacts	Hydrology Water quality (pH, salinity, nutrients) Bird usage (breeding use and bird abundance) Presence of freshwater fish species Fringing vegetation extent and condition Weed dominance	WGCMA (2007) Ecos (unpublished)
Dowd Morass	Deep freshwater marsh Supports: • Ibis and spoonbill breeding colony • Waterbirds of significance such as great egret, hooded robin, little bittern, Australasian bittern, freckled duck, egret, painted snipe and white bellied sea eagle	Values at time of listing are likely to continue to be supported but ecological condition has deteriorated Broad scale (greater than 100 hectare) changes to fringing vegetation extent and community type (for example, *Phragmites* to *Melaleuca*) since listing Bird usage in smaller numbers than previously recorded Water quality now predominantly brackish except following high flow events. Low pH due to possible ASS impacts. Algal blooms recorded.	Long term salinity intrusion from Lake Wellington and catchment sources Reduced variability of flows from the catchment (more regular inundation during large events) Activation of ASS from altered water regimes as well as nutrient enrichment	Hydrology Geomorphology Water quality (pH, salinity, nutrients) Bird usage (breeding use and bird abundance) Fringing vegetation extent and condition Vegetation ratio of *Phragmites* : *Melaleuca* and possible increase in saltmarsh taxa	Boon et al. (2008); WGCMA (2007) Ecos (unpublished)
Heart Morass	Deep freshwater marsh Supports: • Ibis breeding colony in swamp scrub • waterbird usage including white bellied sea eagle	Values at time of listing are likely to continue to be supported but ecological condition has deteriorated Broad scale changes to vegetation extent and community type (for example, *Phragmites* to *Melaleuca*) and increased presence of *Juncus* (saltmarsh species)	Long term salinity intrusion from Lake Wellington and catchment Reduced variability of flows from the catchment (more regular inundation) Activation of ASS from	Hydrology Water quality (pH, salinity, nutrients) Geomorphology Bird usage (breeding use and bird abundance)	WGCMA (2007) Ecos (unpublished)

Waterbody/ wetland name	Habitat types and wetland values supported at time of listing (1982) (A)	Description of trends/ impacts to wetland values during the period since listing (1982 – 2010)	Likely reason/source of impact(s)	Key indicators for assessing future impacts (links to Monitoring Needs)	Source of Information
		Loss of terrestrial vegetation (for example, Eucalyptus species) as a result of secondary salinisation and/or water logging Water quality now predominantly brackish except following high flow events	altered water regimes as well as nutrient enrichment	Fringing vegetation extent and condition Vegetation ratio of *Phragmites* : *Melaleuca* and possible increase in saltmarsh taxa	
Lake Coleman and Tucker Swamp (within the site boundary)	Deep freshwater marsh (Lake Coleman {east} and Tucker Swamp) Supports: • Habitat for growling grass frog (EPBC) and waterbirds • Swamp Scrub communities in Tucker Swamp provide important breeding habitat for pied cormorant	Values at time of listing are likely to continue to be supported but ecological condition has deteriorated Long term hydrology changes leading to increased salinity in Lake Coleman Contaminants in water quality from sewage treatment and paper mill discharge can affect water quality Possible historic contamination residues from Department of Defence use	Long term salinity intrusion from Lake Wellington and the catchment Historical legacy of paper mill and sewage effluent at Dutson Downs Activation of ASS from altered water regimes as well as nutrient enrichment	Hydrology Water quality (salinity, nutrients and toxicants (residue from Defence use) Geomorphology Bird usage (breeding use by cormorants and bird abundance) Fringing vegetation extent and condition Vegetation ratio of *Phragmites* : *Melaleuca* and possible increase in saltmarsh taxa	WGCMA (2007) Ecos (unpublished) HLA (2007)
Clydebank Morass	Deep freshwater marsh Supports: • Waterbird usage but no substantial breeding colonies	Values at time of listing are likely to continue to be supported but ecological condition has deteriorated Long term hydrology changes; greater connectively with Lake Wellington as a result of major floods in 1990. Large areas are now permanently dry. Loss of fringing vegetation (reed beds) Greatly affected by salinity (including groundwater) with extensive saltmarsh species now present	Long term salinity intrusion from Lake Wellington and the catchment and decreased freshwater flows from river basins Reduced variability of flows from the catchment (more regular inundation) and groundwater salinity	Hydrology Water quality (salinity) Geomorphology Bird usage (bird abundance) Fringing vegetation extent and condition Vegetation ratio of *Phragmites : Melaleuca* and possible increase in saltmarsh taxa	Ecos (unpublished)
Lake Wellington	Permanent freshwater lake Supports: • Large numbers of waterbirds (black swan, crested tern, common tern)	Values at time of listing are likely to continue to be supported but ecological condition has deteriorated Significant water quality deterioration from	Decreased catchment runoff from large rivers Salinity results from marine inflows from the	Hydrology Water quality (salinity, turbidity and nutrients)	Ecos (unpublished)

Waterbody/ wetland name	Habitat types and wetland values supported at time of listing (1982) ([A])	Description of trends/ impacts to wetland values during the period since listing (1982 – 2010)	Likely reason/source of impact(s)	Key indicators for assessing future impacts (links to Monitoring Needs)	Source of Information
		nutrient and sediment inputs and associated algal blooms Loss of fringing vegetation (reed beds)	permanent connection to the sea at Lakes Entrance and groundwater salinity Increased water column turbidity as a result of sediment resuspension and lack of vegetative (seagrass) cover Nutrient enrichment from catchment sources	Sediment – water - nutrient flux Frequency/intensity of algal blooms Shoreline erosion/vegetation extent	
McLennan Strait and Isthmus and wetlands of Roseneath Peninsula Victoria Lagoon, Morley Swamp and Lake Betsy	Narrow coastal strait and estuarine wetland complex but including predominantly freshwater areas Supports: • Broad area supporting growling grass/ green and golden bell frog habitat • Feeding habitat for breeding waterbirds	Values at time of listing are likely to continue to be supported Vegetation reported to be largely intact but susceptible to increased salinity and conversion to saltmarsh Regular inflows from Lake Wellington	N/A	Hydrology Water quality (salinity) Bird usage (feeding) Presence of frog species Fringing vegetation extent and condition Vegetation ratio of *Phragmites : Melaleuca* and possible increase in saltmarsh taxa	Ecos (unpublished) WGCMA (2007)
Lake Victoria (including Blond Bay Wildlife Reserve but excluding Jones Bay)	Coastal brackish lake/lagoon with subtidal seagrass beds Supports: • Large numbers of waterbirds • Seagrass assemblages • Blond Bay supports breeding waterbirds	No major changes to ecological characteristics or functions were identified in the literature review Some water quality deterioration from nutrient and sediment inputs and associated algal blooms and increasing salinity Some decreases in the condition and dieback of seagrass has been observed as part of recent sampling but may reflect natural variability	Algal blooms driven from catchment nutrients are seen as the most likely cause of the changes	Seagrass extent/condition Sediment – water - nutrient flux Frequency/intensity of algal blooms Shoreline erosion/vegetation extent	Ecos (unpublished) Hindell (2008)
Lake Reeve	Saline coastal lagoon and saltmarsh complex (predominantly hypersaline) Supports: • Important breeding habitat for waterbird species	Stable - No major changes to ecological characteristics or functions were identified in the literature review	N/A	Geomorphology (integrity of sand dunes) Hydrology Saltmarsh vegetation extent and condition	Parks Victoria (1998) Ecos (unpublished)

Waterbody/ wetland name	Habitat types and wetland values supported at time of listing (1982) ([A])	Description of trends/ impacts to wetland values during the period since listing (1982 – 2010)	Likely reason/source of impact(s)	Key indicators for assessing future impacts (links to Monitoring Needs)	Source of Information
	• Nursery area for many fish species • Contains valuable remnants of vegetation communities that have been disturbed throughout their range			Sea level rise Fish usage	
Macleod Morass (freshwater because of stormwater and sewage)	Deep freshwater marsh Supports: • Ibis and black-winged stilt breeding colony • Roosting site for waterbirds • Habitat for green and golden bell frog, southern bell frog	No major changes to ecological characteristics or functions were identified in the literature review Some changes to flow regime from volume of outflows associated with STP Changes to water quality from STP discharge Loss of fringing vegetation (reed beds)	Increased allocation of water from the Mitchell STP discharge of wastewater into the wetland Management of flow regime and rehabilitation projects have been implemented to maintain/improve condition	Hydrology Water quality (nutrients) Bird usage (breeding, roosting) Presence of freshwater fish species Presence of frog species	Parks Victoria (2003) Ecos (unpublished) East Gippsland Water Reports
Jones Bay	Coastal brackish lake/lagoon Supports: • Large numbers of waterbird and migratory waterbirds	Stable - No major changes to ecological characteristics or functions were identified in the literature review Some water quality deterioration from nutrient and sediment inputs Initiation point for many algal blooms	STP discharge through Macleod Morass	Water quality (nutrients, salinity and turbidity) Frequency/intensity of algal blooms Sediment – water - nutrient flux Shoreline erosion/vegetation extent	Ecos (unpublished)
Lake King (including Lakes Entrance)	Coastal brackish lake/lagoon with subtidal seagrass beds Supports: • Large numbers of waterbirds • Supports one per cent of national little tern population and fairy terns	Some water quality deterioration from nutrient and sediment inputs and associated algal blooms Some decrease in the condition and dieback of seagrass has been observed as part of recent sampling but this may be part of natural variability	Algal blooms driven from catchment nutrients are seen as the most likely cause of the changes	Seagrass extent/condition Water quality (nutrients, salinity and turbidity) Sediment – water - nutrient flux Frequency/intensity of algal blooms Shoreline erosion/vegetation extent	Ecos (unpublished) Hindell (2008)
Lake Tyers	Intermittently closed and open lagoon (Lake Tyers) with seagrass beds	Stable - No major changes to ecological characteristics or functions were identified in the literature review	N/A	Submerged plant extent/condition	Fisheries Victoria (2007)

Waterbody/ wetland name	Habitat types and wetland values supported at time of listing (1982) ([A])	Description of trends/ impacts to wetland values during the period since listing (1982 – 2010)	Likely reason/source of impact(s)	Key indicators for assessing future impacts (links to Monitoring Needs)	Source of Information
	Supports: • Black bream and dusky flathead spawning site • Nursery habitat for fisheries • Waterbird feeding area • Lake Tyers is a historic breeding site for little tern • Green and golden bell frog habitat			Breeding usage by little tern Abundance of black bream and dusky flathead Sediment – water - nutrient flux Water quality (nutrients, salinity and turbidity) Shoreline erosion/vegetation extent	GCB (2006) Ecos (unpublished)
Lake Bunga and Lake Bunga Arm	Freshwater coastal lagoon intermittently opening to an estuary (Lake Bunga) with subtidal seagrass beds Bunga Arm supports: • breeding populations of fairy tern, hooded plover and white-bellied sea-eagle • Nursery habitat for fisheries	Stable - No major changes to ecological characteristics or functions were identified in the literature review Some decrease in the condition and dieback of seagrass has been observed as part of recent sampling but this may be part of natural variability	N/A	Breeding usage by seabirds (little tern) Water quality (nutrients, salinity and turbidity) Seagrass extent/condition Bird feeding habitat (on seagrass)	Ecos (unpublished) WGCMA (2007) Hindell (2008)

6.4 Assessment of Changes to Ecological Character Against LAC

The National ECD Framework requires that the assessment of changes to ecological character make reference to whether or not any limits of acceptable change (LAC) set as part of the ECD have been exceeded.

Drawing upon the waterbody/wetland scale assessment presented in Table 6-2, Table 6-3 provides an assessment against the LAC as outlined in Section 4 of this document. Table 6-4 provides a specific analysis of the LAC for the critical component wetland habitats focussing on whether or not the classification of the wetland (using Corrick and Norman 1980) has changed since listing.

Table 6-3 Assessment of ecological character changes against LAC

LAC		Has there been an exceedance of the LAC since listing?	Comments
LAC for Critical Components – Habitats (refer Table 4-1)			
Habitat Extent/Condition	(C1) Seagrass and subtidal algal beds	Uncertain but possible. Seagrass assemblages show considerable natural variability but appear to have significant reduced densities and extent since 1997 based on recent assessments by Hindell based on original mapping by Roob and Ball. The rate of recovery of these assemblages following cessation of algal blooms and increased rainfall in unknown, and Hindell did not rule out that observed changes could have been a result of natural variability.	Refer to recent seagrass assessment by Hindell (2008).
	(C2) Saline or brackish lagoons	Unlikely; water quality shows episodic loads of total suspended solids and nutrients but long term stability with the median baseline (that is, pre-listing values) between the 20^{th} and 80^{th} percentile values for key parameters. Refer Appendix B. There has not been a 'change in state' in terms of the eastern lakes since listing whereas Lake Wellington was already considered to have turned from a predominantly clear, macrophyte dominated system to a more turbid, algae-dominated system prior to listing (c. 1965).	The incidence of recent algal blooms in the eastern lakes are likely an acute rather than chronic response to nutrient and sediment loads as a result of large fires in the catchment in 2007. Lake Tyers remains in a near natural state with representative habitats for the drainage division.
	(C3) Fringing wetlands - freshwater	Uncertain but possible due to drought and reduced freshwater inflows. The draft Management Plan for Macleod Morass (Parks Victoria 2003) discusses the trend of common reed and cumbungi	There has not been an ecological condition assessment of Sale Common or Macleod Morass reviewed as part of the current study. Long term habitat extent (based on analysis of EVC) is relatively stable.

LAC		Has there been an exceedance of the LAC since listing?	Comments
		replacing/supplanting giant rush communities. Water quality and hydrological impacts on ecological values is an information gap within these wetland systems.	Likewise, it is unlikely there has been the loss of any of the identified wetland types since listing.
	(C4) Fringing wetlands - brackish	Uncertain but possible based on the fact that long term changes to vegetation structure at least one morass (Dowd) have occurred and similar effects have been observed at neighbouring wetlands. Based on studies by Boon et al. (2008), less than 50 per cent of the *Phragmites* reed habitats present within Dowd Morass have been replaced by *Melaleuca* indicating that this LAC has been met since listing. Water quality and hydrological impacts on ecological values is an information gap within these wetland systems.	Long term habitat extent (based on analysis of EVC) is relatively stable. The key issue is the declining condition of the habitat in the context of the loss/replacement and structure of key vegetation community types (*Phragmites* being replaced by *Melaleuca* and saltmarsh species), and the extent to which this has been caused by underlying critical processes such as the freshwater flow regime and tidal inflows. Refer to the long term study by Boon et al. (2008) for Dowd Morass. The other wetlands require similar studies about long term extent and condition to be carried out.
	(C5) Fringing wetlands - saltmarsh	Unknown but unlikely on the basis that these species are resilient to changes or increases in salinity within the range of natural variability. Water quality and hydrological impacts on ecological values is an information gap within these wetland systems.	Lake Reeve remains in a near natural state with representative habitats for the drainage division. Key saltmarsh areas within the site are also largely contained in protected tenure (for example, Lake Reeve). Long term changes to hydrology (for example, from climate change) may have a future impact on these communities. Long term habitat extent (based on analysis of EVC) is relatively stable. Likewise, it is unlikely there has been the loss of any of the identified wetland types since listing.
LAC for Critical Components – Species (refer Table 4-1)			
Species/Groups	(C6) Waterbirds	Unknown but possible based on overall reduction in bird usage as noted in Ecos (unpublished). In terms of the species listed in the previous RIS (Casanelia 1999) as meeting the one per cent threshold, musk duck (*Biziura lobata*), and Eurasian coot (*Fulica atra*) are most likely to no longer meet the Convention requirement for the site. The other one per cent species are reported by Ecos (unpublished) as possibly declining or relatively stable.	Trends in waterbird usage have been derived by Ecos (unpublished) but do not represent actual bird counts or a formal comprehensive survey. The survey data considered in the present ECD (see Appendix C) were insufficient to derive an appropriate empirical baseline. As indicated in the LAC, a more reliable baseline (with multiple sampling episodes over a ten year period) is needed to assess this LAC over time.
	(C7) Threatened frogs	Unknown; through key habitat (freshwater/brackish wetlands) are in decline in some areas.	Presence and usage of the site by these species is not well understood; suitable habitats include McLennan Strait, Sale Common, Macleod Morass and the Heart

LAC		Has there been an exceedance of the LAC since listing?	Comments
			Morass.
	(C8) Threatened flora species	Unknown due to a lack of information about species usage of the site.	Presence and usage of the site by these flora species is not well understood or documented; suitable habitats include various terrestrial wetland habitats including mesic heathlands, swamps and waterbody margins. It is notable that metallic sun orchid has become nationally endangered since the listing of the site.
LAC for Critical Processes (refer Table 4-1)			
(P1) Hydrological regime		General LAC for hydrology have been set based on expert opinion and literature review. It is unknown whether they have been exceeded since the listing date for the wetlands listed. More defined ecological flow requirements for the hydrological regime of the Gippsland Lakes have been determined as part of the Environmental Water Requirements study (Stages 1 and 2 – refer Tilleard et al. 2009 and Tilleard and Lawson 2010). The extent to which these flow objectives have been met since listing or are currently being met will require more detailed modelling and historical analysis that is outside the scope of the current study.	The environmental water requirements for various wetlands and their values as mentioned in this ECD are currently being considered and assessed by the Victorian Government as part of the implementation of the Sustainable Water Strategy (State of Victoria 2010).
(P2) Waterbird breeding		Unknown but possible for certain species in terms of breeding success and overall waterbird usage.	While trends in waterbird usage have been derived by Ecos (unpublished), these are not based on actual bird counts or a formal comprehensive survey of life cycle functions such as key breeding sites, roosting sites and similar. This is a key information gap noting that waterbird usage would also have been affected by the persistent drought conditions over the past decade but may be recovering following more recent conditions.
LAC for Critical Services/Benefits (refer Table 4-1)			
(S1) Threatened species		See above for threatened species that are critical components. In relation to painted snipe and Australasian bittern - Unknown; though key habitats (*Phragmites* reed beds) are in decline in some areas (McLennan Strait and Dowd Morass).	Presence and usage of the site by these species is not well understood. Suitable habitat exists in McLennan Strait, Sale Common, Dowd and the Heart Morass, Macleod Morass and upper reaches of Lake Tyers. Ecos (unpublished) reports that Australasian bittern may be lost as a breeding species in the site but how this

LAC	Has there been an exceedance of the LAC since listing?	Comments
		has been determined is unknown.
	In relation to Australian grayling, unknown due to a lack of information about species usage of the site but unlikely.	Based on environmental flow assessments for the Thomson and Macalister Rivers, it was argued that abundances of this species were low and populations were unlikely to be self sustaining (Thomson Macalister Environmental Flows Task Force 2004) in these Rivers. However, the other river catchments (for example, Mitchell, Nicholson, Tambo) would likely continue to support Grayling. Presence and usage of the site during the obligate larval stage of this species is not well understood; a survey of the species usage of the site is required.
(S2) Fisheries resource values	Unknown. An ecological character change is possible in relation to black bream populations which show a marked decline in abundance since 1986.	Refer to recent seagrass assessment by Hindell (2008) and analysis of black bream populations in the Lakes (Section 3 of this document). Black bream spawning occurs in the tidal interface/lower reaches of the rivers leading into the site including upper areas of Lake Tyers. The extent to which spawning activity has been affected by long term and contemporary environmental conditions is unknown. A series of surveys would be required to establish a baseline and to determine any change in fish species richness and in the context of life cycle history usage and proportions of the key fish species.

Table 6-4 Assessment of ecological character changes against LAC for wetlands habitat types

Wetland type (based on Corrick and Norman 1980)	**Description of typology[10]**	**Has the 1980 typology been maintained since listing?**
Deep freshwater marsh	Wetlands that generally remain inundated to a depth of one to two metres throughout the year during years of average or above average rainfall. Using the description of the 'saline wetland' type as a guide (see below), water quality in these wetlands should generally be less than three grams per litre.	Sale Common and Macleod Morass – No change in typology is determined to have occurred in these wetlands since listing.
		Dowd Morass – The typology is largely still applicable as the wetland continues to be managed as a freshwater wetland (Parks Victoria 2008). However, it should be noted that the wetland experiences brackish/saline water quality conditions (between 2.6 and 12 grams per litre) with periods above the three grams per litre limit. In terms of inundation and water depth, the wetland has been actively managed since 1997 to allow more periodic wetting and drying that is characteristic of the wetland's hydrology during pre-European settlement (Tilleard and Ladson 2010; Parks Victoria 2008).
		The Heart Morass - The typology is largely still applicable. Similar comments to Dowd Morass in terms of salinity and management regime.
		Clydebank Morass and Eastern Lake Coleman (for example, Tucker Swamp) – these wetlands experience more persistent high salinity levels (greater than six grams per litre and up to 29 grams per litre) and have characteristic saline/brackish vegetation communities present. It could be argued they now should be classified either as 'semi-permanent saline' or as 'permanent saline wetlands' using the Corrick and Norman classification system.
Permanent open freshwater	Wetlands that are usually more than one metre deep. They can be natural or artificial. Wetlands are described to be permanent if they retain water for longer than 12 months; however they can have periods of drying.	Lake Wellington – Water quality data shows that it experiences a wide range of salinity conditions (ranging from 0.2 to 21 grams per litre based on EPA data from 1986 – 2008 – refer Section 3 of this document) but this may not be considered sufficient to change its characterisation to a 'permanent saline wetland'. Based on this, it is suggested that the typology 'permanent open freshwater' is still appropriate.
Semi permanent saline	These wetlands may be inundated to a depth of two metre for as long as eight months each year. Saline wetlands are those in which salinity exceeds three grams per litre throughout the whole year.	Lake Reeve; wetlands around western Lake Victoria (McLennan Strait) – No change in typology is determined to have occurred in these wetlands since listing.
Permanent	These wetlands include coastal	Lake Tyers, Lake Victoria, Lake King – No change in typology is

[10] From Corrick and Norman (1980) and information on the DSE website:*Wetland Categories*

Wetland type (based on Corrick and Norman 1980)	Description of typology[10]	Has the 1980 typology been maintained since listing?
saline	wetlands and parts of intertidal zones. Saline wetlands are those in which salinity exceeds three grams per litre throughout the whole year.	determined to have occurred in these lakes/lagoons since listing.

Source: The description of the typology in the table is sourced from information on the DSE Website: www.land.vic.gov.au\DSE\ 'Wetland Categories' and Corrick and Norman 1980.

6.5 Conclusions about Ecological Character Changes

As outlined in Table 6-3, the review of available data and studies indicates a possible reduction in abundance of waterbirds (mainly those species that rely on or regularly use freshwater habitats), a possible reduction in abundance of key fish species such as black bream (based on commercial catch data), a possible reduction in density of seagrass assemblages and long term changes to vegetation communities in the fringing marsh wetlands of Lake Wellington (for example, from *Phragmites* wetland to *Melaleuca* and swamp scrub dominated wetlands in Dowd Morass).

Table 6-4 describes qualitatively how several of the wetland habitats of Gippsland Lakes are now considered to have a different ecological character to that determined at the time of listing, when comparing current conditions with the original wetland classification scheme of Corrick and Norman (1980).

Clydebank Morass and Lake Coleman (characterised as Deep Freshwater Marshes by Corrick and Norman 1980) have become increasingly estuarine since the time of listing with salinity levels and vegetation communities much more characteristic of 'semi-permanent saline wetlands' (similar to Lake Reeve) than 'deep freshwater marshes'. These wetlands are now managed as estuarine wetlands under the 2008 Parks Victoria Management Plan.

The causes of these observed changes to ecological character appear to be a complex combination of natural and anthropogenic factors. These factors include: long term estuarine and marine inflows from Lakes Entrance that have affected wetland salinity regimes; the regulation and diversion of freshwater from tributaries that enter the western portions of the Gippsland Lakes; historical water control structures situated in the marshes and other fringing wetlands that have modified local flow regimes; and periods of prolonged drought. In combination, these factors have contributed to long term changes in the timing of inflows and inundation regime of wetland habitats within the site. In particular, there are more irregular freshwater flows into the Lake system (as opposed to the naturally variable wetting and drying cycle), high levels of groundwater and surface water salinity inputs from the catchments and increased incidences of algal blooms in the main lagoons (DSE 2003).

Based on the above, there is no clear or demonstrable evidence that the limits of acceptable change (LAC) defined for the site have been exceeded since listing. On this basis, it is determined that an empirical change to ecological character of the site cannot be established.

7 INFORMATION GAPS, MONITORING AND EDUCATION

7.1 Information Gaps

The ECD preparation process promotes the identification of information or knowledge gaps about the Ramsar site.

General information and data gaps

In general, Ecos (unpublished) and associated analysis and findings within that document were used as a starting point for this ECD. This information was augmented with a broad literature review of published plans, strategies and studies as well as a substantial amount of raw data review and analysis using data sets sourced from various Victorian Government Departments and other organisations such as Birds Australia. This data review focussed on perceived gaps and/or verification (where possible) of the Ecos (unpublished) analysis in areas such as water quality data, waterbird data, fish catch data and similar.

Overall, in evaluating the existing data sets supplied, the study team found that while there was a significant number of data sources available and a substantial amount of work being done in the Gippsland Lakes area, it was difficult to obtain the precise, accurate, consistent and statistically robust data needed to make the accurate conclusions needed for the ECD. As such, ‘hard numbers’ to be used, for example, for setting an LAC, couldn’t be easily derived or defended on robust scientific grounds.

Some examples are provided below:

- 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).
- Comprehensive seagrass mapping was undertaken by Roob and Ball (1997) 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 and more recent studies[11] 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 and Ball’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 except in particular cases (Dowd Morass).

[11] Advice from Chris Barry, Gippsland Coastal Board 2010 is that a number of further seagrass assessments (following on from those reported in Hindell 2008) have been commissioned for the Gippsland Lakes.

- Similarly, while site-specific records of flora and fauna species of conservation significance previously recorded within the Ramsar site were available, little research has been conducted on the ecology and biology of these species of significance.

- Water quality data was obtained from the EPA Victoria but is limited to the monitoring sites within the main lagoons for relevant timescales back to the date of listing. As the data spanned over such a long period, it required significant review and manipulation prior to being able to be plotted in graphs but was able to be combined effectively with flow data and forms the summary analysis that appears in Appendix B.

- Likewise, while there is comprehensive information now available in relation to the proportion of extracted versus total flows for each major river system flowing into the lakes summarised as part of the State Water Audit/Account reports published by the Victorian Government, similar information was not readily available for periods prior the 1980s and 1990s to assist in identifying trends since the date of listing.

Overall these basic data and information gaps indicate the pressing need for a much broader and more coordinated approach to acquiring and reviewing existing, baseline data sets related to the Ramsar site. This is discussed in the Monitoring Needs section (refer Section 7.2).

Specific information gaps

Cognisant of these general data gaps, in the context of the identified critical services/benefits, components and processes, Table 7-1 summarises more specific information and knowledge gaps.

Table 7-1 Summary of information/knowledge gaps

Critical CPS	Description of information/knowledge gap[12]	
Critical components		
Habitats	(C1) Seagrass	Little is known about the growth, condition or ecology of seagrasses in the Gippsland Lakes, especially in comparison with better studied temperate sites such as Corner Inlet or tropical seagrass beds in the north of Australia. Nothing is known about these topics for seagrasses in Lake Tyers. Although there is information on historical changes and the extent of seagrass beds in the Gippsland Lakes based on mapping in 1997 (Roob and Ball) and a further condition assessment in 2008 (Hindell), little research effort has been directed to understanding the fundamental ecology of the seagrass species or fundamental ecological processes that operate in Gippsland Lakes/Lake Tyers seagrass beds. Key knowledge gaps are: • Causes of changes in seagrass extent over the past four decades • Rates of primary production of seagrasses and their associated algal communities • Relative roles of light limitation and nutrient limitation to seagrass growth and distributions • Sensitivity of seagrasses to environmental change, particularly altered water clarity and nutrient enrichment arising from human activities in the catchment, and altered temperature regimes consequent to climate change • Likely impacts of introduced marine weeds such as *Codium* sp.
	(C2) Saline or brackish lagoons	Despite the long-term studies by the EPA and the syntheses undertaken by Harris et al. (1998), CSIRO (2001) and Cook et al. (2008), much remains to be learnt about planktonic processes in the lagoonal environments of the Gippsland Lakes. Key knowledge gaps are: • A holistic understanding of the water quality in the Gippsland • Relative roles of light and nutrients (nitrogen and phosphorus) in controlling rates of primary production by phytoplankton • Role of phytoplankton in food webs • Impacts of altered freshwater inflows on phytoplankton community composition and productivity • The effects of fire on sediment and nutrient loads into the Lakes • Effects of the decay of algal blooms on fundamental ecosystem-scale processes, such as food-web dynamics, sediment biogeochemistry and nutrient release • Sensitivity of phytoplankton to environmental change, particularly altered water clarity and nutrient enrichment arising from human activities in the catchment, and altered temperature regimes consequent to climate change. The wetland processes (hydrology and water quality) and components (such as seagrass) of Lake Tyers are regarded as a significant knowledge gap. The Lake Tyers Fisheries Reserve Management Plan (FV 2007) also identifies a range of information gaps and monitoring needs specific to recreational fisheries management.
	(C3 – C5) Fringing wetlands – freshwater, brackish and saline	Despite the amount of knowledge generated on some wetlands of the Gippsland Lakes Ramsar site (for example, Dowd Morass), very large knowledge gaps remain. Five were identified by Ecos (unpublished) as most critical:

[12] Based on findings of the current study, from Ecos (unpublished) and other literature reviewed.

Critical CPS		Description of information/knowledge gap[12]
		• Detailed and quantitative information on the ecology (for example, wetting and drying cycles and their salinity regimes) of many wetlands in the Ramsar site. • Although the recent mapping of vegetation by Parks Victoria in the larger wetlands has been conducted, there is no spatially informed and consistent vegetation data for many of the other wetlands. • Key ecological processes, such as rates of primary production, relative importance of vascular plants compared with benthic microalgae in whole-of-wetland primary production, decomposition pathways for organic matter, and food-web structure, are virtually unstudied except for Dowd Morass. Even in Dowd Morass, the knowledge is patchy for many of these processes (Boon et al. 2008). • Likely responses of individual wetlands to altered environmental conditions, such as increased water permanency, increased salinity, soil acidification etc, are not well understood beyond broad generalizations. • At the level of individual species, critical information is lacking on fundamental topics such as salinity responses, conditions required for sexual recruitment, longevity of adults. Detailed information is available for swamp paperbark and, to a lesser extent, common reed, however, basic regenerative characteristics of other common taxa is not available.
Species/Groups	(C6) Waterbirds	Currently there are no estimates of the total number of waterbirds of particular species in the Gippsland Lakes Ramsar site. Without such information its importance as a Ramsar site that possibly supports one per cent of the individuals in a population of one species or subspecies of waterbird (Ramsar Criterion 6) cannot be determined. Data reviewed as part of the current study supplied by DSE and Birds Australia showed that the database was largely incomplete and did not provide consistent or quality data over time across the site. While qualitative information is available about key life-cycle habitats for avifauna within the broader site (such as locations of breeding colonies, spawning sites, etc), these are not quantified or regulatory monitored. In the context of future monitoring, the key information needs would be addressed through sampling in accordance with the following: • Migratory shorebirds - Early and late summer monitoring events at key roost sites and feeding grounds (to be conducted annually), with particular attention directed to surveys for common greenshank, red-necked stint, sharp-tailed sandpiper, and Latham's snipe (as species which may provide useful surrogates for numbers of other shorebirds using the site, of site habitat usage, and as indicators of changes in ecological character). • Non-migratory waterbirds – Late-winter and late-summer monitoring events at key roost sites and feeding grounds (to be conducted annually) to target black swan, great cormorant, little black cormorant, great egret, Australian shoveler, musk duck, chestnut teal, Australasian grebe, purple swamphen, Eurasian coot, black-winged stilt and red-necked avocet (as species which either currently exceed the one per cent threshold and/or provide useful surrogate for numbers of other waterbirds using the site of site habitat usage, and as indicators of changes in ecological character).
	(C7) Threatened frogs	No accurate information on the distribution of growling grass frogs and green and golden bell frogs is available. These two species naturally hybridise where their distributions overlap, such as in the Gippsland Lakes. Whether the hybridisation that is occurring is influenced by ecological changes to the lakes due to anthropogenic effects is not known. Research is needed to identify key threatened frog populations and for those populations, monitor presence/absence, breeding evidence (tadpoles and metamorphs), and maintenance of parapatry between threatened frog taxa and congeneric sibling species during optimum breeding conditions until

<table>
<tr><th>Critical CPS</th><th colspan="2">Description of information/knowledge gap[12]</th></tr>
<tr><td></td><td></td><td>markers/trends of population variability are evident. Quarterly monitor water quality for key population sites (for example, salinity, dissolved oxygen, nitrate levels, and other toxicants). Annual monitoring of fringing vegetation (aquatic macrophytes and littoral vegetation).</td></tr>
<tr><td></td><td>(C8) Threatened flora</td><td>The presence and key habitats within the site for these species is an information gap. Ecologic and biologic requirements of species are also unknown such as habitats, fire, population dynamics and breeding biology.</td></tr>
<tr><td colspan="3">Critical processes</td></tr>
<tr><td>(P1) Hydrological processes</td><td colspan="2">Much remains unknown about the detailed functioning of physical and biological processes in the system and that most systems currently depend directly and indirectly on the salinity regime. Improved knowledge is being obtained through more detailed studies currently being undertaken as part of the Environmental Water Requirements study for the East and West Gippsland Catchment Management Authorities. Following the Stage 1 and Stage 2 Scoping Studies (refer Tilleard et al. 2009 and Tilleard and Ladson 2010), it is understood that a range of more detailed studies are planned to be carried out including detailed hydrological studies of the lower Latrobe River.

There is a poor understanding of how groundwater processes interact with surface water wetlands and in particular how saline groundwater drives salinity levels in the fringing brackish wetlands. This remains a significant knowledge gap.</td></tr>
<tr><td>(P2) Waterbird breeding</td><td colspan="2">Waterbird breeding success – Annual assessment of waterbird breeding success (and habitat characteristics) at key sites is required, including: Lake Coleman and Tucker Swamp (Australian pelican); Bunga Arm (little tern, fairy tern, hooded plover); Macleod Morass (Australian white ibis and straw-necked ibis); Sale Common (black swan); Lake Wellington-Dowd Morass (little black cormorant, Australian white ibis, Royal Spoonbill and straw-necked ibis; and Lake Tyers (fairy tern and little tern).</td></tr>
<tr><td colspan="3">Critical services/benefits</td></tr>
<tr><td>(S1) Threatened species</td><td colspan="2">See critical components for threatened flora and fauna species.

The patterns of usage of the site by Australian grayling is unknown. The following are key information gaps:
• Key sites and important habitats within the site requiring further protection and management
• Impacts of flow regime changes on local populations (and establishment of environment flow objectives to meet requirements)
• Water quality tolerances (and established of water quality objectives to meet requirements)
• Population trends in space and time.

The usage of the site by painted snipe and Australasian bittern is unknown in part due to the cryptic nature of the birds. Some historical site records and the presence of suitable habitat is a useful starting point for future monitoring.</td></tr>
<tr><td>(S2) Fisheries resource values</td><td colspan="2">There are significant catch and effort data arising out of the commercial fishery in Gippsland Lakes and some survey information from the recreational fishery but detailed population and recruitment data is absent from the systems. Commercial fish catch data reviewed as part of the current study indicated that this was not a comprehensive or complete data set with considerable anomalies.

This lack of information will become more significant if the Bay and Inlet Fishery continues to shift towards a more recreationally based fishery as it has done so in the past. In addition the impacts of climate change are poorly understood on the fish and fisheries of Victoria. More detailed information is required on the following:
• The major environmental determinants of fish recruitment for the key species
• The habitats that are most important for fish populations
• The relationship between spawning and recruitment, and the environmental intermediaries
• The flow levels that are required to maintain estuarine conditions in the estuaries, and the spatial scale that the species should be managed
• The implications for biodiversity and genetic diversity of estuarine constriction and whether it has the potential to increase the likelihood of hybridisation between estuary perch and bass
• The extent to which species' life cycles are disrupted by loss of connectivity to higher regions of</td></tr>
</table>

Critical CPS	Description of information/knowledge gap[12]
	catchment.

7.2 Monitoring Needs

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 (proliferation of common reed and cumbungi); brackish fringing wetlands (transition of common reed to swamp paperbark to saltmarsh species); and hypersaline wetlands (maintenance of traditional saltmarsh communities as opposed to largely unvegetated salt flats)
    - 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 threatened frogs (Component 7), threatened flora species (Component 8) and other threatened species (Australian snipe, Australasian bittern, and Australian grayling – relevant to Service 1).
- More regular counts of all waterbirds in accordance with the monitoring regime envisioned by the LAC (refer critical Component 6).
- More regular counts of breeding waterbirds at identified breeding colony sites (refer location and description of sites in the discussion of critical Process 2).
- 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).

7.3 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 Gippsland Lakes 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 nine 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 ecological character of the site is underpinned by a set of critical components, processes and services/benefits identified within this ECD. These include a diverse range of wetland habitats, the presence of nationally-threatened wetland fauna, the usage of the site for breeding and other life cycle functions by many species of waterbirds.
- The diversity of habitat types found within the site is the result of a variable salinity regime which is influenced by marine inflows and catchment flooding. Maintenance of the freshwater and brackish fringing wetland habitats of the site are particularly critical to maintenance of the site's ecological character.
- While the ecological character of the site has been largely maintained since listing, possible ecological character changes that require further research and monitoring include reduction in the abundance and density of freshwater-dependent waterbirds, the reduction in the abundance of key fish species (black bream), reduction in the density of seagrass assemblages and long term changes to the vegetation communities in the fringing wetlands of Lake Wellington (for example, from *Phragmites* wetland to *Melaleuca* and swamp scrub dominated wetlands).
- Broad-scale ecological health monitoring is needed for the site in order to inform proper management. This should focus on the LAC and knowledge gaps outlined in this ECD.

7.4 Conclusions

The current study has sought to synthesise an extensive amount of historic and current information about the wetland values of the Gippsland Lakes Ramsar site into an Ecological Character Description (ECD) document that is consistent with the National ECD Framework.

As part of the site overview, the study has reviewed the Ramsar Nomination Criteria under which the site was listed as a Wetland of International Importance and to review the applicability of the revised and new criteria under the Convention that have been added since the site was originally listed in 1982. In this context, the site is now seen as meeting six of the nine Nomination Criteria recognising its representative wetland habitats at a bioregional level, threatened wetland species, support for key life-cycle functions such as waterbird breeding values, its importance for supporting substantial numbers of waterbirds and fish nursery and spawning habitats.

Eight critical components, two critical processes and two critical services/benefits as well as a range of supporting components, processes and services of the site have been identified. Limits of acceptable change (LAC) have been derived to provide guidance to site managers about the tolerances of these critical components, processes and services/benefits to anthropogenic change.

Due to a lack of comprehensive data to form a baseline and generally poor understanding of the natural variability of key parameters, the bulk of the LAC are based on best professional judgement of the authors. As this is the 1st ECD undertaken for the site, subsequent resource assessments should use these LAC as a starting point that is to be reviewed and revised as improved information about trends in extent and condition of key parameters becomes known.

A review of available data and specific studies on the site (and comparison against relevant LAC) demonstrate that an ecological character change is possible for some critical components since site listing in 1982. Relevant studies show a possible reduction in abundance and density of waterbirds (mainly those species that rely on or regularly use freshwater habitats), a possible reduction in abundance of key fish species such as black bream (based on commercial catch data only), possible reduction in density of seagrass assemblages and long term changes to vegetation communities in the fringing marsh wetlands of Lake Wellington (for example from *Phragmites* wetland to *Melaleuca* and swamp scrub dominated wetlands in Dowd Morass). The extent to which the changes are a result of natural and/or anthropogenic change (or a combination of both) is not able to be determined based on the current data set.

There is no clear or demonstrable evidence that the LAC defined for the site have been exceeded since listing. On this basis, it is determined that an empirical change to ecological character of the site cannot be established.

The summary of information gaps and monitoring needs identified in the document should assist in decision-making about future priorities recognising those elements of the Gippsland Lakes that are directly relevant to Ramsar listing.

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9 GLOSSARY OF TERMS

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.

Angiosperm, means a flowering plant.

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.

Berm, means a nearly horizontal or landward-sloping portion of a beach, formed by the deposition of sediment by storm waves.

Charophytes, are a group of green algae that are the most closely related algae to flowering plants.

Congener, means species within the same genus.

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.

Parapatry speciation, is a form of speciation that occurs due to variations in mating frequency of a population within a continuous geographical area.

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).

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 2008). 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 D 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 (LAC) 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

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 Relative 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: WATER QUALITY INFORMATION

SOURCE AND ANALYSIS OF WATER QUALITY DATA

Water quality monitoring data was obtained from the EPA Victoria from five monitoring sites within Lakes Wellington, Victoria and King (refer Figure B-1). The dataset consists of two main monitoring periods, 1) data from 1976 to 1980 from the Victoria State Rivers and Waters Commission (not longer existing) and 2) data from 1986 to present from the Victoria EPA fixed monitoring sites. No data exists from these five sites between 1980 and 1986. Data for catchment flow into the Gippsland Lakes was sourced from the Gippsland Catchment Management Authorities.

The periods 1976-1980 (pre-Ramsar listing) and 1986-2008 (Ramsar period) were analysed separately by calculating the range, 10^{th}, 20^{th}, 50^{th}, 80^{th} and 90^{th} percentiles. The analysed parameters represent surface water measurements (0.5 metre water depth) and include salinity, pH, dissolved oxygen concentration, per cent saturation of dissolved oxygen, total suspended solids, total nitrogen, total phosphorus and chlorophyll *a*.

Where applicable, the calculated values were compared to the guideline values listed in Water of Victoria Schedule F3 (Gippsland Lakes and Catchment, No. S13, Gazette 26/2/1988). The guideline values listed in Schedule F3 differ between Lake Wellington and the eastern Gippsland Lakes. Schedule F3 uses minimum values, 50^{th} and 90^{th} percentiles as water quality objectives.

Total nitrogen, total phosphorus and chlorophyll *a* are not listed in Schedule F3 and therefore the ANZECC (2000) guideline values for southeast Australian estuarine systems were adopted for these parameters. The ANZECC guidelines use the 20^{th} and 80^{th} percentiles as lower and upper low-risk trigger values. It should be noted that the ANZECC guidelines are not specific to the Gippsland Lakes. It is recommended that trigger values for these parameters are developed, which are specific to the Gippsland Lakes ecosystem.

Water quality time series plots and the summed catchment flow discharging into the Gippsland Lakes is shown for Lake Wellington in Figure B-2 and for the eastern Lake Victoria in Figure B-3. Table B-1 and Table B-2 show the calculated percentiles and comparison to guideline values for Lake Wellington and the eastern Lake Victoria sites, respectively. Additional data plots were generated for monitoring data at the other eastern lakes sampling locations and are shown in Figures B-4, B-5 and B-6. Generally, these data plots show similar trends to those presented in Figure B-3.

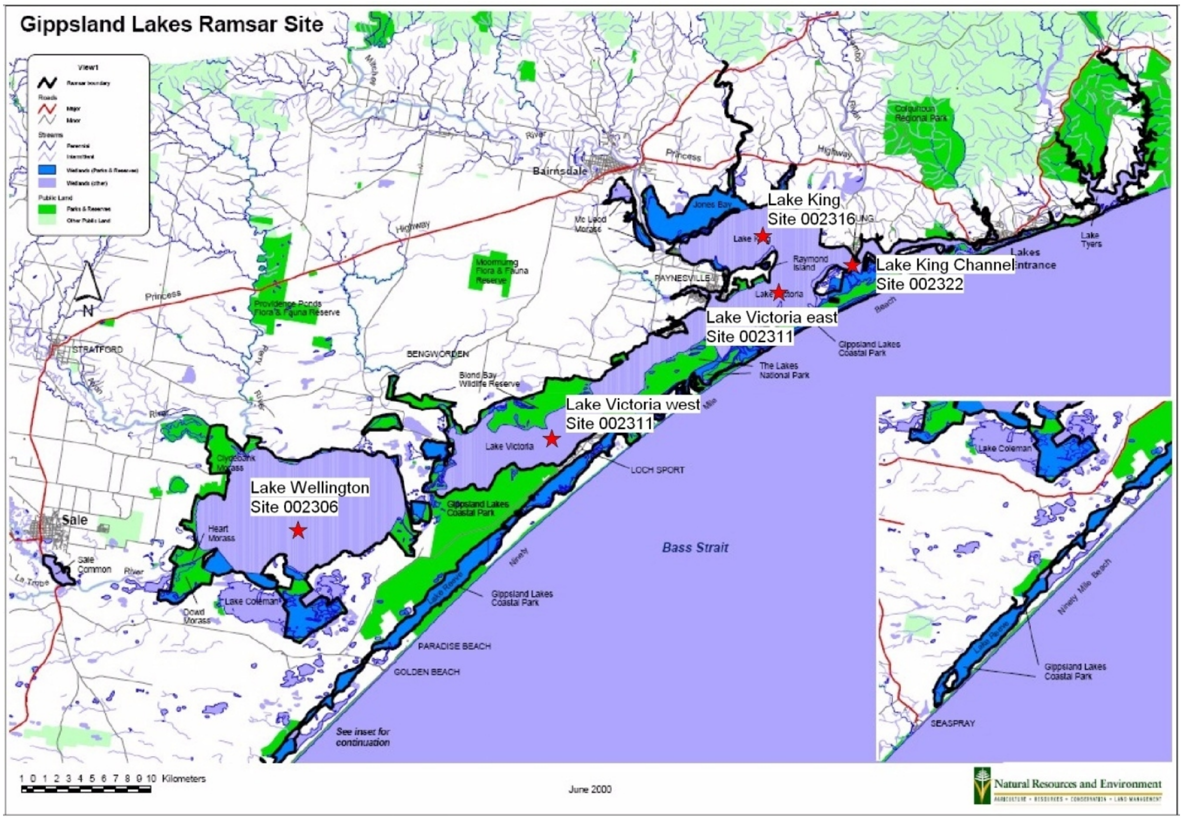


Figure B- 1 Locations of EPA water quality monitoring sites in the Gippsland Lakes. Figure modified from the Victorian Department of Sustainability and Environment.

The water quality in Lake Wellington is strongly determined by flows entering the lake from the catchment (Figure B-2). About one third of river flows in to the Gippsland Lakes and over half of the total nutrient load is supplied to Lake Wellington from the western rivers (mainly the La Trobe, Thomson and Avon Rivers. Due to these high catchment inflows and its distance from the Lakes Entrance in the east, Lake Wellington is less saline than the eastern lakes. Salinities are generally higher during years of low flow compared to lower salinities observed during high flow years (Figure B-2). Correspondingly, increased input of sediments and nutrients during high flow years is reflected in higher concentrations of total suspended solids, total nitrogen and total phosphorus during these periods (Figure B-2). As expected, the higher nutrient availability during high flow years ensues in higher chlorophyll *a* concentrations in the water column. Dissolved oxygen concentrations vary seasonally with higher concentrations during the cold winter months and lower concentrations during the warm summer months due to increased oxygen solubility with decreasing temperatures.

Notable events (refer to Figure B-2):

A) High catchment inflow during the hydrological year 1978-1979 results in freshwater salinities, the highest suspended solid concentration on record and very high total phosphorus concentrations. High flushing of Lake Wellington and high turbidity may explain why the increased nutrient input is not reflected in chlorophyll a concentrations.

B) Several high catchment inflow events during the wetter years 1985 to 1995 lead to increased input of sediments, total nitrogen and total phosphorus from the catchment and corresponding increases in chlorophyll a concentrations. Several blooms of *Nodularia*, dinoflagellates and *Microcystis* fall into this period (Stephens et al. 2004).

C) Notable Nodularia bloom in 1998-1999 associated with high total nitrogen and phosphorus concentrations and high suspended solids concentration.

D) The extended drought period during 1999-2007 and associated reduced catchment input results in decreasing total nutrient concentrations, very low suspended solid concentrations and low chlorophyll.

E) Bushfires in 2006-2007 burning 32 per cent of Gippsland Lakes catchment followed by the 2007 flood period, resulted in the highest nutrient concentrations on record. A massive increase in nitrate loads likely resulted in an unprecedented *Synechococcus* bloom persisting to winter 2008 (Cook et al. 2008). The bloom is reflected in the high chlorophyll *a* concentrations during this period.

Comparison to guideline values (refer to Table B-1)

Salinity – Salinity ranged between 0.3 and 12.8 grams per litre in the period 1976-1980 and between 0.2 and 21.2 grams per litre in 1986-2008. The median salinity marginally exceeded the Waters of Victoria Schedule F3 (WV) guideline value in the period 1976-1980. During the period 1986-2008, the median salinity (6.1 grams per litre) was well below the WV guideline value.

pH – The maximum pH only marginally exceeded the maximum range specified in the WV guideline in the period 1986-2008. Over 90 per cent of all data was well within the range of the guideline values for 1976-1980 and 1986-2008. Median pH was 7.8 in 1976-1980 and 8.0 in 1986-2008.

Dissolved Oxygen – Dissolved oxygen concentrations were always well over the minimum guideline value specified in the WV guideline. 10^{th} percentile values of 8.5 milligrams per litre for 1976-1980 and 8.3 milligrams per litre for 1986-2008 indicates that the surface water was well oxygenised and close to saturation most of the time.

Total suspended solids – Median suspended solid concentrations were below the WV trigger limit for both periods. The 90^{th} percentile of suspended solids exceeded the WV guideline value during the period 1976-1980, whereas the 90^{th} percentile for 1986-2008 was below the guideline trigger value. Median suspended solids concentration was slightly lower for the period 1986-2008.

Total nitrogen – Total nitrogen ranged between 311 micrograms per litre and 1694 micrograms per litre during 1986-2008. No data exists for the period 1976-1980. The median and 80^{th} percentile of total nitrogen exceeded the ANZECC guideline value. It should be noted, however, that the ANZECC guidelines cover the broad area of southeast Australian estuaries and are not specific to the Gippsland Lakes.

Total phosphorus – Total phosphorus ranged between 8.0 micrograms per litre and 225 micrograms per litre during 1976-1980 and between 0.4 micrograms per litre and 285 micrograms per litre in the period 1986-2008. Median total phosphorus was about two times higher in 1986-2008 compared to 1976-1980. The median and 80^{th} percentile exceeded the ANZECC guideline value during both periods. It should be noted, however, that the ANZECC guidelines cover the broad area of southeast Australian estuaries and are not specific to the Gippsland Lakes.

Chlorophyll *a* – Chlorophyll *a* concentrations reached maximum values of 41 micrograms per litre and 53 micrograms per litre for the periods 1976-1980 and 1986-2008, respectively. Median Chlorophyll was more than two times higher in 1986-2008 compared to the pre-Ramsar period. The median and 80th percentile of Chlorophyll *a* exceeded the ANZECC guideline trigger value.

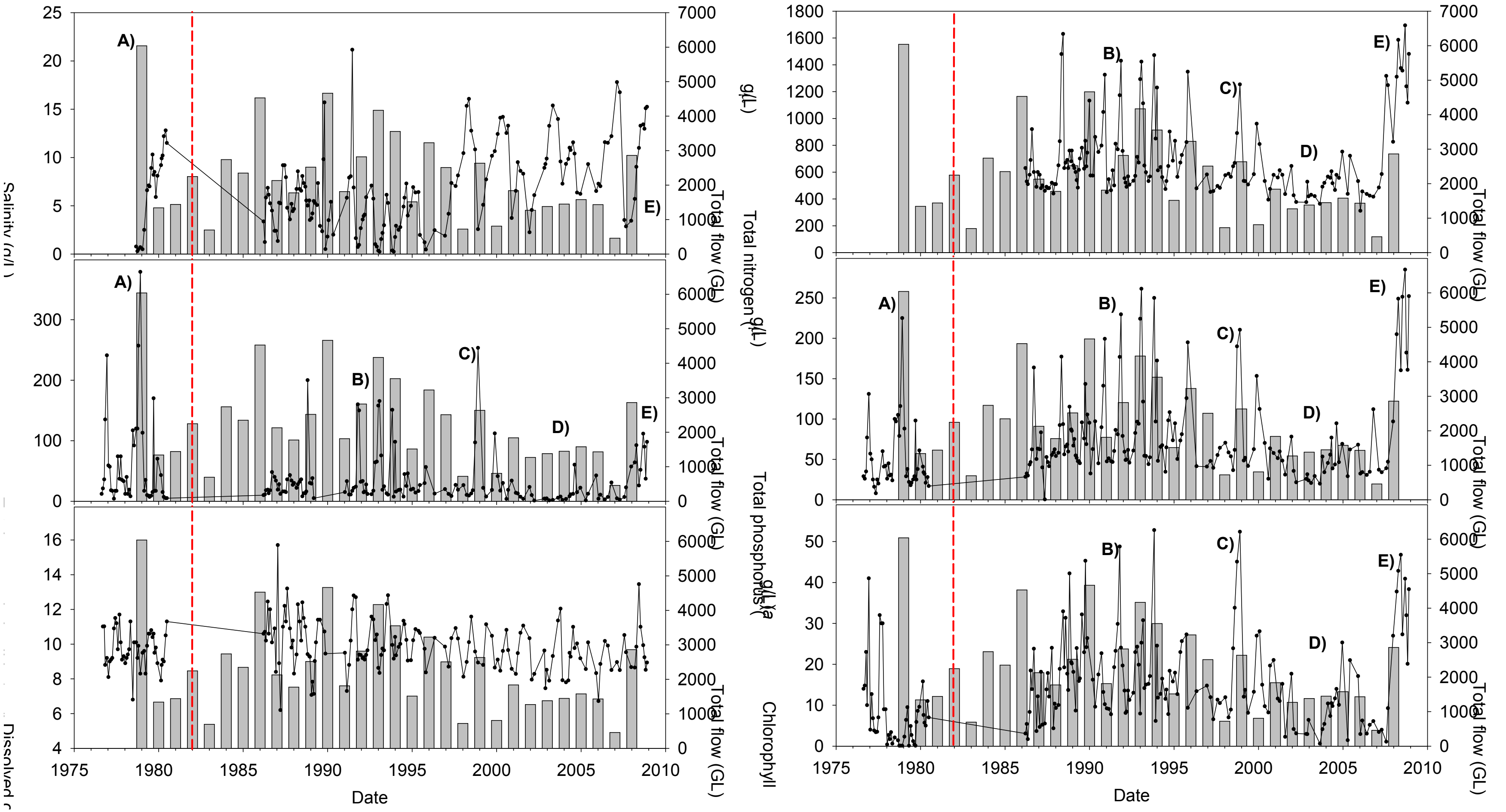


Figure B- 2 Lake Wellington surface water quality data (EPA monitoring site 002306). Total flow represents the summed flow recorded for all major catchment rivers and is given as hydrological year (June-May). Red dotted line denotes listing of Gippsland Lakes as Ramsar wetland in 1982. Refer to text for information on notable events A-E.

Table B- 1 Lake Wellington surface water quality parameters and guideline values from EPA site 002306. Orange and red colour represents slight and distinct exceedance of guideline trigger limits, respectively. Note that the ANZECC guideline values are representative of the broad southeast Australia estuaries and not specific to the Gippsland Lakes.

	Minimum		Maximum		10th percentile		20th percentile		50th percentile		80th percentile		90th percentile		Guideline	Source
	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008		
Salinity (g/L)	0.3	0.2	12.8	21.2	0.5	1.8	0.8	2.9	8.1	6.1	10.2	10.4	11.5	13.2	8	Waters of Victoria
pH	6.8	6.8	8.6	9.1	7.1	7.4	7.2	7.6	7.8	8.0	8.1	8.3	8.2	8.5	6-9	Waters of Victoria
Dissolved oxygen (mg/L)	6.8	6.2	11.7	15.7	8.5	8.3	9.0	8.7	9.6	9.7	10.6	11.0	11.1	11.6	6	Waters of Victoria
Dissolved oxygen (% saturation)		71.0		149.6		92.9		95.7		102.3		110.4		117.0	60	Waters of Victoria
Total suspended solids (mg/L)	4.0	0.9	379.0	253.3	7.4	4.6	11.6	10.0	21.0	18.7	96.2	39.6	129.0	74.5	25/80	Waters of Victoria
Total nitrogen (µg/L)		311.3		1693.9		451.6		490.0		587.1		830.0		1248.0	300	ANZECC
Total phosphorus (µg/L)	8.0	0.4	225.0	285.0	20.3	32.5	24.6	41.8	33.0	60.4	77.8	96.9	99.4	172.4	30	ANZECC
Chlorophyll a (µg/L)	0.1	0.6	41.0	52.8	0.2	4.2	1.4	7.8	5.7	13.8	11.3	24.0	20.1	31.2	4	ANZECC

Eastern Lakes water quality

Time series of water quality parameters for eastern Lake Victoria and total catchment inflow are shown in Figure B-3. Salinities are generally more saline in the eastern lakes compared to Lake Wellington due to their proximity to the Lakes Entrance. As observed for Lake Wellington, salinities in the surface water of the eastern lakes are generally higher during years of low flow and higher during high flow years. Concentrations of suspended solids, total nitrogen and total phosphorus are not as clearly related to flow compared to observations from Lake Wellington. Dissolved oxygen concentrations generally follow a seasonal pattern with higher concentrations during the colder months due to increased oxygen solubility. Relatively low oxygen concentrations during some occasions may have been caused by mixing events with hypoxic bottom water, while particularly high oxygen concentrations may in part be attributable to high oxygen production during periods of algal blooms (Figure B-3).

Notable events (refer to Figure B-3):

A) High catchment inflow during the hydrological year 1978-1979 resulted in relatively low salinities around seven grams per litre and high total suspended solids concentrations. While total phosphorus increased in the surface water, this increase was not as pronounced as observed in Lake Wellington during the same time. Chlorophyll *a* concentrations did not increase during that period, possibly due to high turbidity and flushing of the system.

B) Very high concentrations of total nitrogen and total phosphorus were observed in 1988. During the same time, total suspended solid concentrations also increased markedly. Several algal blooms (*Nodularia* and dinoflagellates) were noted in 1988-1989 (Stephens et al. 2004), which is reflected in the high chlorophyll *a* concentrations during that time. During this period of relatively moderate catchment inflow the high total nitrogen/phosphorus and suspended solid concentrations may have been in part caused by the bloom itself (autochthonous algae production contribute to measured total nutrient and suspended solid concentrations). Photosynthetic activity of the algal bloom is reflected in increased oxygen concentrations.

C) Another *Nodularia* bloom was observed in 2001-2002 (Cook et al. 2008), which is reflected in high total nitrogen and chlorophyll *a* concentrations and moderate increase in suspended solid and total phosphorus concentrations. Photosynthetic activity of the algal bloom manifests in a pronounced peak in oxygen concentration during that time.

D) Bushfires in 2006/2007 burning 32 per cent of Gippsland Lakes catchment followed by the 2007 flood period, resulted in high total nitrogen and total phosphorus concentrations. A massive increase in nitrate loads likely resulted in an unprecedented *Synechococcus* bloom persisting to winter 2008 (Cook et al. 2008). The bloom is reflected in relatively high chlorophyll *a* concentrations as well as an increase in surface water oxygen concentrations during this period.

Comparison to guideline values eastern Lake Victoria (refer to Table B-2)

The observed patterns described below for the eastern Lake Victoria were similar for the other three eastern Lakes monitoring sites, including Lake King. Refer to Figures B-4, B-5 and B-6 for these plots.

Salinity – Salinity ranged between 7.0 grams per litre and 27.6 grams per litre in 1976-1980 and between 4.2 grams per litre and 32.4 grams per litre in the period 1986-2008. Median salinity was slightly lower for the period 1986-2008 (21.2 grams per litre) compared to 1976-1980 (24.1 grams per litre). No guideline value for salinity is given in the Waters of Victoria Schedule F3 guidelines (WV) for the eastern Gippsland Lakes.

pH – The maximum pH exceeded the WV guideline value for the eastern Gippsland Lakes during the period 1986-2008. However, the 10^{th} and 80^{th} percentiles were within the range specified in the guidelines, indicating that pH was within guideline limits most of the time. Median pH was 8.2 in 1976-1980 and 8.3 in the period 1986-2008.

Dissolved oxygen – Minimum dissolved oxygen concentration was within guideline limits during 1976-1980. In contrast, minimum dissolved oxygen concentrations and per cent saturation of dissolved oxygen were distinctly below the WV trigger limits in the period 1986-2008. It should be noted, however, that the 10^{th} percentile of dissolved oxygen was eight milligrams per litre and close to saturation during this period, indicating that the surface water of the eastern Lake Victoria was well oxygenised for over 90 per cent of the time. The particularly low oxygen concentrations may have been caused by transient mixing of the surface water with hypoxic bottom water.

Total suspended solids – The median and 90^{th} percentile of total suspended sediment was well below the WV trigger limit for both periods. Median suspended solid concentration was three times lower during 1986-2008 compared to 1976-1980.

Total nitrogen – Total nitrogen ranged between 219 micrograms per litre and 4730 micrograms per litre for the period 1986-2008. No data exists for the period 1976-1980. The median and 80^{th} percentile of total nitrogen exceeded the ANZECC guideline value. It should be noted, however, that the ANZECC guidelines cover the broad area of southeast Australian estuaries and are not specific to the Gippsland Lakes.

Total phosphorus – Total phosphorus ranged between 8.0 micrograms per litre and 95 micrograms per litre during 1976-1980 and between 13.8 micrograms per litre and 627 micrograms per litre in the period 1986-2008. Median total phosphorus concentration was about 1.5 times higher during 1986-2008 compared to 1976-1980. The median and 80^{th} percentile exceeded the ANZECC guideline value during both periods. It should be noted, however, that the ANZECC guidelines cover the broad area of southeast Australian estuaries and are not specific to the Gippsland Lakes.

Chlorophyll *a* – Chlorophyll a concentrations reached maximum values of 26 micrograms per litre and 183 micrograms per litre for the periods 1976-1980 and 1986-2008, respectively. While the 80^{th} percentile of chlorophyll was below the ANZECC trigger level for the period 1976-1980, the 80^{th} percentile during 1986-2008 exceeded the guideline value about three-fold. However, median chlorophyll a concentrations were close to the guideline value for both periods.

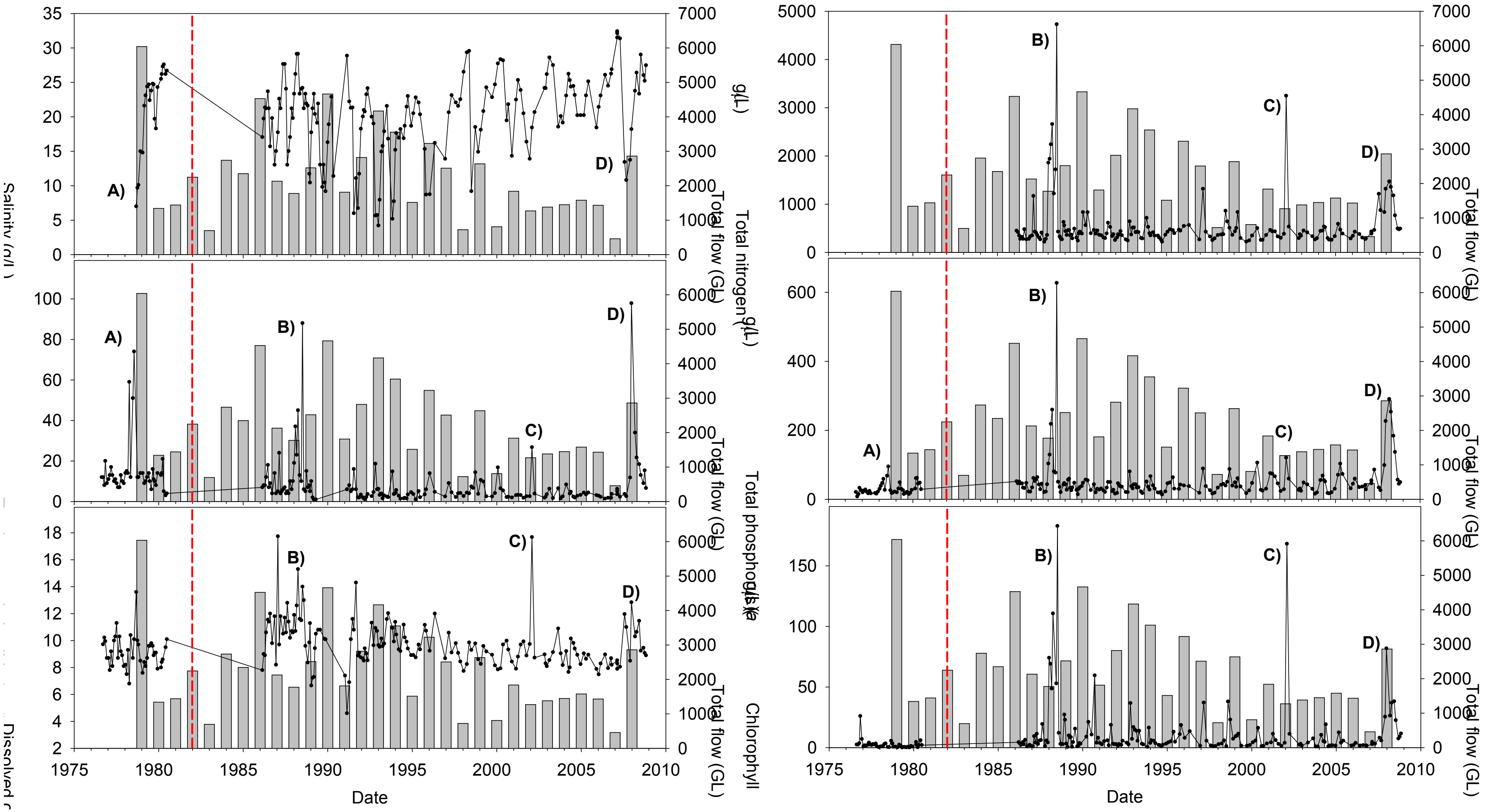


Figure B- 3 Eastern Lake Victoria surface water quality data (EPA monitoring site 002314). Total flow represents the summed flow recorded for all major catchment rivers and is given as hydrological year (June-May). Red dotted line denotes listing of Gippsland Lakes as Ramsar wetland in 1982. Refer to text for information on notable events A-D.

Table B- 2 Eastern Lake Victoria surface water quality parameters and guideline values from EPA site 002314. Red colour represents exceedance of guideline trigger limits. Note that the ANZECC guideline values are representative of the broad southeast Australia estuaries and not specific to the Gippsland Lakes.

	Minimum		Maximum		10th percentile		20th percentile		50th percentile		80th percentile		90th percentile		Guideline	Source
	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008	1976-1980	1986-2008		
Salinity (g/L)	7.0	4.2	27.6	32.4	10.6	11.2	15.7	15.2	24.1	21.2	26.1	24.5	26.7	27.5	N/A	
pH	7.5	7.4	8.5	9.4	7.8	7.9	8.0	8.1	8.2	8.3	8.3	8.5	8.4	8.7	6.5-8.5	Waters of Victoria
Dissolved oxygen (mg/L)	6.8	4.6	13.6	17.7	7.9	8.0	8.2	8.5	9.1	9.4	10.0	10.9	10.3	11.6	6	Waters of Victoria
Dissolved oxygen (% saturation)		60.9		240.2		97.4		100.4		109.8		121.5		132.6	75	Waters of Victoria
Total suspended solids (mg/L)	3.0	1.0	74.0	97.8	7.0	1.8	9.0	2.3	12.0	4.2	14.0	9.2	18.8	15.2	25/80	Waters of Victoria
Total nitrogen (µg/L)		218.9		4730.0		270.0		295.7		393.7		526.7		834.4	300	ANZECC
Total phosphorus (µg/L)	8.0	13.8	95.0	627.2	16.3	20.5	18.0	26.0	25.5	40.0	41.4	57.7	56.0	80.5	30	ANZECC
Chlorophyll a (µg/L)	0.1	0.5	26.0	182.9	0.3	1.4	0.4	1.9	1.7	4.3	3.3	12.9	4.3	24.0	4	ANZECC

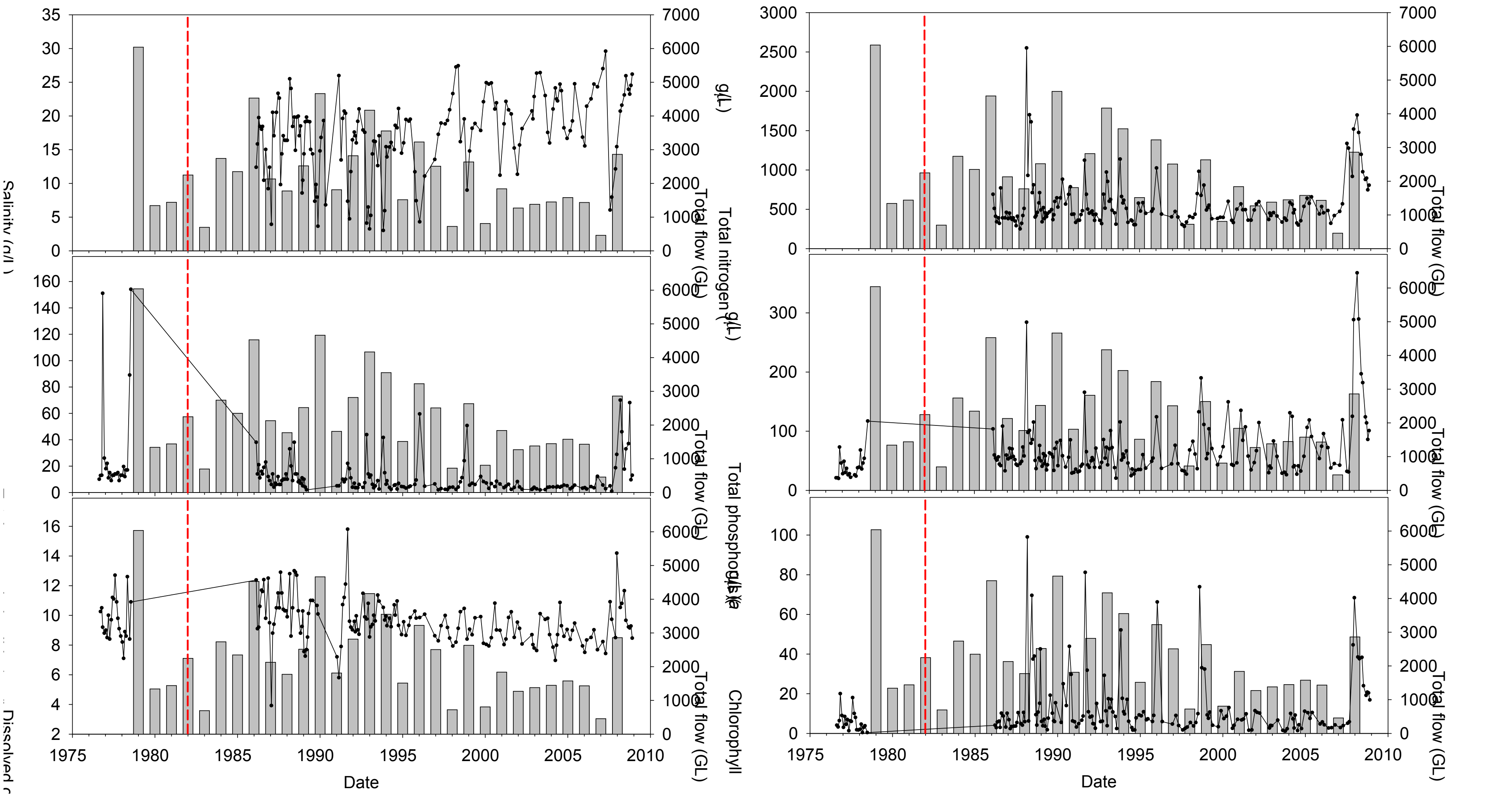


Figure B- 4 Western Lake Victoria surface water quality data (EPA monitoring site 002311). Total flow represents the summed flow recorded for all major catchment rivers and is given as hydrological year (June-May). Red dotted line denotes listing of Gippsland Lakes as Ramsar wetland in 1982.

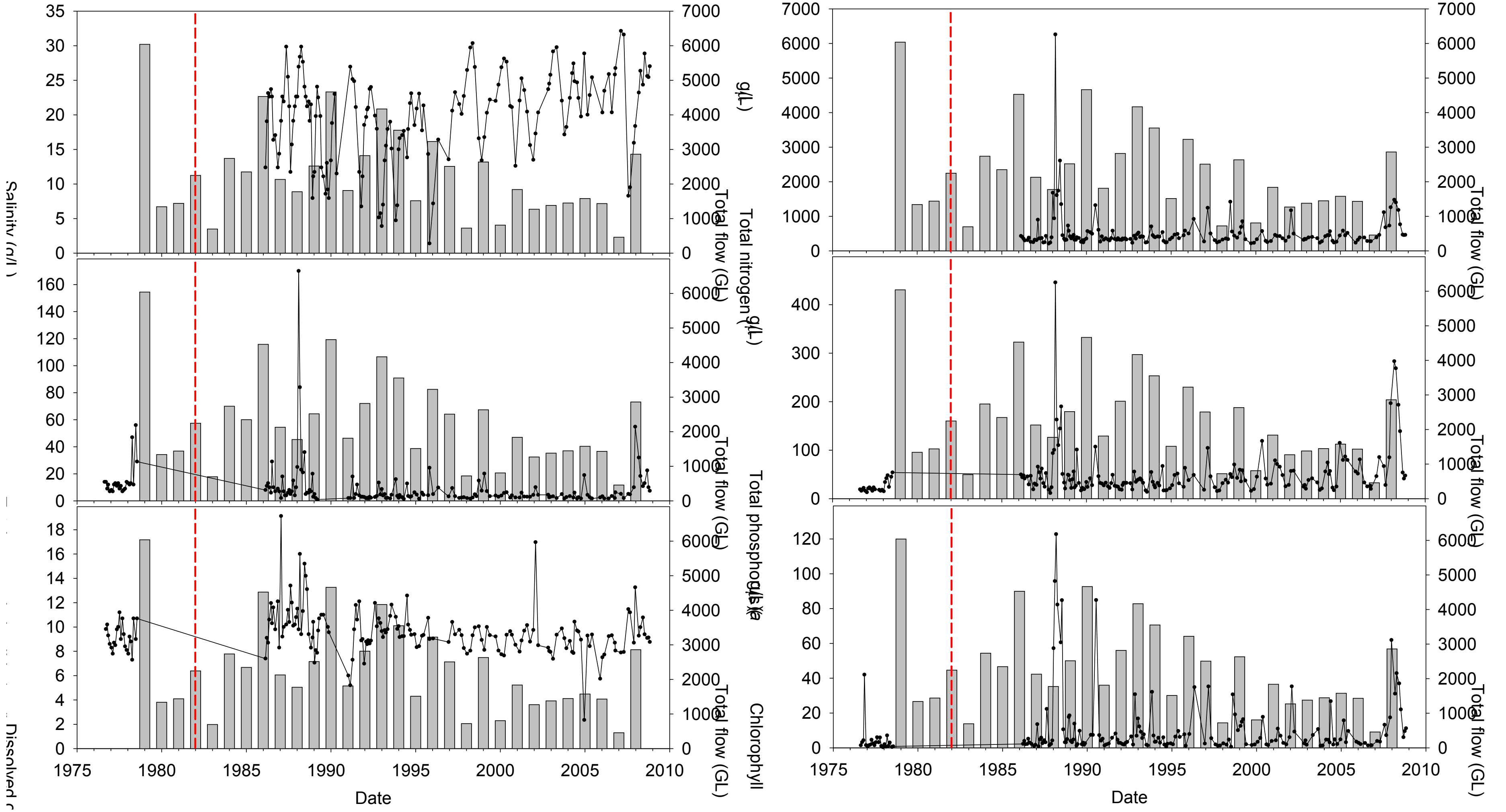


Figure B- 5 Lake King surface water quality data (EPA monitoring site 002316). Total flow represents the summed flow recorded for all major catchment rivers and is given as hydrological year (June-May). Red dotted line denotes listing of Gippsland Lakes as Ramsar wetland in 1982.

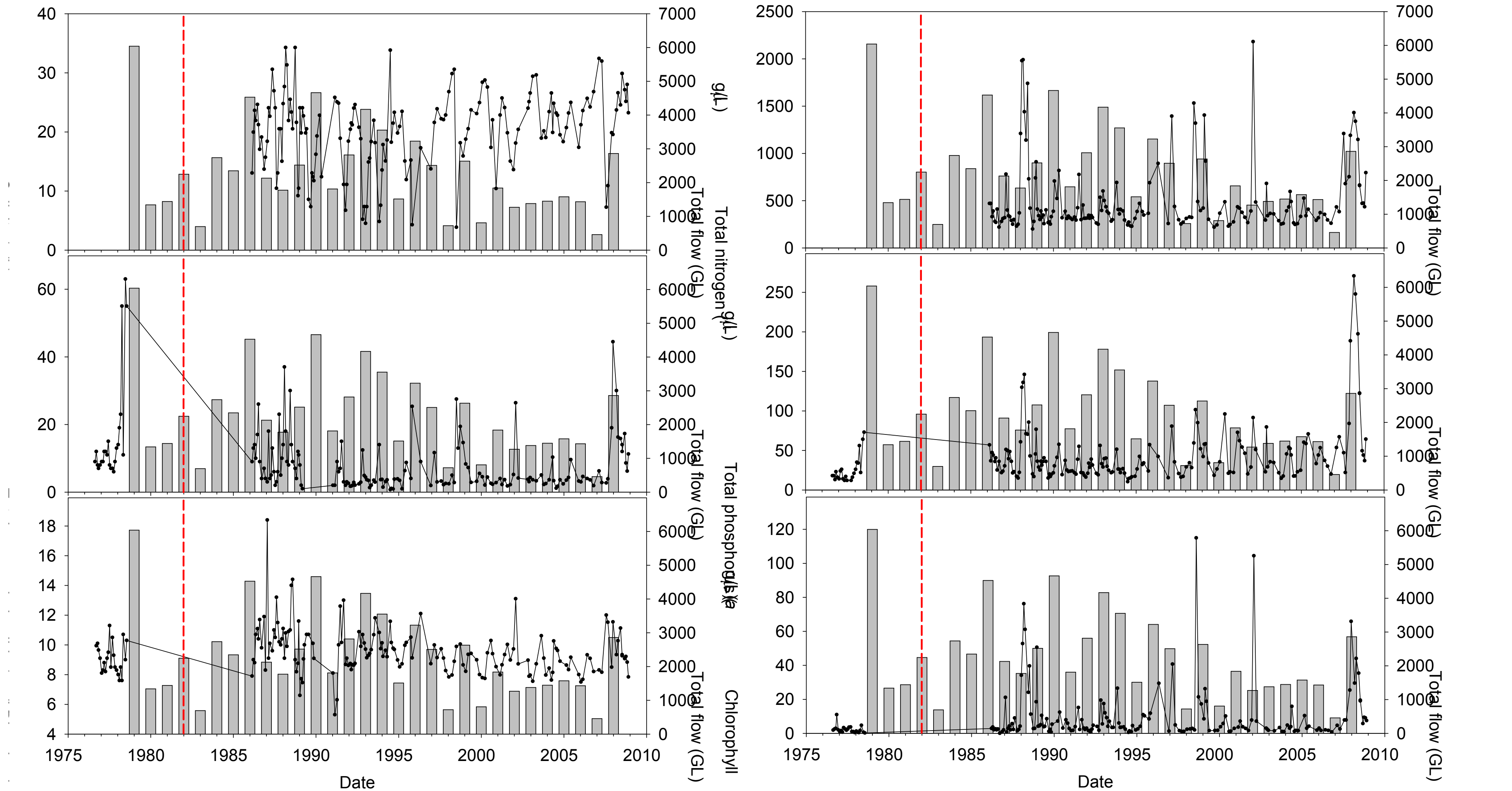


Figure B- 6 Lake King Channel surface water quality data (EPA monitoring site 002322). Total flow represents the summed flow recorded for all major catchment rivers and is given as hydrological year (June-May). Red dotted line denotes listing of Gippsland Lakes as Ramsar wetland in 1982.

APPENDIX C: ADDITIONAL BIRD COUNT DATA ANALYSIS

Data sources

Two data-sets were considered in this assessment:

- DSE Fauna database records outlined in the file titled "fauna100_gippslakes_ramsar_dd94". This database has count data for fauna species recorded at stations within the Gippsland Lakes Ramsar site.
- Birds Australia Atlas data. The Atlas contains counts and survey effort for numerous stations in the Ramsar site.

Selected species

The following species were selected for analysis as they have been identified in this ECD as significant species in the context of meeting the one per cent of the flyway population criterion:

- black swan
- musk duck
- chestnut teal
- Eurasian coot
- fairy tern
- little tern

DSE data

The DSE fauna database contains a comprehensive bird count dataset, although it is noted that counts are not standardised and therefore should be considered as indicative only.

For each species, the following is provided:

- Total numbers of individuals recorded in each year (stations pooled), together with total annual river inflows superimposed (Figure C-1).
- 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 C-1 to C-6)).

It is apparent that there is great year to year variability in counts. The data shows:

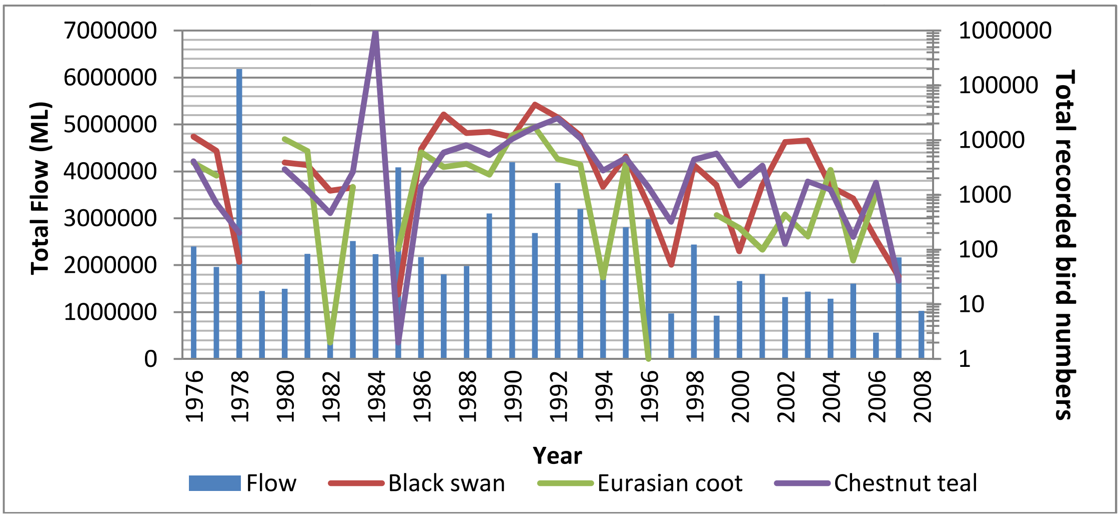
- More little tern were recorded in the last decade than in previous years. This could reflect actual increases in abundance or higher sampling effort for this species.
- Fairy tern – highest counts were recorded in two years in the last decade, however records/counts were very patchy over time.

- Musk duck counts have been consistently low since the late-1990s. In previous decades, numbers were relatively high (approximately 100 individuals counted), but variable between years.
- Black swan and Eurasian coot – It is unclear there is any clear temporal trend for these two species.
- Chestnut teal – numbers appear to have been relatively stable over time, the exception being a peak in 1984.

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 differences 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 or meaningful to derive empirical indices describing changes in bird abundance over time or among stations. Systematic sampling using standardised count methods would be required to develop appropriate bird abundance metrics.



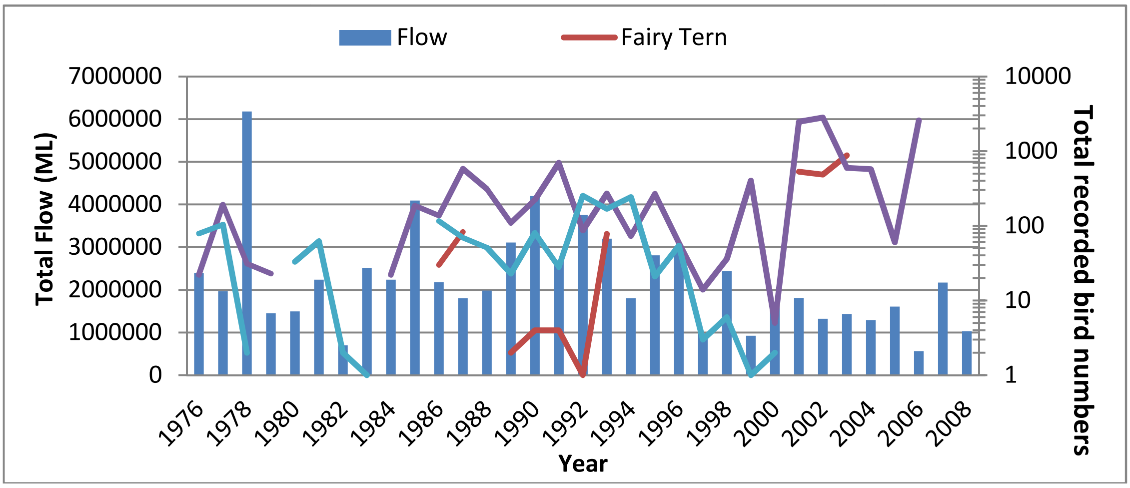


Figure C-1 Total number of individuals recorded in each year for black swan, Eurasian coot, chestnut teal, fairy tern, little tern and musk duck, together with total annual river inflows into the site (DSE Database)

Table C- 1 Summary statistics describing patterns in musk duck abundance (Uppercount) over time at the Gippsland Lake Ramsar site

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: Musk duck from fauna100_gippslakes_ramsar_dd94 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Uppercount, Total	11.394	31.865	2.444	170	0.000	233.000	0
Uppercount, 1931	0.000	•	•	1	0.000	0.000	0
Uppercount, 1975	33.063	51.319	12.830	16	1.000	156.000	0
Uppercount, 1976	15.800	19.357	8.657	5	1.000	44.000	0
Uppercount, 1977	17.333	40.515	16.540	6	0.000	100.000	0
Uppercount, 1978	2.000	•	•	1	2.000	2.000	0
Uppercount, 1979	0.000	•	•	1	0.000	0.000	0
Uppercount, 1980	3.667	3.428	1.143	9	0.000	9.000	0
Uppercount, 1981	3.647	3.639	.883	17	0.000	12.000	0
Uppercount, 1982	2.000	•	•	1	2.000	2.000	0
Uppercount, 1983	1.000	•	•	1	1.000	1.000	0
Uppercount, 1984	0.000	•	•	1	0.000	0.000	0
Uppercount, 1986	23.200	43.043	19.249	5	1.000	100.000	0
Uppercount, 1987	4.313	3.610	.902	16	2.000	12.000	0
Uppercount, 1988	4.636	5.316	1.603	11	1.000	16.000	0
Uppercount, 1989	4.600	3.647	1.631	5	1.000	9.000	0
Uppercount, 1990	5.714	4.906	1.311	14	1.000	19.000	0
Uppercount, 1991	3.111	1.537	.512	9	1.000	6.000	0
Uppercount, 1992	36.143	86.847	32.825	7	1.000	233.000	0
Uppercount, 1993	18.667	26.173	8.724	9	1.000	71.000	0
Uppercount, 1994	27.000	69.460	23.153	9	1.000	212.000	0
Uppercount, 1995	3.500	4.324	1.765	6	1.000	12.000	0
Uppercount, 1996	27.000	35.355	25.000	2	2.000	52.000	0
Uppercount, 1997	3.000	•	•	1	3.000	3.000	0
Uppercount, 1998	3.000	2.828	2.000	2	1.000	5.000	0
Uppercount, 1999	.500	.707	.500	2	0.000	1.000	0
Uppercount, 2000	.333	.816	.333	6	0.000	2.000	0
Uppercount, 2001	0.000	0.000	0.000	4	0.000	0.000	0
Uppercount, 2002	3.000	1.414	1.000	2	2.000	4.000	0
Uppercount, 2006	1.000	•	•	1	1.000	1.000	0

Note: First column is the year of the surveys (referred to as Uppercount). 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. The minimum and maximum values are the lowest and highest number of birds recorded during surveys.

Table C- 2 Summary statistics describing patterns in Eurasian coot abundance (Uppercount) over time at the Gippsland Lake Ramsar site

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: Eurasian coot from fauna100_gippslakes_ramsar_dd94 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Uppercount, Total	185.627	507.386	21.499	557	0.000	8000.000	0
Uppercount, 1931	0.000	0.000	0.000	2	0.000	0.000	0
Uppercount, 1971	0.000	•	•	1	0.000	0.000	0
Uppercount, 1975	404.558	455.858	69.518	43	0.000	2000.000	0
Uppercount, 1976	547.000	633.135	239.302	7	9.000	1600.000	0
Uppercount, 1977	83.407	404.050	77.759	27	0.000	2100.000	0
Uppercount, 1978	0.000	0.000	0.000	17	0.000	0.000	0
Uppercount, 1979	0.000	0.000	0.000	8	0.000	0.000	0
Uppercount, 1980	221.745	358.059	52.228	47	0.000	1500.000	0
Uppercount, 1981	139.844	264.369	39.410	45	0.000	972.000	0
Uppercount, 1982	1.000	1.414	1.000	2	0.000	2.000	0
Uppercount, 1983	175.500	308.695	109.140	8	0.000	811.000	0
Uppercount, 1985	51.000	69.296	49.000	2	2.000	100.000	0
Uppercount, 1986	192.677	361.866	64.993	31	0.000	1000.000	0
Uppercount, 1987	55.569	96.478	12.668	58	1.000	455.000	0
Uppercount, 1988	78.766	125.286	18.275	47	1.000	500.000	0
Uppercount, 1989	155.867	237.814	61.403	15	1.000	823.000	0
Uppercount, 1990	471.423	1564.795	306.882	26	6.000	8000.000	0
Uppercount, 1991	450.158	634.814	102.980	38	4.000	2265.000	0
Uppercount, 1992	180.800	193.470	38.694	25	0.000	600.000	0
Uppercount, 1993	276.538	732.111	203.051	13	3.000	2700.000	0
Uppercount, 1994	10.333	6.658	3.844	3	6.000	18.000	0
Uppercount, 1995	737.800	1382.091	618.090	5	0.000	3180.000	0
Uppercount, 1996	1.000	•	•	1	1.000	1.000	0
Uppercount, 1998	0.000	•	•	1	0.000	0.000	0
Uppercount, 1999	16.960	49.839	9.968	25	0.000	200.000	0
Uppercount, 2000	15.625	50.724	12.681	16	0.000	200.000	0
Uppercount, 2001	14.286	37.796	14.286	7	0.000	100.000	0
Uppercount, 2002	146.667	46.188	26.667	3	120.000	200.000	0
Uppercount, 2003	34.800	34.666	15.503	5	0.000	73.000	0
Uppercount, 2004	177.125	620.569	155.142	16	0.000	2500.000	0
Uppercount, 2005	4.500	7.171	2.535	8	0.000	19.000	0
Uppercount, 2006	200.200	447.102	199.950	5	0.000	1000.000	0

Note: First column is the year of the surveys (referred to as Uppercount). 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. The minimum and maximum values are the lowest and highest number of birds recorded during surveys.

Table C- 3 Summary statistics describing patterns in black swan abundance (Uppercount) over time at the Gippsland Lake Ramsar site

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: black swan from fauna100_gippslakes_ramsar_dd94 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Uppercount, Total	177.283	630.729	17.541	1293	0.000	11530.000	0
Uppercount, 0	120.000	•	•	1	120.000	120.000	0
Uppercount, 1931	0.000	0.000	0.000	2	0.000	0.000	0
Uppercount, 1969	75.000	•	•	1	75.000	75.000	0
Uppercount, 1972	0.000	•	•	1	0.000	0.000	0
Uppercount, 1974	0.000	0.000	0.000	2	0.000	0.000	0
Uppercount, 1975	131.633	226.369	29.224	60	0.000	1000.000	0
Uppercount, 1976	413.607	648.928	122.636	28	0.000	2460.000	0
Uppercount, 1977	233.852	890.372	171.352	27	0.000	4600.000	0
Uppercount, 1978	3.000	13.416	3.000	20	0.000	60.000	0
Uppercount, 1979	0.000	0.000	0.000	10	0.000	0.000	0
Uppercount, 1980	45.256	71.516	7.712	86	0.000	379.000	0
Uppercount, 1981	37.785	55.191	5.723	93	0.000	270.000	0
Uppercount, 1982	91.615	134.413	37.279	13	0.000	420.000	0
Uppercount, 1983	75.500	194.764	45.906	18	0.000	800.000	0
Uppercount, 1984	0.000	0.000	0.000	7	0.000	0.000	0
Uppercount, 1985	3.750	7.500	3.750	4	0.000	15.000	0
Uppercount, 1986	86.423	190.549	21.575	78	0.000	1000.000	0
Uppercount, 1987	219.142	1077.489	93.081	134	0.000	10000.000	0
Uppercount, 1988	157.233	349.785	37.718	86	0.000	2575.000	0
Uppercount, 1989	366.051	492.286	78.829	39	2.000	1670.000	0
Uppercount, 1990	405.179	808.685	152.827	28	0.000	4000.000	0
Uppercount, 1991	894.060	1861.076	263.196	50	6.000	11530.000	0
Uppercount, 1992	480.944	884.205	120.325	54	2.000	5251.000	0
Uppercount, 1993	335.222	379.091	63.182	36	0.000	1612.000	0
Uppercount, 1994	93.467	106.180	27.416	15	2.000	410.000	0
Uppercount, 1995	277.500	780.768	184.029	18	0.000	3383.000	0
Uppercount, 1996	29.000	32.969	7.029	22	0.000	100.000	0
Uppercount, 1997	5.889	4.859	1.620	9	2.000	17.000	0
Uppercount, 1998	83.167	250.715	38.686	42	0.000	1350.000	0
Uppercount, 1999	18.810	73.819	8.305	79	0.000	500.000	0
Uppercount, 2000	1.788	8.498	1.178	52	0.000	54.000	0
Uppercount, 2001	76.050	204.989	45.837	20	0.000	800.000	0
Uppercount, 2002	255.444	207.184	34.531	36	1.000	762.000	0
Uppercount, 2003	229.605	174.064	26.544	43	1.000	700.000	0
Uppercount, 2004	38.486	41.170	6.768	37	0.000	150.000	0
Uppercount, 2005	26.719	78.654	13.904	32	0.000	447.000	0
Uppercount, 2006	17.333	49.762	16.587	9	0.000	150.000	0
Uppercount, 2007	32.000	•	•	1	32.000	32.000	0

Note: First column is the year of the surveys (referred to as Uppercount). 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. The minimum and maximum values are the lowest and highest number of birds recorded during surveys.

Table C- 4 Summary statistics describing patterns in chestnut teal abundance (Uppercount) over time at the Gippsland Lake Ramsar site

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: chestnut teal from fauna100_gippslakes_ramsar_dd94 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Uppercount, Total	124.079	416.525	13.068	1016	0.000	8050.000	0
Uppercount, 1931	0.000	•	•	1	0.000	0.000	0
Uppercount, 1961	0.000	•	•	1	0.000	0.000	0
Uppercount, 1969	1.000	0.000	0.000	2	1.000	1.000	0
Uppercount, 1974	0.000	0.000	0.000	2	0.000	0.000	0
Uppercount, 1975	34.889	66.739	12.844	27	0.000	300.000	0
Uppercount, 1976	242.471	294.967	71.540	17	3.000	1000.000	0
Uppercount, 1977	30.174	109.561	22.845	23	0.000	500.000	0
Uppercount, 1978	11.111	47.140	11.111	18	0.000	200.000	0
Uppercount, 1979	0.000	0.000	0.000	5	0.000	0.000	0
Uppercount, 1980	58.340	250.967	35.492	50	0.000	1765.000	0
Uppercount, 1981	20.593	39.187	5.102	59	0.000	230.000	0
Uppercount, 1982	115.500	127.220	63.610	4	26.000	302.000	0
Uppercount, 1983	136.000	289.584	66.435	19	0.000	1000.000	0
Uppercount, 1984	0.000	0.000	0.000	4	0.000	0.000	0
Uppercount, 1985	.500	1.000	.500	4	0.000	2.000	0
Uppercount, 1986	35.375	82.639	13.066	40	0.000	500.000	0
Uppercount, 1987	69.047	202.357	21.949	85	0.000	1800.000	0
Uppercount, 1988	90.044	224.532	23.668	90	0.000	1695.000	0
Uppercount, 1989	172.032	236.376	42.454	31	2.000	850.000	0
Uppercount, 1990	325.563	634.698	112.200	32	0.000	2740.000	0
Uppercount, 1991	380.600	1228.102	183.075	45	3.000	8050.000	0
Uppercount, 1992	381.677	629.457	78.075	65	2.000	3308.000	0
Uppercount, 1993	308.343	679.429	114.844	35	0.000	3730.000	0
Uppercount, 1994	198.429	304.419	81.360	14	0.000	1047.000	0
Uppercount, 1995	277.706	349.560	84.781	17	8.000	1200.000	0
Uppercount, 1996	98.286	210.214	56.182	14	0.000	806.000	0
Uppercount, 1997	53.500	74.115	30.258	6	0.000	150.000	0
Uppercount, 1998	107.146	349.463	54.577	41	0.000	1817.000	0
Uppercount, 1999	62.822	249.947	26.347	90	0.000	1500.000	0
Uppercount, 2000	23.661	110.741	14.064	62	0.000	700.000	0
Uppercount, 2001	153.636	597.180	127.319	22	0.000	2800.000	0
Uppercount, 2002	15.875	23.558	8.329	8	0.000	64.000	0
Uppercount, 2003	64.704	121.271	23.339	27	0.000	504.000	0
Uppercount, 2004	46.000	105.576	20.318	27	0.000	490.000	0
Uppercount, 2005	15.545	35.175	10.606	11	0.000	120.000	0
Uppercount, 2006	110.200	384.739	99.339	15	0.000	1500.000	0
Uppercount, 2007	9.000	6.245	3.606	3	2.000	14.000	0

Note: First column is the year of the surveys (referred to as Uppercount). 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. The minimum and maximum values are the lowest and highest number of birds recorded during surveys.

Table C- 5 Summary statistics describing patterns in fairy tern abundance (Uppercount) over time at the Gippsland Lake Ramsar site

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: Fairy tern from fauna100_gippslakes_ramsar_dd94 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Uppercount, Total	7.323	12.887	.763	285	0.000	80.000	0
Uppercount, 1976	0.000	•	•	1	0.000	0.000	0
Uppercount, 1977	0.000	0.000	0.000	2	0.000	0.000	0
Uppercount, 1981	0.000	•	•	1	0.000	0.000	0
Uppercount, 1986	15.000	7.071	5.000	2	10.000	20.000	0
Uppercount, 1987	20.750	15.945	7.973	4	2.000	40.000	0
Uppercount, 1988	0.000	0.000	0.000	2	0.000	0.000	0
Uppercount, 1989	2.000	•	•	1	2.000	2.000	0
Uppercount, 1991	4.000	•	•	1	4.000	4.000	0
Uppercount, 1992	1.000	•	•	1	1.000	1.000	0
Uppercount, 1993	78.000	•	•	1	78.000	78.000	0
Uppercount, 1995	1.000	•	•	1	1.000	1.000	0
Uppercount, 1998	0.000	0.000	0.000	3	0.000	0.000	0
Uppercount, 1999	0.000	0.000	0.000	10	0.000	0.000	0
Uppercount, 2000	0.000	0.000	0.000	12	0.000	0.000	0
Uppercount, 2001	9.138	11.157	1.465	58	0.000	49.000	0
Uppercount, 2002	8.083	14.075	1.817	60	0.000	68.000	0
Uppercount, 2003	6.984	12.609	1.128	125	0.000	80.000	0

Note: First column is the year of the surveys (referred to as Uppercount). 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. The minimum and maximum values are the lowest and highest number of birds recorded during surveys.

Table C- 6 Summary statistics describing patterns in little tern abundance (Uppercount) over time at the Gippsland Lake Ramsar site

Descriptive Statistics
Split By: Yr_st
Inclusion criteria: Little tern from fauna100_gippslakes_ramsar_dd94 (imported)

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Uppercount, Total	21.332	59.766	2.422	609	0.000	610.000	0
Uppercount, 1931	0.000	•	•	1	0.000	0.000	0
Uppercount, 1953	0.000	•	•	1	0.000	0.000	0
Uppercount, 1970	0.000	•	•	1	0.000	0.000	0
Uppercount, 1971	0.000	•	•	1	0.000	0.000	0
Uppercount, 1975	53.333	53.780	31.050	3	3.000	110.000	0
Uppercount, 1976	11.000	12.728	9.000	2	2.000	20.000	0
Uppercount, 1977	24.000	39.174	13.850	8	0.000	109.000	0
Uppercount, 1978	6.200	11.756	5.257	5	0.000	27.000	0
Uppercount, 1979	5.750	7.588	3.794	4	0.000	16.000	0
Uppercount, 1980	0.000	•	•	1	0.000	0.000	0
Uppercount, 1981	0.000	0.000	0.000	6	0.000	0.000	0
Uppercount, 1982	6.500	9.192	6.500	2	0.000	13.000	0
Uppercount, 1983	0.000	0.000	0.000	2	0.000	0.000	0
Uppercount, 1984	4.400	6.066	2.713	5	0.000	12.000	0
Uppercount, 1985	62.000	10.583	6.110	3	50.000	70.000	0
Uppercount, 1986	27.400	30.964	13.848	5	0.000	75.000	0
Uppercount, 1987	82.857	91.738	34.674	7	7.000	220.000	0
Uppercount, 1988	44.286	97.522	36.860	7	1.000	265.000	0
Uppercount, 1989	109.000	•	•	1	109.000	109.000	0
Uppercount, 1990	36.833	25.365	10.355	6	20.000	72.000	0
Uppercount, 1991	99.429	91.887	34.730	7	4.000	218.000	0
Uppercount, 1992	12.429	10.179	3.847	7	2.000	30.000	0
Uppercount, 1993	45.000	77.979	31.835	6	0.000	194.000	0
Uppercount, 1994	73.000	•	•	1	73.000	73.000	0
Uppercount, 1995	38.143	45.242	17.100	7	7.000	130.000	0
Uppercount, 1996	7.375	6.632	2.345	8	0.000	19.000	0
Uppercount, 1997	3.500	4.509	2.255	4	0.000	10.000	0
Uppercount, 1998	3.273	9.045	2.727	11	0.000	30.000	0
Uppercount, 1999	11.457	22.568	3.815	35	0.000	109.000	0
Uppercount, 2000	.278	.826	.195	18	0.000	3.000	0
Uppercount, 2001	14.862	32.115	2.485	167	0.000	245.000	0
Uppercount, 2002	22.246	58.748	5.234	126	0.000	300.000	0
Uppercount, 2003	7.766	13.631	1.553	77	0.000	70.000	0
Uppercount, 2004	23.833	57.358	11.708	24	0.000	273.000	0
Uppercount, 2005	3.529	5.938	1.440	17	0.000	19.000	0
Uppercount, 2006	111.391	201.552	42.027	23	0.000	610.000	0

Note: First column is the year of the surveys (referred to as Uppercount). 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. The minimum and maximum values are the lowest and highest number of birds recorded during surveys.

Birds Australia Atlas data

Table C-7 is a summary of trends in bird count data as determined from the Bird Australia Atlas data. Data were only assessed where counts were standardised to 20 minute counts. This reduces some of the sampling effort biases inherent in the DSE data noted above.

While broad trends in habitat use can be derived from the data, there are insufficient data to develop a robust baseline description of abundance for most of the target species. There are exceptions to this, as follows:

- Black swan - there is a good data set describing black swan abundance in the period 1987 to 1990, however very few count data post 2002 (see also Figure C-2). The reason/s for this difference over time is uncertain. Based on available data, counts greater than 100 individuals per 20 minute search occurred in 23 per cent of surveys.
- Chestnut teal – similar to black swan, most surveys containing 20 minute count data occurred in the period 1988 through the 1990's. There are few count data post 2000. Based on available data, counts greater than 50 individuals per 20 minute search occurred in 20 per cent of surveys.
- Eurasian coot – consistent with patterns in black swan and chestnut teal, most 20 minute count data were for the period 1988 to 1999. Based on available data, counts greater than 50 individuals per 20 minute search occurred in 23 per cent of surveys.

There was insufficient data to determine trends in fairy tern, little tern and musk duck abundance.

It is important to note that for all these surveys, while survey effort at a given station in time is standardised, the specific locations of surveys, timing of surveys (seasonality) and frequency of surveys is not inconsistent. This prevents meaningful interpretation of long-term trends in bird abundance. Nonetheless, the Bird Australia data provide a basis for establishing baseline waterbird abundance, focussing on key habitats used by these species.

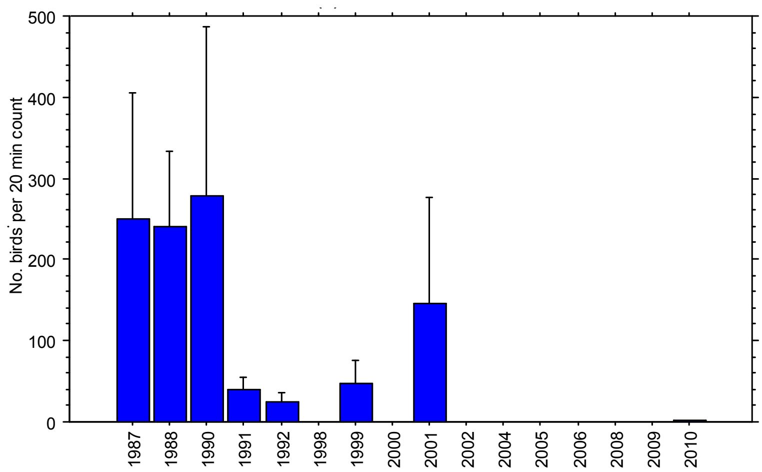


Figure C-2 Mean abundance (error bars ± S.E.) of black swan per 20 minute search (Data source: Birds Australia unpublished)

Table C- 7 Summary of Trends in Birds Australia Atlas Count Data (based on standardised 20 minute search data only)

Species	Number of surveys with 20 min. search count data	Spatial trend	Temporal trend
Black swan	97 surveys	Of the 97 20-minute surveys containing count data: • eight surveys had counts ≥500 individuals per 20 minute search (eight per cent of surveys). • 23 surveys had counts ≥100 individuals per 20 minute search (23 per cent of surveys. • 28 surveys had counts ≥50 individuals per 20 minute search (29 per cent of surveys. Counts ≥100 individuals per 20 minute search recorded at: Bancroft Bay, Bosses Swamp, Bunga Arm, Cunningham Arm, Jones Bay, Lake Bunga and STP, Nicholson River Floodplain and Point Dawson (Lake King). The overall average count (all stations and times pooled) was 148 ± 48.01 S.E. individuals/ 20 minute search.	All records with counts ≥100 individuals occurred pre-2002. In 1987 to 1990 mean bird counts exceeded 200 individuals per 20 minute search (Figure E2). Highest counts recorded Jan to Apr.
Musk duck	19 surveys	Almost all data with counts are located at Lake Bunga Sewage Treatment Plant. Insufficient data assess other trends.	Insufficient data to assess trends.
Chestnut teal	111 surveys	Of the 111 20-minute surveys containing count data: • three surveys had counts ≥500 individuals per 20 minute search (three per cent of surveys. • 12 surveys had counts ≥100 individuals per 20 minute search (11 per cent of	Highest counts recorded Feb to Apr inclusive. All records with counts greater than 20 individuals/20 minute search were recorded in the period 1988 to 1999 (n = 38 surveys).

Species	Number of surveys with 20 min. search count data	Spatial trend	Temporal trend
		surveys. • 22 surveys had counts ≥50 individuals per 20 minute search (20 per cent of surveys. Counts greater than 49 individuals per 20 minute search recorded at: Blue Horizons Main, Aqualand Estate, Jones Bay, Bunga Arm, Cunningham Arm, Lake Bunga & Sewage Ponds, Nicholson floodplain, Picnic Arm, Lake King. The overall average count (all stations and times pooled, using only records with count data) was 58 ± 18.3 S.E. individuals/ 20 minute search.	
Eurasian coot	84 surveys	Of the 84 20-minute surveys containing count data: • three surveys had counts ≥500 individuals per 20 minute search (three per cent of surveys. • 13 surveys had counts ≥100 individuals per 20 min search (15 per cent of surveys. • 20 surveys had counts ≥50 individuals per 20 min search (23 per cent of surveys. Counts greater than 100 individuals per 20 minute search recorded at: Nicholson River floodplain, Blue Horizons Main, Aqualand Estate, Jones Bay, Bunga Arm, Lake Bunga & Sewage Ponds. The overall average count (all stations and times pooled, using only records with count data) was 254 ± 69.3 S.E. individuals/ 20 minute search.	All records with counts greater than 100 individuals/20 minute search were recorded in the period 1988 to 1999 (n = 13 records).
Fairy tern	2 surveys	Both records from Jones Bay. Sitings at other locations but no count data.	Insufficient data to assess trends.

Species	Number of surveys with 20 min. search count data	Spatial trend	Temporal trend
Little tern	12 surveys	Most records from Lake Tyers, Tambo River mouth, Bunga Arm, Lake Bunga, and Jones Bay.	All records from 1988 to 1999. Insufficient data to assess long term trends. Only recorded in summer months, reflecting migratory nature.

Comparison of Data Sets

Table C-8 is a summary of key temporal trends in the counts of key species based on DSE and birds Australia datasets, and findings of the Ecos (unpublished) analysis. In summary, the long-term temporal trends noted in the analysis of DSE data (that is, increase in little tern and fairy tern, decrease in musk duck) were not apparent in the Birds Australia data. As mentioned, inconsistencies in sampling effort in both data sets preclude meaningful analysis of long term trends.

Overall, Ecos (unpublished) suggests that the largest observed declines in waterbird abundance and reporting rate were observed for Eurasian coot and musk duck. While such changes may occurred, the absence of standardised surveys prevents a definitive assessment of changes in abundance of these species since site listing in 1982.

Table C-8 Long-term trend analysis in the abundance of the key species

Species	Ecos analysis	DSE Data (not standardised for effort)	Standarised Birds Australia Atlas count data	Summary
Black swan	Average annual count sizes have declined substantially since the mid 1990s. As common now as in the 1980s, when populations were at a low ebb. Reporting rate has halved since early 1980s but has remained stable since about 1988.	Average annual counts for black swan abundance has been relatively stable since listing.	Low reporting rate (and low average annual abundance) since 1990.	Insufficient information to quantify trends in time
Eurasian coot	Very substantial declines in average annual count size (75 per cent) and reporting rate (60 per cent) since early 1980s	Average annual counts highly variable over time with a peak in 1990 (mean equals 8000 birds). No apparent long term trend could be discerned.	Overall average count of 254 ± 69.3 S.E. individuals/ 20 minute search over monitoring period (1988-2008). Lowest counts occurred in the period after 1999.	Insufficient information to quantify trends in time
Musk duck	Average annual count size and reporting rate very similar.	Musk duck counts have been consistently low since the late-1990s. In previous decades, numbers were	Insufficient data to assess trends.	Insufficient information to quantify trends in time

Species	Ecos analysis	DSE Data (not standardised for effort)	Standarised Birds Australia Atlas count data	Summary
	Has substantially declined since the late 1970s, with some recovery in the 1990s but it currently in steep decline.	relatively high (approximately 100 individuals counted), but variable between years.		
Chestnut teal	Stable noting slight decrease in reporting rates but substantial increases in flock size since the 1980s.	Numbers appear to have been relatively stable over time, the exception being a peak in 1984.	Most surveys containing 20 minute count data occurred in the period 1988 through the 1990's. There are few count data post 2000.	Insufficient information to quantify trends in time
Fairy tern	Stable - No substantial variation reported since 1980s.	Highest counts were recorded in two years in the last decade, however records/counts were very patchy over time.	Insufficient data to assess trends.	Insufficient information to quantify trends in time
Little tern	Stable - May have increased since the 1980s.	More little tern were recorded in the last decade than in previous years. This could reflect actual increases in abundance or higher sampling effort for this species.	Insufficient data to assess trends.	Insufficient information to quantify trends in time

APPENDIX D: SPECIES LIST

Mammal List

Scientific Name	Common Name	EPBC Status
Acrobates pygmaeus	feathertail glider	
Antechinus agilis	agile antechinus	
Antechinus swainsonii	dusky antechinus	
Cercartetus nanus	Eastern pygmy-possum	
Cervus porcinus	hog deer	
Cervus unicolor	Sambar	
Chalinolobus gouldii	Gould's wattled bat	
Chalinolobus morio	chocolate wattled bat	
Dasyurus maculatus	spot-tailed quoll	Endangered
Felis catus	cat	
Hydromys chrysogaster	water rat	
Isoodon obesulus obesulus	southern brown bandicoot	Endangered
Lepus europeaus	European hare	
Macropus giganteus	eastern grey kangaroo	
Macropus rufogriseus	red-necked wallaby	
Miniopterus schreibersii (group)	common bent-wing bat	
Mormopterus sp. EG	freetail bat (eastern form)	
Mus musculus	house mouse	
Myotis macropus	southern myotis	
Nyctophilus geoffroyi	lesser long-eared bat	
Nyctophilus gouldi	Gould's long-eared bat	
Ornithorhynchus anatinus	platypus	
Oryctolagus cuniculus	European rabbit	
Perameles nasuta	long-nosed bandicoot	
Petauroides volans	greater glider	
Petaurus australis	yellow-bellied glider	
Petaurus breviceps	sugar glider	
Phascolarctos cinereus	koala	
Potorous tridactylus	long-nosed potoroo	Vulnerable
Pseudocheirus peregrinus	common ringtail possum	
Pseudomys novaehollandiae	New Holland mouse	Vulnerable
Pteropus poliocephalus	grey-headed flying-fox	Vulnerable
Rattus fuscipes	bush rat	
Rattus lutreolus	swamp rat	

Scientific Name	Common Name	EPBC Status
Rattus rattus	black rat	
Rhinolophus megaphyllus	eastern horseshoe bat	
Saccolaimus flaviventris	yellow-bellied sheathtail bat	
Scotorepens orion	eastern broad-nosed bat	
Sminthopsis leucopus	white-footed dunnart	
Sus scrofa	pig (feral)	
Tachyglossus aculeatus	short-beaked echidna	
Tadarida australis	white-striped freetail bat	
Trichosurus cunninghami	mountain brushtail possum	
Trichosurus vulpecula	common brushtail possum	
Vespadelus darlingtoni	large forest bat	
Vespadelus regulus	southern forest bat	
Vespadelus vulturnus	little forest bat	
Vombatus ursinus	common wombat	
Vulpes vulpes	red fox	
Wallabia bicolor	black wallaby	

Reptile List

Scientific Name	Common Name	EPBC Status
Amphibolurus muricatus	tree dragon	
Austrelaps superbus	lowland copperhead	
Bassiana duperreyi	eastern three-lined skink	
Chelodina longicollis	common long-necked turtle	
Drysdalia coronoides	white-lipped snake	
Egernia coventryi	swamp skink	
Egernia saxatilis intermedia	black rock skink	
Eulamprus heatwolei	yellow-bellied water skink	
Lampropholis delicata	delicate skink	
Lampropholis guichenoti	garden skink	
Lerista bougainvillii	Bougainville's skink	
Nannoscincus maccoyi	McCoy's skink	
Notechis scutatus	tiger snake	
Pseudechis porphyriacus	red-bellied black snake	
Pseudemoia entrecasteauxii	southern grass skink	
Pseudemoia rawlinsoni	glossy grass skink	

Rhinoplocephalus nigrescens	eastern small-eyed snake	
Saproscincus mustelinus	weasel skink	
Tiliqua nigrolutea	blotched blue-tongued lizard	
Tiliqua scincoides	common blue-tongued lizard	
Varanus varius	lace goanna	

Frog List

Scientific Name	Common Name	EPBC Status
Crinia signifera	common froglet	
Geocrinia victoriana	Victorian smooth froglet	
Limnodynastes dumerilii	southern bullfrog (ssp. unknown)	
Limnodynastes dumerilii insularis		
Limnodynastes peronii	striped marsh frog	
Limnodynastes tasmaniensis	spotted marsh frog (race unknown)	
Litoria aurea	green and golden bell frog	Vulnerable
Litoria ewingii	southern brown tree frog	
Litoria lesueuri	Lesueur's frog	
Litoria peronii	Peron's tree frog	
Litoria raniformis	growling grass frog	Vulnerable
Litoria verreauxii verreauxii	Verreaux's tree frog	
Paracrinia haswelli	Haswell's froglet	
Pseudophryne dendyi	Dendy's toadlet	
Pseudophryne semimarmorata	southern toadlet	

Bird List

Scientific Name	Common Name	EPBC Status
Acanthagenys rufogularis	spiny-cheeked honeyeater	
Acanthiza chrysorrhoa	yellow-rumped thornbill	
Acanthiza lineata	striated thornbill	
Acanthiza nana	yellow thornbill	
Acanthiza pusilla	brown thornbill	
Acanthiza reguloides	buff-rumped thornbill	
Acanthorhynchus tenuirostris	eastern spinebill	
Accipiter cirrhocephalus	collared sparrowhawk	
Accipiter fasciatus	brown goshawk	
Accipiter novaehollandiae	grey goshawk	
Acridotheres tristis	common myna	
Acrocephalus australis	Australian reed warbler	
Acrocephalus stentoreus	clamorous reed warbler	
Actitis hypoleucos	common sandpiper	
Aegotheles cristatus	Australian owlet-nightjar	
Alauda arvensis	European skylark	
Alcedo azurea	azure kingfisher	
Alisterus scapularis	Australian king-parrot	
Anas castanea	chestnut teal	
Anas gracilis	grey teal	
Anas platyrhynchos	northern mallard	
Anas rhynchotis	Australasian shoveler	
Anas superciliosa	Pacific black duck	
Anhinga novaehollandiae	Australasian darter	
Anser anser	domestic goose	
Anseranas semipalmata	magpie goose	
Anthochaera carunculata	red wattlebird	
Anthochaera chrysoptera	little wattlebird	
Anthochaera phrygia	regent honeyeater	Endangered
Anthus novaeseelandiae	Australasian pipit	
Apus pacificus	fork-tailed swift	Migratory, Listed
Aquila audax	wedge-tailed eagle	
Ardea ibis	cattle egret	Migratory, Listed

Scientific Name	Common Name	EPBC Status
Ardea intermedia	intermediate egret	
Ardea modesta	eastern great egret	
Ardea pacifica	white-necked heron	
Ardenna carneipes	flesh-footed shearwater	
Ardenna grisea	sooty shearwater	
Ardenna tenuirostris	short-tailed shearwater	
Arenaria interpres	ruddy turnstone	
Artamus cyanopterus	dusky woodswallow	
Artamus personatus	masked woodswallow	
Artamus superciliosus	white-browed woodswallow	
Aythya australis	hardhead	
Biziura lobata	musk duck	
Botaurus poiciloptilus	Australasian bittern	
Cacatua galerita	sulphur-crested cockatoo	
Cacatua sanguinea	little corella	
Cacatua tenuirostris	long-billed corella	
Cacomantis flabelliformis	fan-tailed cuckoo	
Cacomantis variolosus	brush cuckoo	
Calamanthus pyrrhopygius	chestnut-rumped heathwren	
Calidris acuminata	sharp-tailed sandpiper	Migratory, Listed
Calidris alba	sanderling	
Calidris canutus	red knot	Migratory, Listed
Calidris ferruginea	curlew sandpiper	Migratory, Listed
Calidris melanotos	pectoral sandpiper	
Calidris ruficollis	red-necked stint	Migratory, Listed
Calidris tenuirostris	great knot	
Callocephalon fimbriatum	gang-gang cockatoo	
Calyptorhynchus funereus	yellow-tailed black-cockatoo	
Carduelis carduelis	European goldfinch	
Carduelis chloris	European greenfinch	
Cereopsis novaehollandiae	Cape Barren goose	
Charadrius bicinctus	double-banded plover	
Charadrius mongolus	lesser sand plover	
Charadrius ruficapillus	red-capped plover	Listed
Chenonetta jubata	Australian wood duck	

Scientific Name	Common Name	EPBC Status
Chlidonias hybridus	whiskered tern	
Chlidonias leucopterus	white-winged black tern	
Chroicocephalus novaehollandiae	silver gull	
Chrysococcyx basalis	Horsfield's bronze-cuckoo	
Chrysococcyx lucidus	Shining bronze-cuckoo	
Cincloramphus cruralis	brown songlark	
Cincloramphus mathewsi	rufous songlark	
Cinclosoma punctatum	spotted quail-thrush	
Circus approximans	swamp harrier	
Circus assimilis	spotted harrier	
Cisticola exilis	golden-headed cisticola	
Cladorhynchus leucocephalus	banded stilt	
Climacteris affinis	white-browed treecreeper	
Climacteris erythrops	red-browed treecreeper	
Climacteris picumnus victoriae	brown treecreeper (south-eastern ssp.)	
Colluricincla harmonica	grey shrike-thrush	
Columba leucomela	white-headed pigeon	
Columba livia	rock dove	
Coracina novaehollandiae	black-faced cuckoo-shrike	
Coracina papuensis	white-bellied cuckoo-shrike	
Coracina tenuirostris	cicadabird	
Coracina tenuirostris	common cicadabird	
Corcorax melanorhamphos	white-winged chough	
Cormobates leucophaeus	white-throated treecreeper	
Corvus coronoides	Australian raven	
Corvus mellori	little raven	
Corvus orru	Torresian crow	
Corvus tasmanicus	forest raven	
Coturnix pectoralis	stubble quail	
Coturnix ypsilophora	brown quail	
Cracticus nigrogularis	pied butcherbird	
Cracticus torquatus	grey butcherbird	
Cuculus pallidus	pallid cuckoo	
Cygnus atratus	black swan	
Dacelo novaeguineae	laughing kookaburra	

Scientific Name	Common Name	EPBC Status
Daphoenositta chrysoptera	varied sittella	
Daption capense	cape petrel	
Dasyornis brachypterus	eastern bristlebird	
Dicaeum hirundinaceum	mistletoebird	
Dicrurus bracteatus	spangled drongo	
Diomedea exulans	wandering albatross	Vulnerable, Migratory, Listed
Dromaius novaehollandiae	emu	
Egretta garzetta	little egret	
Egretta novaehollandiae	white-faced heron	
Elanus axillaris	black-shouldered kite	
Elseyornis melanops	black-fronted dotterel	
Eolophus roseicapillus	galah	
Eopsaltria australis	eastern yellow robin	
Epthianura albifrons	white-fronted chat	
Erythrogonys cinctus	red-kneed dotterel	
Eudynamys orientalis	eastern koel	
Eudyptula minor	little penguin	
Eurostopodus mystacalis	white-throated nightjar	
Eurystomus orientalis	dollarbird	
Falco berigora	brown falcon	
Falco cenchroides	nankeen kestrel	
Falco hypoleucos	grey falcon	
Falco longipennis	Australian hobby	
Falco peregrinus	peregrine falcon	
Falco subniger	black falcon	
Falcunculus frontatus	crested shrike-tit	
Fulica atra	Eurasian coot	
Gallinago hardwickii	Latham's snipe	Migratory, Listed
Gallinula tenebrosa	dusky moorhen	
Gallinula ventralis	black-tailed native-hen	
Gallirallus philippensis	buff-banded rail	
Gelochelidon nilotica	gull-billed tern	
Geopelia striata	peaceful dove	
Gerygone mouki	brown gerygone	
Gerygone olivacea	white-throated gerygone	

Scientific Name	Common Name	EPBC Status
Glossopsitta concinna	musk lorikeet	
Glossopsitta porphyrocephala	purple-crowned lorikeet	
Glossopsitta pusilla	little lorikeet	
Grallina cyanoleuca	magpie-lark	
Grantiella picta	painted honeyeater	
Gymnorhina tibicen	Australian magpie	
Haematopus fuliginosus	sooty oystercatcher	
Haematopus longirostris	pied oystercatcher	
Haliaeetus leucogaster	white-bellied sea-eagle	Migratory, Listed
Haliastur sphenurus	whistling kite	
Hamirostra melanosternon	black-breasted buzzard	
Heteroscelus brevipes	grey-tailed tattler	
Hieraaetus morphnoides	little eagle	
Himantopus himantopus	black-winged stilt	Listed
Hirundapus caudacutus	white-throated needletail	Migratory, Listed
Hirundo ariel	fairy martin	
Hirundo neoxena	welcome swallow	
Hirundo nigricans	tree martin	
Hydroprogne caspia	Caspian tern	
Ixobrychus minutus	little bittern	
Lalage sueurii	white-winged triller	
Larus dominicanus	kelp gull	
Larus pacificus pacificus	Pacific gull	
Lathamus discolor	swift parrot	Endangered, Listed
Leucosarcia melanoleuca	Wonga pigeon	
Lewinia pectoralis	Lewin's rail	
Lichenostomus chrysops	yellow-faced honeyeater	
Lichenostomus fuscus	fuscous honeyeater	
Lichenostomus leucotis	white-eared honeyeater	
Lichenostomus melanops	yellow-tufted honeyeater	
Lichenostomus penicillatus	white-plumed honeyeater	
Limicola falcinellus	broad-billed sandpiper	
Limosa lapponica	bar-tailed godwit	
Limosa limosa	black-tailed godwit	
Lophoictinia isura	square-tailed kite	

Scientific Name	Common Name	EPBC Status
Lopholaimus antarcticus	topknot pigeon	
Macronectes giganteus	southern giant-petrel	Endangered, Migratory, Listed
Malacorhynchus membranaceus	pink-eared duck	
Malurus cyaneus	superb fairy-wren	
Manorina flavigula	yellow-throated miner	
Manorina melanocephala	noisy miner	
Manorina melanophrys	bell miner	
Megalurus gramineus	little grassbird	
Melanodryas cucullata	hooded robin	
Meliphaga lewinii	Lewin's honeyeater	
Melithreptus brevirostris	brown-headed honeyeater	
Melithreptus lunatus	white-naped honeyeater	
Menura novaehollandiae	superb lyrebird	
Merops ornatus	rainbow bee-eater	Migratory, Listed
Microcarbo melanoleucos	little pied cormorant	
Microeca fascinans	jacky winter	
Milvus migrans	black kite	
Mirafra javanica	Horsfield's bushlark	
Monarcha melanopsis	black-faced monarch	Migratory, Listed
Morus serrator	Australasian gannet	
Myiagra cyanoleuca	satin flycatcher	Migratory, Listed
Myiagra inquieta	restless flycatcher	
Myiagra rubecula	leaden flycatcher	
Myzomela sanguinolenta	scarlet honeyeater	
Neochmia temporalis	red-browed finch	
Neophema chrysostoma	blue-winged parrot	
Ninox connivens	barking owl	
Ninox novaeseelandiae	southern boobook	
Ninox strenua	powerful owl	
Numenius madagascariensis	eastern curlew	
Numenius phaeopus	whimbrel	
Nycticorax caledonicus	nankeen night heron	
Ocyphaps lophotes	crested pigeon	
Oriolus sagittatus	olive-backed oriole	
Oxyura australis	blue-billed duck	

Scientific Name	Common Name	EPBC Status
Pachycephala olivacea	olive whistler	
Pachycephala pectoralis	golden whistler	
Pachycephala rufiventris	rufous whistler	
Pachyptila turtur	fairy prion	
Pardalotus punctatus	spotted pardalote	
Pardalotus striatus	striated pardalote	
Passer domesticus	house sparrow	
Passer montanus	Eurasian tree sparrow	
Pavo cristatus	Indian peafowl	
Pelecanoides urinatrix	common diving-petrel	
Pelecanus conspicillatus	Australian pelican	
Petroica boodang	scarlet robin	
Petroica goodenovii	red-capped robin	
Petroica phoenicea	flame robin	
Petroica rodinogaster	pink robin	
Petroica rosea	rose robin	
Pezoporus wallicus	ground parrot	
Phalacrocorax carbo	great cormorant	
Phalacrocorax fuscescens	black-faced cormorant	
Phalacrocorax sulcirostris	little black cormorant	
Phalacrocorax varius	pied cormorant	
Phaps chalcoptera	common bronzewing	
Phaps elegans	brush bronzewing	
Philemon citreogularis	little friarbird	
Philemon corniculatus	noisy friarbird	
Phylidonyris melanops	tawny-crowned honeyeater	
Phylidonyris novaehollandiae	New Holland honeyeater	
Phylidonyris pyrrhoptera	crescent honeyeater	
Platalea flavipes	yellow-billed spoonbill	
Platalea regia	royal spoonbill	
Platycercus elegans	crimson rosella	
Platycercus eximius	eastern rosella	
Plegadis falcinellus	glossy ibis	
Pluvialis fulva	Pacific golden plover	
Pluvialis squatarola	grey plover	

Scientific Name	Common Name	EPBC Status
Podargus strigoides	tawny frogmouth	
Podiceps cristatus	great crested grebe	
Poliocephalus poliocephalus	hoary-headed grebe	
Porphyrio porphyrio	purple swamphen	
Porzana fluminea	Australian spotted crake	
Porzana pusilla	Baillon's crake	
Porzana tabuensis	spotless crake	
Psophodes olivaceus	eastern whipbird	
Pterodroma inexpectata	mottled petrel	
Pterodroma macroptera	great-winged petrel	
Ptilonorhynchus violaceus	satin bowerbird	
Puffinus gavia	fluttering shearwater	
Pycnoptilus floccosus	pilotbird	
Recurvirostra novaehollandiae	red-necked avocet	
Rhipidura albiscarpa	grey fantail	
Rhipidura leucophrys	willie wagtail	
Rhipidura rufifrons	rufous fantail	Migratory, Listed
Rostratula australis	Australian painted snipe	Vulnerable
Scythrops novaehollandiae	channel-billed cuckoo	
Sericornis frontalis	white-browed scrubwren	
Sericornis magnirostris	large-billed scrubwren	
Smicrornis brevirostris	weebill	
Stagonopleura bella	beautiful firetail	
Stagonopleura guttata	diamond firetail	
Stercorarius antarcticus	brown skua	
Stercorarius parasiticus	Arctic Jaeger	
Sterna hirundo	common tern	
Sterna paradisaea	Arctic tern	
Sterna striata	white-fronted tern	
Sternula albifrons	little tern	Migratory, Listed
Sternula nereis	fairy tern	
Stictonetta naevosa	Freckled duck	
Stipiturus malachurus	southern emu-wren	
Strepera graculina	pied currawong	
Strepera versicolor	grey currawong	

Scientific Name	Common Name	EPBC Status
Streptopelia chinensis	spotted turtle-dove	
Sturnus vulgaris	common starling	
Sula leucogaster	brown booby	
Tachybaptus novaehollandiae	Australasian grebe	
Tadorna tadornoides	Australian shelduck	
Taeniopygia bichenovii	double-barred finch	
Thalaseus bergii	crested tern	
Thalassarche cauta	shy albatross	Vulnerable, Migratory, Listed
Thalassarche chlororhynchos	yellow-nosed albatross	
Thalassarche chrysostoma	grey-headed albatross	Endangered, Migratory
Thinornis rubricollis	hooded plover	Listed
Threskiornis molucca	Australian white ibis	
Threskiornis spinicollis	straw-necked ibis	
Todiramphus sanctus	sacred kingfisher	
Trichoglossus haematodus	rainbow lorikeet	
Tringa nebularia	common greenshank	
Tringa stagnatilis	marsh sandpiper	
Turdus merula	common blackbird	
Turnix varia	painted button-quail	
Tyto javanica	Pacific barn owl	
Tyto novaehollandiae	masked owl	
Tyto tenebricosa	sooty owl	
Vanellus miles	masked lapwing	
Vanellus tricolor	banded lapwing	
Xenus cinereus	terek sandpiper	
Zoothera lunulata	Bassian Thrush	
Zosterops lateralis	silvereye	

Waterbird List

Scientific Name	Common Name	EPBC Act
Actitis hypoleucos	common sandpiper	
Anas castanea	chestnut teal	
Anas gracilis	grey teal	
Anas rhynchotis	Australasian shoveler	
Anas superciliosa	Pacific black duck	
Anhinga novaehollandiae	Australasian darter	

Scientific Name	Common Name	EPBC Act
Anseranas semipalmata	magpie goose	
Ardea intermedia	intermediate egret	
Ardea modesta	eastern great egret	
Ardea pacifica	white-necked heron	
Arenaria interpres	ruddy turnstone	
Aythya australis	hardhead	
Biziura lobata	musk duck	
Botaurus poiciloptilus	Australasian bittern	
Calidris acuminata	sharp-tailed sandpiper	Migratory, Listed
Calidris canutus	red knot	Migratory, Listed
Calidris ferruginea	curlew sandpiper	Migratory, Listd
Calidris ruficollis	red-necked stint	Migratory, Listed
Calidris tenuirostris	great knot	
Charadrius bicinctus	double-banded plover	
Charadrius mongolus	lesser sand plover	
Charadrius ruficapillus	red-capped plover	
Chenonetta jubata	Australian wood duck	
Chlidonias hybridus	whiskered tern	
Chlidonias leucopterus	white-winged black tern	
Chroicocephalus novaehollandiae	silver gull	
Cladorhynchus leucocephalus	banded stilt	
Cygnus atratus	black swan	
Egretta garzetta	little egret	
Egretta novaehollandiae	white-faced heron	
Elseyornis melanops	black-fronted dotterel	
Erythrogonys cinctus	red-kneed dotterel	
Fulica atra	Eurasian coot	
Gallinago hardwickii	Latham's snipe	Migratory, Listed
Gallinula tenebrosa	dusky moorhen	
Gallinula ventralis	black-tailed native-hen	
Gallirallus philippensis	buff-banded rail	
Haematopus fuliginosus	sooty oystercatcher	
Haematopus longirostris	pied oystercatcher	
Heteroscelus brevipes	grey-tailed tattler	
Himantopus himantopus	black-winged stilt	
Hydroprogne caspia	Caspian tern	
Larus dominicanus	kelp gull	
Larus pacificus pacificus	Pacific gull	

Scientific Name	Common Name	EPBC Act
Lewinia pectoralis	Lewin's rail	
Limosa lapponica	bar-tailed godwit	
Microcarbo melanoleucos	little pied cormorant	
Morus serrator	Australasian gannet	
Numenius madagascariensis	eastern curlew	
Numenius phaeopus	whimbrel	
Nycticorax caledonicus	nankeen night heron	
Oxyura australis	blue-billed duck	
Pelecanus conspicillatus	Australian pelican	
Phalacrocorax carbo	great cormorant	
Phalacrocorax fuscescens	black-faced cormorant	
Phalacrocorax sulcirostris	little black cormorant	
Phalacrocorax varius	pied cormorant	
Platalea flavipes	yellow-billed spoonbill	
Platalea regia	royal spoonbill	
Plegadis falcinellus	glossy ibis	
Pluvialis fulva	Pacific golden plover	
Podiceps cristatus	great crested grebe	
Poliocephalus poliocephalus	hoary-headed grebe	
Porphyrio porphyrio	purple swamphen	
Porzana fluminea	Australian spotted crake	
Porzana pusilla	Baillon's crake	
Porzana tabuensis	spotless crake	
Recurvirostra novaehollandiae	red-necked avocet	
Rostratula australis	Australian painted snipe	Vulnerable
Sterna hirundo	common tern	
Sterna striata	white-fronted tern	
Sternula albifrons	little tern	Migratory, Listed
Sternula nereis	fairy tern	
Stictonetta naevosa	freckled duck	
Tachybaptus novaehollandiae	Australasian grebe	
Tadorna tadornoides	Australian shelduck	
Thalaseus bergii	crested tern	
Thinornis rubricollis	hooded plover	Listed
Threskiornis molucca	Australian white ibis	
Threskiornis spinicollis	straw-necked ibis	
Tringa nebularia	common greenshank	
Tringa stagnatilis	marsh sandpiper	

Scientific Name	Common Name	EPBC Act
Vanellus miles	masked lapwing	
Vanellus tricolor	banded lapwing	
Xenus cinereus	terek sandpiper	

Fish List

(Sourced from Ecos 2008, based mostly after Jeremy Hindell, unpublished data, 2007)

Scientific Name	Common Name	EPBC Act
Acanthaluteres spilomelanurus	bridled leatherjacket	
Acanthaluteres vittiger	toothbrush leatherjacket	
Acanthopagrus australis	yellow-fin bream	
Acanthopagrus butcheri	black bream	
Afurcagobius tamarensis	Tamar River goby	
Alabes dorsalis	common shore-eel	
Alabes hoesei	dwarf shore-eel	
Alabes parvulus	pygmy shore-eel	
Aldrichetta forsteri	yellow-eye mullet	
Allomycterus pilatus	small-spined porcupinefish	
Ambassis jacksoniensis	Port Jackson chanda perch	
Ammotretis rostratus	longsnout flounder	
Anguilla australis	shortfin eel	
Anguilla reinhardtii	Longfin eel	
Aracana aurita	Shaw's cowfish	
Arenigobius bifrenatus	bridled goby	
Arenigobius frenatus	half-bridled goby	
Argyrosomus hololepidotus	mulloway	
Arripis georgiana	tommy rough	
Arripis trutta	Eastern Australian salmon	
Arripis truttaceus	Western Australian salmon	
Aspasmogaster tasmaniensis	Tasmanian clingfish	

Scientific Name	Common Name	EPBC Act
Atherinason hepsetoides	deepwater hardyhead	
Atherinosoma microstoma	smallmouthed hardyhead	
Atypichthys strigatus	mado	
Bathygobius kreffti	frayedfin goby	
Brachaluteres jacksonianus	southern pygmy leatherjacket	
Brachynectes fasciatus	weedy threefin	
Centropogon australis	eastern fortesque	
Cepola australis	bandfish	
Cheilodactylus fuscus	red morwong	
Chelidonichthys kumu	red gurnard	
Contusus brevicaudatus	prickly toadfish	
Creocele cardinalis	broad clingfish	
Cristiceps australis	southern crested weedfish	
Dactylophora nigricans	dusky morwong	
Dasyatis brevicaudata	smooth stingray	
Dasyatis thetidis	black stingray	
Dicotylichthys punctulatus	three-barred porcupinefish	
Dinolestes lewini	longfin pike	
Diodon nicthemerus	globefish	
Engraulis australis	Australian anchovy	
Enoplosus armatus	old wife	
Eubalichthys mosaicus	mosaic leatherjacket	
Favonigobius lateralis	long-finned goby	
Gadopsis marmoratus	river blackfish	
Galaxias olidus	mountain galaxias	
Galaxias truttaceus	spotted galaxias	
Galaxiella pusilla	dwarf galaxias	Vulnerable
Genus A sp. 2	brownspotted spiny clingfish	

Scientific Name	Common Name	EPBC Act
Genus B sp.	rat clingfish	
Genus C sp.1	grass clingfish	
Genypterus tigerinus	rock ling	
Geotria australis	pouched lamprey	
Gerres subfasciatus	southern silver biddy	
Girella tricuspidata	luderick	
Gobiomorphus australis	striped gudgeon	
Gobiomorphus coxii	Cox’s gudgeon	
Gobiopterus semivestitus	glass goby	
Gonorynchus greyi	beaked salmon	
Gymnapistes marmoratus	soldierfish	
Haletta semifasciata	blue rock whiting	
Herklotsichthys castelnaui	sprat	
Heteroclinus kuiteri	Kuiter's weedfish	
Heteroclinus perspicillatus	spotshoulder weedfish	
Heteroclinus puellarum	little weedfish	
Heteroclinus sp.3	longtail weedfish	
Hippocampus abdominalis	big-bellied seahorse	Listed
Hippocampus breviceps	shortsnout seahorse	Listed
Hippocampus whitei	white's seahorse	Listed
Histiogamphelus briggsii	Brigg's crested pipefish	Listed
Hyperlophus vittatus	sandy sprat	
Hypnos monopterygium	Australian numbfish	
Hyporhamphus australis	Eastern Sea garfish	
Hyporhamphus melanochir	Southern Sea garfish	
Hyporhamphus regularis	river garfish	
Hypselognathus rostratus	knifesnout pipefish	Listed

Scientific Name	Common Name	EPBC Act
Hypseoltris compressa	empire gudgeon	
Iso rhothophilus	surf sardine	
Kathetostoma laeve	common stargazer	
Lepidoblennius haplodactylus	Jumping joey	
Lepidotrigla papilio	spiny gurnard	
Leptatherina presbyteroides	silver fish	
Lissocampus caudalis	smooth pipefish	
Lissocampus runa	javelin pipefish	Listed
Liza argentea	flat-tailed mullet	
Macquaria colonorum	estuary perch	
Macquaria novemaculeata	Australian bass	
Maxillicosta scabriceps	little scorpionfish	
Meuschenia freycineti	six-spined leatherjacket	
Meuschenia scaber	velvet leatherjacket	
Meuschenia trachylepis	yellow-finned leatherjacket	
Mitotichthys semistriatus	halfbanded pipefish	Listed
Monacanthus chinensis	Fanbelly leatherjacket	
Mugil cephalus	sea mullet	
Muraenichthys breviceps	short-headed worm-eel	
Myliobatis australis	eagle ray	
Myxus elongatus	sand mullet	
Narcine tasmaniensis	Tasmanian numbfish	
Nelusetta ayraudi	Chinaman leatherjacket	
Neoodax balteatus	little rock whiting	
Neoplatycephalus aurimaculatus	toothy flathead	
Neoplatycephalus richardsoni	tiger flathead	
Nesogobius hinsbyi	orangespotted goby	

Scientific Name	Common Name	EPBC Act
Nesogobius pulchellus	Castelnau's goby	
Nesogobius sp. 1	girdled goby	
Nesogobius sp. 3	twinbar goby	
Nesogobius sp. 5	sicklefin sandgoby	
Nesogobius sp. 6	opalescent sandgoby	
Nesogobius sp. 7	speckled sandgoby	
Norfolkia clarkei	common threefin	
Notolabrus fucicola	saddled wrasse	
Omobranchus anolius	oyster blenny	
Ophiclinops varius	variegated snakeblenny	
Ophisurus serpens	serpent eel	
Pagrus auratus	snapper	
Parablennius tasmanianus	Tasmanian blenny	
Parequula melbournensis	silverbelly	
Parvicrepis parvipinnis	smallfin clingfish	
Parvicrepis sp. 1	longsnout clingfish	
Parvicrepis sp. 2	obscure clingfish	
Pegasus lancifer	sculptured seamoth	
Phyllopteryx taeniolatus	weedy Seadragon	Listed
Platycephalus bassensis	southern sand flathead	
Platycephalus caeruleopunctatus	eastern blue-spotted flathead	
Platycephalus fuscus	dusky flathead	
Platycephalus laevigatus	rock flathead	
Pomatomus saltatrix	tailor	
Potamalosa richmondia	freshwater herring	
Pristiophorus nudipinnis	southern sawshark	
Prototroctes maraena	Australian grayling	Vulnerable

Scientific Name	Common Name	EPBC Act
Pseudocaranx dentex	silver trevally	
Pseudocaranx wrighti	skipjack trevally	
Pseudogobius olorum	western blue-spotted goby	
Pseudogobius sp. 9	eastern blue-spotted goby	
Pseudophycis breviuscula	bastard red cod	
Pseudophysis bachus	red rock cod	
Pseudophysis barbata	bearded rock cod	
Pugnaso curtirostris	pugnose pipefish	
Raja lemprieri	thornback skate	
Raja whitleyi	Melbourne skate	
Redigobius macrostoma	large-mouthed goby	
Retropinna semoni	Australian smelt	
Rhabdosargus sarba	tarwhine	
Rhombosolea tapirina	greenback flounder	
Salmo salar	Atlantic salmon	
Salmo trutta	brown trout	
Sardinops neopilchardus	pilchard	
Scobinichthys granulatus	rough leatherjacket	
Scorpaena papillosus	red rock cod	
Scorpis aequipinnis	sea sweep	
Sillaginodes punctata	King George whiting	
Sillago ciliata	sand whiting	
Sillago flindersi	school whiting	
Siphaemia cephalotes	Wood’s siphon fish	
Siphonognathus attenuatus	slender weed whiting	
Solegnathus spinosissimus	spiny pipehorse	Listed
Sphyraena novaehollandiae	shortfin seapike	

Scientific Name	Common Name	EPBC Act
Spratelloides robustus	blue sprat	
Sprattus novaehollandiae	Australian sprat	
Stigmatopora argus	spotted pipefish	Listed
Stigmatopora nigra	wide-bodied pipefish	Listed
Stipecampus cristatus	ring-backed pipefish	Listed
Synaptura nigra	black sole	
Taratretis derwentensis	Derwent flounder	
Tasmanogobius gloveri	marine goby	
Tasmanogobius lasti	lagoon goby	
Tasmanogobius lordi	Tasmanian goby	
Tetractenos glaber	smooth toadfish	
Tetractenos hamiltoni	common toadfish	
Torquigener pleurogramma	weeping toado	
Trachurus novaezelandiae	yellowtail	
Tridentiger trigonocephalus	Japanese goby	
Trygonoptera mucosa	western stingaree	
Trygonorrhina guanerius	southern fiddler ray	
Urocampus carinirostris	hairy pipefish	Listed
Urolophus curciatus	banded stingaree	
Urolophus gigas	spotted stingaree	
Urolophus paucimaculatus	sparsely-spotted stingaree	
Vanacampus margaritifer	mother-of-pearl pipefish	Listed
Vanacampus phillipi	Port Phillip pipefish	Listed
Zeus faber	john dory	

Flora List

Source: Data extracted from FIS database

Scientific Name	Common name	EPBC Status
Acacia caerulescens	limestone blue wattle	Vulnerable

Scientific Name	Common name	EPBC Status
Acacia dealbata	silver wattle	
Acacia genistifolia	spreading wattle	
Acacia implexa	lightwood	
Acacia mearnsii	black wattle	
Acacia melanoxylon	blackwood	
Acacia oxycedrus	spike wattle	
Acacia pycnantha	golden wattle	
Acacia spp.	wattle	
Acacia stricta	hop wattle	
Acacia suaveolens	sweet wattle	
Acacia terminalis	sunshine wattle	
Acacia ulicifolia	juniper wattle	
Acacia verticillata	prickly moses	
Acacia verticillata subsp. ovoidea	ovoid prickly moses	
Acacia verticillata subsp. verticillata	prickly moses	
Acaena agnipila	hairy sheep's burr	
Acaena agnipila/ovina complex	hairy/Australian sheep's burr	
Acaena echinata	sheep's burr	
Acaena novae-zelandiae	bidgee-widgee	
Acaena ovina	Australian sheep's burr	
Acaena spp.	sheep's burr	
Acianthus exsertus s.l.	gnat orchid	
Acianthus exsertus s.s.	large mosquito-orchid	
Acianthus pusillus	small mosquito-orchid	
Acianthus spp.	mosquito orchid	
Acrocladium chlamydophyllum	spear moss	
Acronychia oblongifolia	yellow-wood	
Acrotriche serrulata	honey-pots	
Actites megalocarpa	dune thistle	
Adiantum aethiopicum	common maidenhair	
Agrostis s.l. spp.	bent/blown grass	
Ajuga australis	Austral bugle	
Alisma plantago-aquatica	water plantain	

Scientific Name	Common name	EPBC Status
Allocasuarina littoralis	black sheoak	
Allocasuarina misera	slender sheoak	
Allocasuarina misera/paradoxa	slender/green sheoak	
Allocasuarina paludosa	scrub sheoak	
Allocasuarina paradoxa	green sheoak	
Allocasuarina spp.	sheoak	
Allocasuarina verticillata	drooping sheoak	
Almaleea subumbellata	wiry bush-pea	
Alternanthera denticulata s.l.	lesser joyweed	
Alternanthera denticulata s.s.	lesser joyweed	
Alyxia buxifolia	sea box	
Amperea xiphoclada var. xiphoclada	broom spurge	
Amphipogon strictus	grey-beard grass	
Amyema miquelii	box mistletoe	
Amyema pendula	drooping mistletoe	
Amyema pendula subsp. pendula (s.s.)	drooping mistletoe	
Amyema spp.	mistletoe	
Angianthus preissianus	salt angianthus	
Anisopogon avenaceus	oat spear-grass	
Aotus ericoides	common aotus	
Apalochlamys spectabilis	showy cassinia	
Aphelia pumilio	dwarf aphelia	
Apium prostratum subsp. prostratum	sea celery	
Apium prostratum subsp. prostratum var. filiforme	sea celery	
Apium prostratum subsp. prostratum var.	sea celery	
Apodasmia brownii	coarse twine-rush	
Arthropodium minus	small vanilla-lily	
Arthropodium strictum s.l.	chocolate lily	
Asperula conferta	common woodruff	
Asperula spp.	woodruff	
Asperula subsimplex	water woodruff	
Asplenium bulbiferum subsp. gracillimum	mother spleenwort	
Asplenium flabellifolium	necklace fern	

Scientific Name	Common name	EPBC Status
Asplenium flaccidum subsp. flaccidum	weeping spleenwort	
Asplenium trichomanes	common spleenwort	
Asterella drummondii	licorice strap	
Astroloma humifusum	cranberry heath	
Astroloma pinifolium	pine heath	
Astrotricha parvifolia	small-leaf star-hair	
Atriplex australasica	native orache	
Atriplex cinerea	coast saltbush	
Atriplex paludosa subsp. paludosa	marsh saltbush	
Atriplex semibaccata	berry saltbush	
Atriplex spp.	saltbush	
Australina pusilla subsp. muelleri	shade nettle	
Austrocynoglossum latifolium	forest hound's-tongue	
Austrodanthonia caespitosa	common wallaby-grass	
Austrodanthonia eriantha	hill wallaby-grass	
Austrodanthonia geniculata	kneed wallaby-grass	
Austrodanthonia penicillata	weeping wallaby-grass	
Austrodanthonia pilosa	velvet wallaby-grass	
Austrodanthonia racemosa var. racemosa	slender wallaby-grass	
Austrodanthonia setacea	bristly wallaby-grass	
Austrodanthonia setacea var. setacea	bristly wallaby-grass	
Austrodanthonia spp.	wallaby grass	
Austrodanthonia tenuior	purplish wallaby-grass	
Austrofestuca littoralis	coast fescue	
Austrostipa blackii	crested spear-grass	
Austrostipa flavescens	coast spear-grass	
Austrostipa mollis	supple spear-grass	
Austrostipa pubinodis	tall spear-grass	
Austrostipa rudis	veined spear-grass	
Austrostipa rudis subsp. nervosa	veined spear-grass	
Austrostipa rudis subsp. rudis	veined spear-grass	
Austrostipa scabra	rough spear-grass	
Austrostipa scabra subsp. scabra	rough spear-grass	

Scientific Name	Common name	EPBC Status
Austrostipa semibarbata	fibrous spear-grass	
Austrostipa spp.	spear grass	
Austrostipa stuposa	quizzical spear-grass	
Azolla filiculoides	Pacific azolla	
Banksia integrifolia subsp. integrifolia	coast banksia	
Banksia marginata	silver banksia	
Banksia serrata	saw banksia	
Baumea acuta	pale twig-sedge	
Baumea articulata	jointed twig-sedge	
Baumea juncea	bare twig-sedge	
Baumea rubiginosa s.s.	soft twig-sedge	
Baumea spp.	twig sedge	
Bedfordia arborescens	blanket leaf	
Berula erecta	water parsnip	
Beyeria lasiocarpa	wallaby-bush	
Beyeria lechenaultii	pale turpentine-bush	
Beyeria viscosa	pinkwood	
Billardiera scandens s.l.	common apple-berry	
Blechnum cartilagineum	gristle fern	
Blechnum nudum	fishbone water-fern	
Blechnum patersonii subsp. patersonii	strap water-fern	
Bolboschoenus caldwellii	salt club-sedge	
Bolboschoenus medianus	marsh club-sedge	
Bolboschoenus spp.	club sedge	
Boronia anemonifolia	sticky boronia	
Boronia anemonifolia subsp. anemonifolia	sticky boronia	
Bossiaea cinerea	showy bossiaea	
Bossiaea heterophylla	variable bossiaea	
Bossiaea obcordata	spiny bossiaea	
Bossiaea prostrata	creeping bossiaea	
Bossiaea spp.	bossiaea	
Botrychium australe	Austral moonwort	
Brachyloma daphnoides	daphne heath	

Scientific Name	Common name	EPBC Status
Brachyscome graminea	grass daisy	
Brachyscome parvula	coast daisy	
Brachyscome spathulata subsp. spathulata	spoon daisy	
Brachyscome spp.	daisy	
Brachythecium rutabulum	rough-stalked feather-moss	
Bromus spp.	brome	
Bulbine bulbosa	bulbine Lily	
Bulbine semibarbata	leek Lily	
Burchardia umbellata	milkmaids	
Bursaria spinosa subsp. spinosa	Sweet bursaria	
Caesia parviflora	pale grass-lily	
Caladenia alata	fairy orchid	
Caladenia carnea s.s.	pink fingers	
Caladenia dilatata s.l.	green-comb spider-orchid	
Caladenia latifolia	pink fairies	
Caladenia phaeoclavia	brown-clubbed spider-orchid	
Caladenia pusilla	tiny pink-fingers	
Caladenia spp.	caladenia	
Caladenia tentaculata	mantis orchid	
Caladenia tessellata	thick-lip spider-orchid	
Caladenia valida	robust spider-orchid	
Caladenia vulgaris	slender pink-fingers	
Caleana major	large duck-orchid	
Callistemon pallidus	lemon bottlebrush	
Callistemon sieberi	river bottlebrush	
Callistemon subulatus	dwarf bottlebrush	
Callitriche muelleri	round water-starwort	
Callitriche spp.	water starwort	
Calocephalus lacteus	milky beauty-heads	
Calochilus robertsonii	purple beard-orchid	
Calochlaena dubia	common ground-fern	
Calyptrochaeta apiculata	priest's-cap mitre-moss	
Calystegia marginata	forest bindweed	

Scientific Name	Common name	EPBC Status
Calystegia sepium subsp. roseata	large bindweed	
Calystegia spp.	bindweed	
Calytrix spp.	fringe myrtle	
Calytrix tetragona	common fringe-myrtle	
Campylopus introflexus	heath star moss	
Cardamine gunnii s.l.	common bitter-cress	
Cardamine paucijuga s.l.	annual bitter-cress	
Carex appressa	tall sedge	
Carex breviculmis	common grass-sedge	
Carex fascicularis	tassel sedge	
Carex gaudichaudiana	fen sedge	
Carex incomitata	hillside sedge	
Carex inversa	knob sedge	
Carex longebrachiata	bergalia tussock	
Carex polyantha	river sedge	
Carex pumila	strand sedge	
Carex spp.	sedge	
Carex tereticaulis	poong'ort	
Carpobrotus glaucescens	bluish pigface	
Carpobrotus rossii	karkalla	
Cassinia aculeata	common cassinia	
Cassinia longifolia	shiny cassinia	
Cassinia maritima	coast cassinia	
Cassinia spp.	cassinia	
Cassinia trinerva	three-nerved cassinia	
Cassytha glabella	slender dodder-laurel	
Cassytha melantha	coarse dodder-laurel	
Cassytha phaeolasia	rusty dodder-laurel	
Cassytha pubescens s.s.	downy dodder-laurel	
Cassytha spp.	dodder laurel	
Casuarina spp.	sheoak	
Caustis flexuosa	curly Wig	
Caustis pentandra	thick twist-rush	

Scientific Name	Common name	EPBC Status
Caustis spp.	twist rush	
Celastrus australis	staff climber	
Centaurium spicatum	spiked centaury	
Centella cordifolia	centella	
Centella spp.	centella	
Centipeda cunninghamii	common sneezeweed	
Centrolepis strigosa subsp. strigosa	hairy centrolepis	
Cheilanthes austrotenuifolia	green rock-fern	
Cheilanthes sieberi subsp. sieberi	narrow rock-fern	
Chenopodiaceae spp.	chenopod	
Chenopodium glaucum	glaucous goosefoot	
Chenopodium pumilio	clammy goosefoot	
Chenopodium spp.	goosefoot	
Chiloglottis gunnii s.l.	common bird-orchid	
Chiloglottis reflexa	autumn wasp-orchid	
Chiloglottis trapeziformis	dainty wasp-orchid	
Chloris truncata	windmill grass	
Chrysocephalum semipapposum	clustered everlasting	
Cissus hypoglauca	jungle grape	
Cladium procerum	leafy twig-sedge	
Clematis aristata	mountain clematis	
Clematis glycinoides	forest clematis	
Clematis microphylla s.l.	small-leaved clematis	
Clematis microphylla var. microphylla spp. agg.	small-leaved clematis	
Clematis spp.	clematis	
Comesperma calymega	blue-spike milkwort	
Comesperma defoliatum	leafless milkwort	
Comesperma volubile	love creeper	
Convolvulus erubescens spp. agg.	pink bindweed	
Coprosma quadrifida	prickly currant-bush	
Correa reflexa	common correa	
Correa reflexa var. speciosa	eastern correa	
Corunastylis despectans	sharp midge-orchid	

Scientific Name	Common name	EPBC Status
Corybas aconitiflorus	spurred helmet-orchid	
Corybas diemenicus s.l.	veined helmet-orchid	
Corybas fimbriatus	fringed helmet-orchid	
Corybas incurvus	slaty helmet-orchid	
Corybas spp.	helmet orchid	
Corybas unguiculatus	small pelican-orchid	
Cotula australis	common cotula	
Cotula spp.	cotula	
Craspedia glauca spp. agg.	common billy-buttons	
Crassula decumbens var. decumbens	spreading crassula	
Crassula helmsii	swamp crassula	
Crassula peduncularis	purple crassula	
Crassula sieberiana s.l.	sieber crassula	
Crassula sieberiana s.s.	sieber crassula	
Crassula spp.	crassula	
Crassula tetramera	Australian stonecrop	
Cryptandra amara s.s.	bitter cryptandra	
Cryptostylis subulata	large tongue-orchid	
Cyathea australis	rough tree-fern	
Cymbonotus lawsonianus	bear's-ear	
Cymbonotus preissianus	Austral bear's-ear	
Cynodon dactylon	couch	
Cynoglossum australe	Australian hound's-tongue	
Cynoglossum spp.	hound's tongue	
Cynoglossum suaveolens	sweet hound's-tongue	
Cyperaceae spp.	sedge	
Cyperus lucidus	leafy flat-sedge	
Cyrtostylis reniformis	small gnat-orchid	
Cyrtostylis robusta	large gnat-orchid	
Dampiera spp.	dampiera	
Dampiera stricta	blue dampiera	
Danthonia s.l. spp.	wallaby grass	
Daucus glochidiatus	Australian carrot	

Scientific Name	Common name	EPBC Status
Daviesia latifolia	hop bitter-pea	
Daviesia leptophylla	narrow-leaf bitter-pea	
Daviesia ulicifolia	gorse bitter-pea	
Daviesia ulicifolia subsp. ulicifolia	gorse bitter-pea	
Dennstaedtia davallioides	lacy ground-fern	
Desmodium gunnii	southern tick-trefoil	
Desmodium spp.	tick trefoil	
Deyeuxia contracta	compact bent-grass	
Deyeuxia minor	small bent-grass	
Deyeuxia quadriseta	reed bent-grass	
Deyeuxia rodwayi	Tasman bent-grass	
Deyeuxia spp.	bent-grass	
Dianella brevicaulis	small-flower flax-lily	
Dianella caerulea s.l.	paroo lily	
Dianella longifolia s.l.	pale flax-lily	
Dianella revoluta s.l.	black-anther flax-lily	
Dianella revoluta var. revoluta s.l.	black-anther flax-lily	
Dianella spp.	flax lily	
Dianella tasmanica	Tasman flax-lily	
Dichelachne crinita	long-hair plume-grass	
Dichelachne rara	common plume-grass	
Dichelachne sciurea spp. agg.	short-hair plume-grass	
Dichelachne sieberiana	rough plume-grass	
Dichelachne spp.	plume grass	
Dichondra repens	kidney-weed	
Dicksonia antarctica	soft tree-fern	
Dicranoloma dicarpum	pale fork-moss	
Dillwynia cinerascens s.l.	grey parrot-pea	
Dillwynia cinerascens s.s.	grey parrot-pea	
Dillwynia glaberrima	smooth parrot-pea	
Dillwynia sericea	showy parrot-pea	
Dillwynia spp.	parrot pea	
Diplazium australe	Austral lady-fern	

Scientific Name	Common name	EPBC Status
Dipodium punctatum s.l.	hyacinth orchid	
Dipodium punctatum s.s.	purple hyacinth-orchid	
Dipodium roseum s.s.	rosy hyacinth-orchid	
Disphyma crassifolium subsp. clavellatum	rounded noon-flower	
Distichlis distichophylla	Australian salt-grass	
Diuris orientis	wallflower orchid	
Diuris pardina	leopard orchid	
Diuris punctata var. punctata	purple diuris	
Diuris sulphurea	tiger orchid	
Dodonaea viscosa subsp. angustissima	slender hop-bush	
Dodonaea viscosa subsp. spatulata	sticky hop-bush	
Doodia aspera	prickly rasp-fern	
Doodia australis	common rasp-fern	
Drosera macrantha	climbing sundew	
Drosera peltata	pale sundew	
Drosera peltata subsp. auriculata	tall sundew	
Drosera peltata subsp. peltata	pale sundew	
Drosera spp.	sundew	
Drymophila cyanocarpa	turquoise berry	
Echinopogon caespitosus var. caespitosus	bushy hedgehog-grass	
Echinopogon ovatus	common hedgehog-grass	
Echinopogon spp.	hedgehog grass	
Einadia hastata	saloop	
Einadia nutans subsp. nutans	hodding saltbush	
Einadia spp.	einadia	
Einadia trigonos subsp. trigonos	lax goosefoot	
Elaeocarpus reticulatus	blue oliveberry	
Eleocharis acuta	common spike-sedge	
Eleocharis atricha	tuber spike-sedge	
Eleocharis gracilis	slender spike-sedge	
Eleocharis pusilla	small spike-sedge	
Eleocharis sphacelata	tall spike-sedge	
Elymus scaber var. scaber	common wheat-grass	

Scientific Name	Common name	EPBC Status
Empodisma minus	spreading rope-rush	
Entolasia marginata	bordered panic	
Epacris impressa	common heath	
Epacris obtusifolia	blunt-leaf heath	
Epilobium billardierianum	variable willow-herb	
Epilobium billardierianum subsp. billardierianum	smooth willow-herb	
Eragrostis spp.	love grass	
Eriochilus cucullatus	Parson's bands	
Eucalyptus aff. willisii (Gippsland Lakes)	Gippsland Lakes peppermint	
Eucalyptus angophoroides	apple box	
Eucalyptus baueriana	blue box	
Eucalyptus bosistoana	coast grey-box	
Eucalyptus bridgesiana s.l.	but but	
Eucalyptus bridgesiana s.s.	but but	
Eucalyptus camaldulensis	river red-gum	
Eucalyptus cephalocarpa s.s.	mealy stringybark	
Eucalyptus consideniana	yertchuk	
Eucalyptus conspicua	silver swamp stringybark	
Eucalyptus croajingolensis	Gippsland peppermint	
Eucalyptus cypellocarpa	mountain grey-gum	
Eucalyptus elata	river peppermint	
Eucalyptus globoidea	white stringybark	
Eucalyptus globulus subsp. bicostata	eurabbie	
Eucalyptus globulus subsp. pseudoglobulus	Gippsland blue-gum	
Eucalyptus melliodora	yellow box	
Eucalyptus muelleriana	yellow stringybark	
Eucalyptus obliqua	messmate stringybark	
Eucalyptus ovata	swamp gum	
Eucalyptus ovata var. ovata	swamp gum	
Eucalyptus pauciflora subsp. pauciflora	white sallee	
Eucalyptus polyanthemos	red box	
Eucalyptus polyanthemos subsp. vestita	red box	
Eucalyptus sieberi	silvertop ash	

Scientific Name	Common name	EPBC Status
Eucalyptus spp.	eucalypt	
Eucalyptus tereticornis subsp. mediana	Gippsland red-gum	
Eucalyptus tricarpa	red ironbark	
Eucalyptus tricarpa subsp. tricarpa	red ironbark	
Eucalyptus viminalis	manna gum	
Eucalyptus viminalis subsp. pryoriana	coast manna-gum	
Eucalyptus X williamsonii	mallacoota gum	
Euchiton collinus s.l.	clustered/creeping cudweed	
Euchiton collinus s.s.	creeping cudweed	
Euchiton involucratus s.l.	common cudweed	
Euchiton involucratus s.s.	star cudweed	
Euchiton sphaericus	annual cudweed	
Euchiton spp.	cudweed	
Eupomatia laurina	bolwarra	
Euryomyrtus ramosissima subsp. prostrata	Nnodding baeckea	
Eustrephus latifolius	wombat berry	
Exocarpos cupressiformis	cherry ballart	
Exocarpos spp.	ballart	
Festuca spp.	fescue	
Ficinia nodosa	knobby club-sedge	
Ficus spp.	fig	
Fissidens curvatus	Portuguese pocket-moss	
Fissidens taylorii	pygmy pocket-moss	
Gahnia clarkei	tall saw-sedge	
Gahnia filum	chaffy saw-sedge	
Gahnia melanocarpa	black-fruit saw-sedge	
Gahnia radula	thatch saw-sedge	
Gahnia sieberiana	red-fruit saw-sedge	
Gahnia spp.	saw sedge	
Gahnia trifida	coast saw-sedge	
Galium australe	tangled bedstraw	
Galium binifolium	reflexed bedstraw	
Galium gaudichaudii	rough bedstraw	

Scientific Name	Common name	EPBC Status
Galium migrans	wandering bedstraw	
Galium propinquum	Maori bedstraw	
Galium spp.	bedstraw	
Gastrodia spp.	potato orchid	
Geitonoplesium cymosum	scrambling lily	
Gemmabryum sauteri	Sauter's thread-moss	
Geranium gardneri	rough crane's-bill	
Geranium homeanum	rainforest crane's-bill	
Geranium potentilloides	soft crane's-bill	
Geranium potentilloides var. potentilloides	soft crane's-bill	
Geranium retrorsum s.l.	grassland crane's-bill	
Geranium solanderi s.l.	Austral crane's-bill	
Geranium sp. 2	variable crane's-bill	
Geranium spp.	crane's bill	
Gleichenia microphylla	scrambling coral-fern	
Glossodia major	wax-lip orchid	
Glyceria australis	Australian sweet-grass	
Glycine clandestina	twining glycine	
Glycine microphylla	small-leaf glycine	
Glycine spp.	glycine	
Glycine tabacina s.l.	variable glycine	
Glycine tabacina s.s.	variable glycine	
Gnaphalium indutum	tiny cudweed	
Gnaphalium spp.	cudweed	
Gompholobium huegelii	common wedge-pea	
Gonocarpus humilis	shade raspwort	
Gonocarpus micranthus	creeping raspwort	
Gonocarpus micranthus subsp. micranthus	creeping raspwort	
Gonocarpus spp.	raspwort	
Gonocarpus tetragynus	common raspwort	
Gonocarpus teucrioides s.l.	germander raspwort	
Gonocarpus teucrioides s.s.	germander raspwort	
Goodenia humilis	swamp goodenia	

Scientific Name	Common name	EPBC Status
Goodenia ovata	hop goodenia	
Goodenia paniculata	branched goodenia	
Gratiola pedunculata	stalked brooklime	
Gratiola peruviana	Austral brooklime	
Gratiola peruviana	Austral brooklime	
Grevillea celata	Colquhoun grevillea	Vulnerable
Grevillea chrysophaea	golden grevillea	
Grevillea lanigera	woolly grevillea	
Gymnostomum calcareum	lime cave-moss	
Gynatrix pulchella s.l.	hemp bush	
Hakea decurrens subsp. physocarpa	bushy needlewood	
Hakea eriantha	tree hakea	
Hakea teretifolia subsp. hirsuta	dagger hakea	
Hakea ulicina	furze hakea	
Haloragis brownii	swamp raspwort	
Halosarcia pergranulata subsp. pergranulata	blackseed glasswort	
Halosarcia spp.	glasswort	
Hardenbergia violacea	purple coral-pea	
Helichrysum leucopsideum	satin everlasting	
Helichrysum rutidolepis s.l.	pale everlasting	
Helichrysum rutidolepis s.s.	pale everlasting	
Helichrysum scorpioides	button everlasting	
Helichrysum spp.	everlasting	
Hemarthria uncinata var. uncinata	mat grass	
Hemichroa pentandra	trailing hemichroa	
Hibbertia acicularis	prickly Guinea-flower	
Hibbertia aspera s.l.	rough Guinea-flower	
Hibbertia aspera subsp. aspera s.s.	rough Guinea-flower	
Hibbertia calycina	juniper Guinea-flower	
Hibbertia empetrifolia s.l.	tangled Guinea-flower	
Hibbertia empetrifolia s.l.	tangled Guinea-flower	
Hibbertia fasciculata var. prostrata	bundled Guinea-flower	
Hibbertia obtusifolia	grey Guinea-flower	

Scientific Name	Common name	EPBC Status
Hibbertia riparia	erect Guinea-flower	
Hibbertia spp.	Guinea-flower	
Hibbertia stricta s.l.	upright Guinea-flower	
Hibbertia virgata	twiggy Guinea-flower	
Histiopteris incisa	bat's wing fern	
Howittia trilocularis	blue wowittia	
Hydrocotyle acutiloba	broad-leaf pennywort	
Hydrocotyle callicarpa	small pennywort	
Hydrocotyle foveolata	yellow pennywort	
Hydrocotyle hirta	hairy pennywort	
Hydrocotyle laxiflora	stinking pennywort	
Hydrocotyle pterocarpa	wing pennywort	
Hydrocotyle sibthorpioides	shining pennywort	
Hydrocotyle spp.	pennywort	
Hydrocotyle tripartita	slender pennywort	
Hydrocotyle verticillata	shield pennywort	
Hymenophyllum cupressiforme	common filmy-fern	
Hypericum gramineum	small St John's wort	
Hypericum japonicum	matted St John's wort	
Hypnum cupressiforme	common plait-moss	
Hypolaena fastigiata	tassel rope-rush	
Hypolepis glandulifera	downy ground-fern	
Hypolepis muelleri	harsh ground-fern	
Hypolepis rugosula	ruddy ground-fern	
Hypolepis spp.	ground-fern	
Hypoxis hygrometrica	golden weather-glass	
Hypoxis hygrometrica var. villosisepala	golden weather-glass	
Imperata cylindrica	blady grass	
Indigofera australis	Austral indigo	
Isolepis cernua	nodding club-sedge	
Isolepis cernua var. cernua	nodding club-sedge	
Isolepis cernua var. platycarpa	broad-fruit club-sedge	
Isolepis fluitans	floating club-sedge	

Scientific Name	Common name	EPBC Status
Isolepis fluitans var. fluitans	floating club-sedge	
Isolepis fluitans var. lenticularis	floating club-sedge	
Isolepis hookeriana	grassy club-sedge	
Isolepis inundata	swamp club-sedge	
Isolepis marginata	little club-sedge	
Isolepis spp.	club-sedge	
Isotoma fluviatilis subsp. australis	swamp isotome	
Joycea pallida	silvertop wallaby-grass	
Juncus australis	Austral rush	
Juncus bufonius	toad rush	
Juncus caespiticius	grassy rush	
Juncus continuus	pithy rush	
Juncus flavidus	gold rush	
Juncus fockei	slender joint-leaf rush	
Juncus gregiflorus	green rush	
Juncus ingens	giant rush	
Juncus ingens	giant rush	
Juncus kraussii subsp. australiensis	sea rush	
Juncus pallidus	pale rush	
Juncus pauciflorus	loose-flower rush	
Juncus planifolius	broad-leaf rush	
Juncus prismatocarpus	branching rush	
Juncus procerus	tall rush	
Juncus revolutus	creeping rush	
Juncus sarophorus	broom rush	
Juncus spp.	rush	
Juncus subsecundus	finger rush	
Kennedia prostrata	running postman	
Korthalsella rubra subsp. rubra	jointed mistletoe	
Kunzea ericoides spp. agg.	burgan	
Lachnagrostis aemula s.l.	leafy blown-grass	
Lachnagrostis billardierei s.l.	coast blown-grass	
Lachnagrostis billardierei subsp. billardierei	coast blown-grass	

Scientific Name	Common name	EPBC Status
Lachnagrostis filiformis	common blown-grass	
Lachnagrostis filiformis var. 1	common blown-grass	
Lachnagrostis punicea subsp. filifolia	purple blown-grass	
Lachnagrostis robusta	salt blown-grass	
Lagenophora gracilis	slender bottle-daisy	
Lagenophora spp.	bottle-daisy	
Lagenophora stipitata	common bottle-daisy	
Landoltia punctata	thin duckweed	
Lasiopetalum macrophyllum	shrubby velvet-bush	
Lastreopsis acuminata	shiny shield-fern	
Lawrencia spicata	salt lawrencia	
Laxmannia orientalis	dwarf wire-lily	
Lemna disperma	common duckweed	
Lepidium foliosum	leafy peppercress	
Lepidium pseudotasmanicum	shade peppercress	
Lepidium spp.	peppercress	
Lepidosperma concavum	sandhill sword-sedge	
Lepidosperma elatius	tall sword-sedge	
Lepidosperma gladiatum	coast sword-sedge	
Lepidosperma laterale	variable sword-sedge	
Lepidosperma laterale var. laterale	variable sword-sedge	
Lepidosperma longitudinale	pithy sword-sedge	
Lepidosperma spp.	sword-sedge	
Lepilaena spp.	water mat	
Leptinella longipes	coast cotula	
Leptinella reptans s.l.	creeping cotula	
Leptinella reptans s.s.	creeping cotula	
Leptocarpus tenax	slender twine-rush	
Leptodictyum riparium	marsh feather-moss	
Leptorhynchos nitidulus	shiny buttons	
Leptospermum continentale	prickly tea-tree	
Leptospermum emarginatum	twin-flower tea-tree	
Leptospermum grandifolium	mountain tea-tree	

Scientific Name	Common name	EPBC Status
Leptospermum lanigerum	woolly tea-tree	
Leptospermum myrsinoides	heath tea-tree	
Leptospermum spp.	tea-tree	
Leptostigma reptans	dwarf nertera	
Leucophyta brownii	cushion bush	
Leucopogon ericoides	pink beard-heath	
Leucopogon juniperinus	long-flower beard-heath	
Leucopogon parviflorus	coast beard-heath	
Leucopogon spp.	beard-heath	
Leucopogon virgatus	common beard-heath	
Leucopogon virgatus var. virgatus	common beard-heath	
Lilaeopsis polyantha	Australian lilaeopsis	
Lindsaea linearis	screw fern	
Linum marginale	native flax	
Lissanthe strigosa subsp. subulata	peach heath	
Lobelia anceps	angled lobelia	
Lobelia spp.	lobelia	
Lomandra confertifolia subsp. leptostachya	slender mat-rush	
Lomandra filiformis	wattle mat-rush	
Lomandra filiformis subsp. filiformis	wattle mat-rush	
Lomandra glauca s.s.	blue mat-rush	
Lomandra longifolia	spiny-headed mat-rush	
Lomandra longifolia subsp. exilis	cluster-headed mat-rush	
Lomandra longifolia subsp. longifolia	spiny-headed mat-rush	
Lomandra nana	dwarf mat-rush	
Lomandra spp.	mat-rush	
Lomatia ilicifolia	holly lomatia	
Lotus australis var. australis	Austral trefoil	
Ludwigia peploides subsp. montevidensis	clove-strip	
Luzula campestris spp. agg.	field woodrush	
Luzula meridionalis	common woodrush	
Luzula meridionalis var. flaccida	common woodrush	
Luzula meridionalis var. meridionalis	common woodrush	

Scientific Name	Common name	EPBC Status
Luzula spp.	woodrush	
Lycopus australis	Australian gipsywort	
Lyperanthus suaveolens	brown-beaks	
Lysimachia japonica	creeping loosestrife	
Lythrum hyssopifolia	small loosestrife	
Marsdenia flavescens	yellow milk-vine	
Marsdenia rostrata	milk-vine	
Marsilea hirsuta	short-fruit nardoo	
Mazus pumilio	swamp mazus	
Melaleuca ericifolia	swamp paperbark	
Melaleuca parvistaminea	rough-barked honey-myrtle	
Melaleuca squarrosa	scented paperbark	
Melicytus dentatus s.l.	tree violet	
Melicytus dentatus s.s.	tree violet	
Mentha diemenica	slender mint	
Micrantheum hexandrum	box micrantheum	
Microlaena stipoides var. stipoides	weeping grass	
Microseris scapigera spp. agg.	yam daisy	
Microsorum pustulatum subsp. pustulatum	kangaroo fern	
Microsorum scandens	fragrant fern	
Microtis arenaria	notched onion-orchid	
Microtis parviflora	slender onion-orchid	
Microtis unifolia	common onion-orchid	
Mimulus repens	creeping monkey-flower	
Mimulus spp.	monkey flower	
Monotoca elliptica s.l.	tree broom-heath	
Monotoca elliptica s.s.	tree broom-heath	
Monotoca scoparia	prickly broom-heath	
Morinda jasminoides	jasmine morinda	
Muehlenbeckia adpressa	climbing lignum	
Muellerina celastroides	coast mistletoe	
Muellerina eucalyptoides	creeping mistletoe	
Myosotis australis	Austral forget-me-not	

Scientific Name	Common name	EPBC Status
Myriophyllum caput-medusae	coarse water-milfoil	
Myriophyllum crispatum	upright water-milfoil	
Myriophyllum simulans	amphibious water-milfoil	
Myriophyllum verrucosum	red water-milfoil	
Myrsine howittiana	mutton-wood	
Neckera pennata	feathered neckera	
Neopaxia australasica	white rurslane	
Notelaea venosa	large mock-olive	
Notodanthonia longifolia	long-leaf wallaby-grass	
Notodanthonia semiannularis	wetland wallaby-grass	
Olearia argophylla	musk daisy-bush	
Olearia axillaris	coast daisy-Bush	
Olearia glutinosa	sticky daisy-bush	
Olearia lirata	snowy daisy-bush	
Olearia phlogopappa	dusty daisy-bush	
Olearia ramulosa var. ramulosa	twiggy daisy-bush	
Olearia viscosa	viscid daisy-bush	
Opercularia aspera	coarse stinkweed	
Opercularia hispida	hairy stinkweed	
Opercularia spp.	stinkweed	
Opercularia varia	variable stinkweed	
Ophioglossum lusitanicum	Austral adder's-tongue	
Oplismenus hirtellus	Australian basket-grass	
Orthoceras strictum	horned orchid	
Oxalis corniculata s.l.	yellow wood-sorrel	
Oxalis exilis	shady wood-sorrel	
Oxalis perennans	grassland wood-sorrel	
Oxalis radicosa	stout-rooted wood-sorrel	
Oxalis rubens	dune wood-sorrel	
Oxalis spp.	wood sorrel	
Ozothamnus argophyllus	spicy everlasting	
Ozothamnus conditus	pepper everlasting	
Ozothamnus cuneifolius	wedge-leaf everlasting	

Scientific Name	Common name	EPBC Status
Ozothamnus ferrugineus	tree everlasting	
Ozothamnus spp.	everlasting	
Ozothamnus turbinatus	coast everlasting	
Pandorea pandorana	Wonga vine	
Papillaria flavolimbata	festoon moss	
Paracaleana minor	small duck-orchid	
Parietaria debilis s.l.	shade pellitory	
Parietaria debilis s.s.	shade pellitory	
Parsonsia brownii	twining silkpod	
Pelargonium australe	Austral stork's-bill	
Pelargonium inodorum	kopata	
Pelargonium spp.	stork's bill	
Pellaea falcata s.l.	sickle fern	
Pellaea falcata s.s.	sickle fern	
Pentapogon quadrifidus var. quadrifidus	five-awned spear-grass	
Persicaria decipiens	slender knotweed	
Persicaria hydropiper	water pepper	
Persicaria lapathifolia	pale knotweed	
Persicaria praetermissa	spotted knotweed	
Persicaria subsessilis	hairy knotweed	
Persoonia juniperina	prickly geebung	
Persoonia linearis	narrow-leaf geebung	
Phebalium squamulosum	forest phebalium	
Philydrum lanuginosum	woolly waterlily	
Phragmites australis	common reed	
Phyllanthus gunnii	shrubby spurge	
Phyllanthus hirtellus	thyme spurge	
Pimelea axiflora	bootlace bush	
Pimelea axiflora subsp. axiflora	bootlace bush	
Pimelea curviflora s.s.	curved rice-flower	
Pimelea glauca	smooth rice-flower	
Pimelea humilis	common rice-flower	
Pimelea linifolia subsp. linifolia	slender rice-flower	

Scientific Name	Common name	EPBC Status
Pimelea serpyllifolia subsp. serpyllifolia	thyme rice-flower	
Pimelea spp.	rice flower	
Pittosporum spp.	pittosporum	
Plantago debilis	shade plantain	
Plantago gaudichaudii	narrow plantain	
Plantago spp.	plantain	
Plantago varia	variable plantain	
Platylobium formosum	handsome flat-pea	
Platylobium obtusangulum	common flat-pea	
Platysace ericoides	heath platysace	
Platysace lanceolata	shrubby platysace	
Plectranthus parviflorus	cockspur flower	
Poa australis spp. agg.	tussock grass	
Poa clelandii	Noah's Ark	
Poa ensiformis	sword tussock-grass	
Poa fordeana	forde poa	
Poa labillardierei	common tussock-grass	
Poa labillardierei var. labillardierei	common tussock-grass	
Poa morrisii	soft tussock-grass	
Poa poiformis	coast tussock-grass	
Poa poiformis var. poiformis	coast tussock-grass	
Poa sieberiana	grey tussock-grass	
Poa sieberiana var. hirtella	grey tussock-grass	
Poa sieberiana var. sieberiana	grey tussock-grass	
Poa spp.	tussock grass	
Poa tenera	slender tussock-grass	
Polystichum proliferum	mother shield-fern	
Polytrichum juniperinum	juniper haircap	
Pomaderris aspera	hazel pomaderris	
Pomaderris elliptica var. elliptica	smooth pomaderris	
Pomaderris eriocephala	woolly-head pomaderris	
Pomaderris ferruginea	rusty pomaderris	
Pomaderris oraria subsp. calcicola	limestone pomaderris	

Scientific Name	Common name	EPBC Status
Pomaderris paniculosa subsp. paralia	coast pomaderris	
Pomaderris prunifolia var. prunifolia	prunus pomaderris	
Pomax umbellata	pomax	
Poranthera microphylla s.l.	small poranthera	
Potamogeton tricarinatus s.l.	floating pondweed	
Prasophyllum correctum	gaping leek-orchid	Endangered
Prasophyllum elatum	tall leek-orchid	
Prasophyllum frenchii	maroon Leek-orchid	Endangered
Prasophyllum spp.	leek orchid	
Prostanthera lasianthos	Victorian Christmas-bush	
Pseudanthus ovalifolius	oval-leaf pseudanthus	
Pseudognaphalium luteoalbum	jersey cudweed	
Pteridium esculentum	Austral bracken	
Pteris tremula	tender brake	
Pteris umbrosa	jungle brake	
Pterostylis alpina s.s.	mountain greenhood	
Pterostylis alveata	coastal greenhood	
Pterostylis concinna	trim greenhood	
Pterostylis curta	blunt greenhood	
Pterostylis falcata s.s.	large sickle greenhood	
Pterostylis fischii	Fisch's greenhood	
Pterostylis grandiflora	cobra greenhood	
Pterostylis longifolia s.l.	tall greenhood	
Pterostylis nana	dwarf greenhood	
Pterostylis nutans	nodding greenhood	
Pterostylis parviflora s.l.	tiny greenhood	
Pterostylis pedunculata	maroonhood	
Pterostylis spp.	greenhood	
Ptychomitrium mittenii	pincushion	
Pultenaea daphnoides	large-leaf bush-pea	
Pultenaea dentata	clustered bush-pea	
Pultenaea humilis	dwarf bush-pea	
Pultenaea retusa	blunt bush-pea	

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Pyrorchis nigricans	red-beaks	
Pyrrosia rupestris	rock felt-fern	
Racopilum cuspidigerum var. convolutaceum	common carpet-moss	
Ranunculus amphitrichus	small river buttercup	
Ranunculus inundatus	river buttercup	
Ranunculus plebeius s.l.	forest/hairy buttercup	
Ranunculus plebeius s.s.	forest buttercup	
Ranunculus sessiliflorus	annual buttercup	
Ranunculus sessiliflorus var. sessiliflorus	annual buttercup	
Ranunculus spp.	buttercup	
Rhagodia candolleana subsp. candolleana	seaberry saltbush	
Rhagodia spp.	saltbush	
Rhytidosporum procumbens	white marianth	
Ricinocarpos pinifolius	wedding bush	
Rubus parvifolius	small-leaf bramble	
Rubus rosifolius var. rosifolius	rose-leaf bramble	
Rubus spp.	bramble	
Rulingia prostrata	dwarf kerrawang	Endangered
Rumex bidens	mud dock	
Rumex brownii	slender dock	
Rumex spp.	dock	
Ruppia megacarpa	large-fruit tassel	
Sambucus gaudichaudiana	white elderberry	
Samolus repens	creeping brookweed	
Sarcochilus australis	butterfly orchid	
Sarcocornia blackiana	thick-head glasswort	
Sarcocornia quinqueflora	beaded glasswort	
Sarcocornia quinqueflora subsp. quinqueflora	beaded glasswort	
Sarcocornia spp.	glasswort	
Sarcopetalum harveyanum	pearl vine	
Scaevola albida	small-fruit fan-flower	
Scaevola hookeri	creeping fan-flower	
Scaevola ramosissima	hairy fan-flower	

Scientific Name	Common name	EPBC Status
Schizaea bifida s.s.	forked comb-fern	
Schoenoplectus pungens	sharp club-sedge	
Schoenoplectus tabernaemontani	river club-sedge	
Schoenus apogon	common bog-sedge	
Schoenus brevifolius	zig-zag bog-sedge	
Schoenus ericetorum	heathy bog-sedge	
Schoenus imberbis	beardless bog-sedge	
Schoenus maschalinus	leafy bog-sedge	
Schoenus nitens	shiny bog-sedge	
Schoenus spp.	bog sedge	
Scutellaria humilis	dwarf skullcap	
Sebaea ovata	yellow sebaea	
Selaginella uliginosa	swamp selaginella	
Selliera radicans	shiny swamp-mat	
Sematophyllum homomallum	bronze signal-moss	
Senecio biserratus	jagged fireweed	
Senecio glomeratus	annual fireweed	
Senecio hispidulus s.l.	rough fireweed	
Senecio hispidulus s.s.	rough fireweed	
Senecio linearifolius	fireweed groundsel	
Senecio minimus	shrubby fireweed	
Senecio pinnatifolius	variable groundsel	
Senecio quadridentatus	cotton fireweed	
Senecio spathulatus s.l.	dune groundsel	
Senecio spp.	groundsel	
Senecio squarrosus s.s.	leafy fireweed	
Senecio tenuiflorus spp. agg.	slender fireweed	
Senecio X orarius	coast fireweed	
Sicyos australis	star cucumber	
Sigesbeckia orientalis subsp. orientalis	Indian weed	
Smilax australis	Austral sarsaparilla	
Solanum aviculare	kangaroo apple	
Solanum laciniatum	large kangaroo apple	

Scientific Name	Common name	EPBC Status
Solanum opacum	green-berry nightshade	
Solanum prinophyllum	forest nightshade	
Solanum pungetium	eastern nightshade	
Solanum spp.	nightshade	
Solanum vescum	gunyang	
Solenogyne dominii	smooth solenogyne	
Solenogyne gunnii	hairy solenogyne	
Sonchus hydrophilus	native sow-thistle	
Spergularia marina s.l.	salt sand-spurrey	
Spergularia media s.l.	coast sand-spurrey	
Spergularia sp. 1	native sea-spurrey	
Sphaerolobium minus	eastern globe-pea	
Sphaerolobium vimineum s.l.	leafless globe-pea	
Sphaerolobium vimineum s.s.	leafless globe-pea	
Sphagnum novozelandicum	peat moss	
Spinifex sericeus	hairy spinifex	
Sporobolus virginicus	salt couch	
Sprengelia incarnata	pink swamp-heath	
Spyridium parvifolium	dusty miller	
Stackhousia monogyna	creamy stackhousia	
Stackhousia spathulata	coast stackhousia	
Stackhousia spp.	stackhousia	
Stellaria angustifolia	swamp starwort	
Stellaria flaccida	forest starwort	
Stellaria multiflora	rayless starwort	
Stellaria pungens	prickly starwort	
Stellaria spp.	starwort	
Stuartina muelleri	spoon cudweed	
Stylidium armeria	common triggerplant	
Stylidium graminifolium s.s.	grass triggerplant	
Stylidium inundatum	hundreds and thousands	
Stylidium spp.	trigger plant	
Suaeda australis	Austral seablite	

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Suaeda spp.	seablite	
Taraxacum spp.	dandelion	
Tetragonia implexicoma	bower spinach	
Tetragonia spp.	native spinach	
Tetragonia tetragonioides	New Zealand spinach	
Tetrarrhena juncea	forest wire-grass	
Tetratheca ciliata	pink-bells	
Tetratheca pilosa	hairy pink-bells	
Tetratheca pilosa subsp. latifolia	hairy pink-bells	
Thelionema spp.	tufted lily	
Thelymitra arenaria	forest sun-orchid	
Thelymitra aristata	great sun-orchid	
Thelymitra circumsepta	naked sun-orchid	
Thelymitra epipactoides	metallic sun-orchid	Endangered
Thelymitra flexuosa	twisted sun-orchid	
Thelymitra ixioides s.s.	spotted sun-orchid	
Thelymitra nuda	plain sun-orchid	
Thelymitra planicola	shy sun-orchid	
Thelymitra rubra	salmon sun-orchid	
Thelymitra spp.	sun orchid	
Themeda triandra	kangaroo grass	
Thryptomene micrantha	ribbed thryptomene	
Thuidiopsis furfurosa	golden weft-moss	
Thysanotus patersonii	twining fringe-lily	
Tricoryne elatior	yellow rush-lily	
Triglochin microtuberosa	eastern water-ribbons	
Triglochin minutissima	tiny arrowgrass	
Triglochin mucronata	prickly arrowgrass	
Triglochin procera s.l.	water ribbons	
Triglochin procera s.s.	common water-ribbons	
Triglochin spp.	water ribbons	
Triglochin striata	streaked arrowgrass	
Triquetrella papillata	common twine-moss	

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Tylophora barbata	bearded tylophora	
Typha domingensis	narrow-leaf cumbungi	
Typha orientalis	broad-leaf cumbungi	
Typha spp.	bulrush	
Urtica incisa	scrub nettle	
Veronica calycina	hairy speedwell	
Veronica gracilis	slender speedwell	
Veronica plebeia	trailing speedwell	
Veronica spp.	speedwell	
Villarsia exaltata	erect marsh-flower	
Villarsia reniformis	running marsh-flower	
Viminaria juncea	golden spray	
Viola hederacea sensu Entwisle (1996)	ivy-leaf violet	
Viola hederacea sensu Willis (1972)	ivy-leaf violet	
Vittadinia cuneata var. cuneata	fuzzy New Holland daisy	
Wahlenbergia gracilenta s.l.	annual bluebell	
Wahlenbergia gracilenta s.s.	hairy annual-bluebell	
Wahlenbergia gracilis	sprawling bluebell	
Wahlenbergia graniticola s.l.	granite bluebell	
Wahlenbergia gymnoclada	naked bluebell	
Wahlenbergia multicaulis	branching bluebell	
Wahlenbergia spp.	bluebell	
Wahlenbergia stricta subsp. stricta	tall bluebell	
Westringia glabra	violet westringia	
Wijkia extenuata	spear moss	
Wilsonia backhousei	narrow-leaf wilsonia	
Wurmbea dioica	common early nancy	
Xanthorrhoea australis	Austral grass-tree	
Xanthorrhoea minor subsp. lutea	small grass-tree	
Xanthorrhoea resinosa	spear grass-tree	
Xanthorrhoea spp.	grass tree	
Xanthosia spp.	xanthosia	
Xerochrysum bracteatum	golden everlasting	

Scientific Name	Common name	EPBC Status
Xerochrysum palustre	swamp everlasting	Vulnerable
Zieria arborescens subsp. arborescens	stinkwood	
Zieria smithii subsp. smithii	sandfly zieria	
Zieria veronicea subsp. veronicea	pink zieria	
Zoysia macrantha subsp. macrantha	prickly couch	
Zoysia macrantha subsp. walshii	walsh's couch	

EPBC Status indicates the listing of a particular species under the *Environmental Protection and Biodiversity Conservation Act 1999* as of October 29, 2010. ‘Migratory’ species are those listed under international and bilateral agreements for the conservation of migratory species (Bonn Convention, JAMBA, CAMBA). ‘Listed’ species include marine species declared under s248 of the Act and migratory species listed separate to international agreements.