



Australian Government

**Department of Sustainability, Environment,
Water, Population and Communities**

Gippsland Lakes Ramsar site

Ecological Character Description

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Chapters 4 - 5

Other chapters can be downloaded from:

www.environment.gov.au/water/publications/environmental/wetlands/21-ecd.html

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 cyanobacteria 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	<ul style="list-style-type: none"> 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 <i>Zostera</i> 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: <ul style="list-style-type: none"> Fraser Island Point Fullerton, Lake King Point King, Raymond Island, Lake King Gorcrow Point – Steel Bay, Lake Victoria Waddy Island, Lake Victoria 	<p>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.</p> <p>Note that the seagrass assessment by Hindell (2008) did not produce mapping but did use similar sampling sites to Roob and Ball.</p>	<p>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.</p>	P1
C2	Coastal brackish or saline lagoons (for example, Lake King, Lake Victoria, Lake Wellington, Lake Tyers)	<p>Long Term</p> <p>Long Term</p> <p>Short Term</p>	<ul style="list-style-type: none"> 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. 	<p>To be determined based on expert review.</p> <p>To be determined based on expert review.</p> <p>Algal bloom extent (per cent lakes area and location) and number should be reported annually, but assessed on an ongoing basis.</p>	<p>Level B - VMCS mapping data describes wetland extent. This is coarse scale mapping and should be considered as indicative only.</p> <p>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.</p>	P1, S2

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

LIMITS OF ACCEPTABLE CHANGE

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	<ul style="list-style-type: none"> 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.	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	<ul style="list-style-type: none"> In existing freshwater wetland areas, the annual median salinity should not be greater than one gram per litre in two successive years. <i>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.</i> 	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	<p>For all fringing brackish wetlands:</p> <ul style="list-style-type: none"> 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	<p>For Dowd Morass and the Heart Morass:</p> <ul style="list-style-type: none"> The annual median salinity will be less than four grams per litre in five successive years. <i>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.</i> 	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	<ul style="list-style-type: none"> 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.	

LIMITS OF ACCEPTABLE CHANGE

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	<ul style="list-style-type: none"> • 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. 	<p>To be determined based on expert review.</p> <p>Sampling to occur at least twice within the decade under consideration.</p>	As for C3.	P1, C6
C6	Abundance and diversity of waterbirds	Medium Term	<ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> ○ 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. <i>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).</i> 	<p>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.</p> <p>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).</p> <p>Recommended baseline monitoring program should include:</p> <ul style="list-style-type: none"> • A combination of aerial and ground surveys. • Representative coverage of primary habitats within the site. 	<p>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.</p> <p>Level A - Records for these species are reliable. Birds Australia and DSE data can be used to assess this qualitative LAC.</p> <p>There are no baseline data available for this LAC.</p>	P1, P2

LIMITS OF ACCEPTABLE CHANGE

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	<ul style="list-style-type: none"> The site will continue to support suitable habitat for growing 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). 	<p>Refer to C3.</p> <p>Recommended baseline monitoring program should comprise a minimum two annual sampling periods separated by at least one year (and within a 5 year period).</p>	<p>Level C - Surveys for these species have been opportunistic. The most recent record for growing 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.</p>	P1
C8	Presence of threatened wetland flora species	Long Term	<ul style="list-style-type: none"> The three threatened flora species (<i>Rulingia prostrata</i>, <i>Thelymitra epipactoides</i> and <i>Xerochrysum palustre</i>) continue to be supported within the boundaries of the Gippsland Lakes Ramsar site. 	<p>Based on opportunistic searches.</p>	<p>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.</p>	P1

LIMITS OF ACCEPTABLE CHANGE

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 Processes																						
P1	Hydrological regime	Short Term – Medium Term	<p>Wetland wetting frequency, flushing frequency and flushing volume are maintained as follows:</p> <table border="1"> <thead> <tr> <th>Wetland</th> <th>Wetting Frequency</th> <th>Flushing Frequency</th> <th>Required Flushing Volume</th> </tr> </thead> <tbody> <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> </tbody> </table> <p>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).</p>	Wetland	Wetting Frequency	Flushing Frequency	Required Flushing Volume	Sale Common	Annual with 100 per cent reliability	2-3 times/decade	4 GL	Dowd Morass	5-7 times/decade	2-3 times/decade	15GL	The Heart Morass	5-7 times/decade	2-3 times/decade	15GL	Refer to LAC for details. Values measured at existing gauging stations in the lower reaches of the Rivers or otherwise in the wetlands themselves.	<p>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.</p> <p>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.</p> <p>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.</p>	C1 – C8 S1, S2
Wetland	Wetting Frequency	Flushing Frequency	Required Flushing Volume																			
Sale Common	Annual with 100 per cent reliability	2-3 times/decade	4 GL																			
Dowd Morass	5-7 times/decade	2-3 times/decade	15GL																			
The Heart Morass	5-7 times/decade	2-3 times/decade	15GL																			
P2	Waterbird breeding	Short Term	<p>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:</p> <ul style="list-style-type: none"> • 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. 	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 - 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.	C6																

LIMITS OF ACCEPTABLE CHANGE

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	<ul style="list-style-type: none"> 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. 	<p>Median measured over 5 years.</p> <p>Annual median value for the period October to December.</p> <p>As above</p>	<p>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.</p> <p>Level C – based on conditions outlined in Tilleard (2009).</p>	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	<ul style="list-style-type: none"> • Irreversible Impacts at the Broad Scale or Regional Scale • Medium Term Impact at the Broad Scale
Medium	<ul style="list-style-type: none"> • Irreversible Impact at a Local Scale • Medium Term Impacts at the Regional Scale • Short Term impact at a Broad Scale
Low	<ul style="list-style-type: none"> • 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 Phillip 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, barbecues, 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.