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Coorong, Lower Lakes and Murray Mouth (CLLMM) Wetland Condition Assessments: Coorong sites, 2015

Report to the Department of Environment, Water and Natural Resources, South Australia.

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EXECUTIVE SUMMARY

The Coorong and Lower Lakes region, at the terminus of the Murray River in South Australia, is one of Australia's iconic wetland systems and has been formally recognised as internationally important under the Ramsar Convention since 1985. The wetlands support a diverse array of ecological, cultural, social and economic values to the surrounding region and its community. A Ramsar Management Plan for the wetlands system was produced in 2000 to guide government agencies and the regional community in the management of this area (Department of Environment and Heritage (DEH) 2000). One of the key strategies of the plan was the development of a detailed mapping program and database for the Ramsar site. Between July 2002 and June 2003, field based wetland assessments were carried out as part of the Coorong and Lower Lakes Mapping Program (Seaman 2003).

From the period 2006 to 2010, the region experienced a severe drought and consequently many of the CLLMM wetlands experienced unprecedented drying due to the lack of flows from the Murray River above Wellington. This caused a dramatic recession of the shorelines of Lakes Alexandrina and Albert, and impacted on a range of other hydrologically contiguous areas such as Goolwa Channel, the Finniss River, Currency Creek, the Murray Mouth and the Coorong.

Further to a similar assessment completed in 2014 by NGT Consulting, reporting on a comparative assessment of the condition of wetlands primarily around the Lower Lakes portion of the site, this report summarises the survey of a sub-set of wetland habitats in the Coorong that have not been re-assessed since 2003. Across the 95 sites surveyed throughout this project, thirteen different Ramsar wetland types were identified.

Assessments of the habitat condition at the 95 sites in 2015 found that 34 (36%) have improved in condition, 40 (42%) have not changed condition, and 21 (22%) have declined in condition since 2003. Of the 21 sites that declined in condition between 2003 and 2015, only two were recorded as Degraded, the poorest condition category recorded on the survey. The two sites that changed to Degraded in 2015 were both vegetated islands and markedly decreased in condition from Excellent or Very Good. However, it is worth noting that at the majority of sites where a change in condition was observed (47 of 55), the change was only up or down one category, for example up from Good to Excellent, or down Pristine to Excellent. Hence the degree of change for the majority of sites is unlikely to have been very significant, especially given the accuracy limitations of the qualitative method employed in the project.

A regular finding throughout the survey was the need to remap wetland polygons and in many cases it is also recommended to reclassify the Ramsar Wetland Types of wetland polygons (27%) in the Coorong region. Based on the combination of 2013 aerial imagery overlaid by the wetland polygons provided by DEWNR and ground-truthing during the project, it is evident that the scale and detail of wetland mapping presents some significant, albeit understandable, inconsistencies. Some polygons were very small and specific, while others were so large they often contain multiple wetland vegetation or Ramsar wetland types clearly defined by the aerial imagery. This likely occurred by necessity as the Coorong and Lower Lakes Ramsar Habitat Mapping Program (Seaman 2003) occurred across a very large number of sites (761) and hence scale, over a relatively short period of time. It is likely that while some sites received a higher degree of individual attention (with specific mapping) most were only considered at a larger (more generic) scale, with a corresponding level of accuracy. This is in contrast to the current assessment in 2015, where a smaller subset of 95 sites was assessed onsite.

The mapping inconsistencies were most apparent when assigning a Ramsar wetland type to the polygons. The 2015 assessment recommends 26 changes to the Ramsar wetland type across the 95 sites, or changes to 27% of sites. The largest change is proposed to occur with the addition of Intertidal marshes (H) category, which was identified at 11 sites in 2015 and the removal of Seasonal/intermittent freshwater lakes (P) category, which was recorded at one site in 2003. No change was observed in the Coastal brackish/saline lagoons (J) and Permanent rivers/streams/creeks (M) Ramsar wetland types, which both occurred at only two sites.

However, it is worth noting that the change of extent of different Ramsar types is the product of having coarsely mapped polygons and the original interpretation of Ramsar wetland types, and not an indication that the system has undergone a significant ecological shift.

With this in mind, a reassessment of Ramsar wetland type classification and mapping detail (similar to that achieved in the 2015 survey) across the system is recommended, to increase the accuracy of Ramsar site condition reporting in the future.

Hence, based on the findings and qualitative nature of the project methodology, key further recommendations proposed for future consideration include:

1. Updating mapping of wetland polygons in the CLLMM region to:
    - consider reassigning Ramsar wetland types as required;
    - refine spatial differences in vegetation associations based on the 2013 aerial imagery;
    - record spatial changes in the extent of wetland areas and;
    - map any previously unmapped wetlands.
2. Repeating the habitat assessment process in the Coorong at semi-regular intervals (every 2-4 years at the same time of year).
    - A range of monitoring methods (and their target subjects) are required to help inform the future adaptive management of releases of water into the South Lagoon from the Upper South East via Salt Creek, and for better understanding the ongoing dependence of Coorong wetland habitats upon barrage flows.
3. To try and reduce observer bias in habitat condition assessments, it is suggested that a modified system be considered in future that incorporates some basic quantitative elements, but maintains its rapid approach.
    - For example, it is recommended that vegetation communities are also given a ‘health’ score so that future assessors can see whether there is a trajectory of vegetation community health change within the existing classification system.
    - In this regard, the rapid wetland condition assessment method developed by ForestrySA may provide a useful reference.

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1 INTRODUCTION

1.1 Background

The Coorong and Lower Lakes region, at the terminus of the Murray River in South Australia, is a focal region for the Department of Environment, Water and Natural Resources (DEWNR). Management across the site is coordinated and primarily delivered by DEWNR's Coorong, Lower Lakes and Murray Mouth (CLLMM) Program, consistent with the South Australian Government's "Long-Term Plan for the Coorong, Lower Lakes and Murray Mouth", released in June 2010 (Department for Environment and Heritage (DEH) 2010). The goal of the Long-Term Plan is for the region to be a healthy, productive and resilient wetland system that maintains its international importance. An integral component of the CLLMM Program is the monitoring of the condition of wetlands throughout the region and the responses to adaptive management actions proposed in the Long-Term Plan.

In 1985, the Coorong and Lakes Alexandrina and Albert Wetland was formally recognised under the Ramsar Convention, as internationally significant wetlands, supporting a diverse range of habitats and species. The area is also of high cultural significance for the local Ngarrindjeri Nation, forming an essential part of their living culture. A Ramsar Management Plan for the wetlands system was produced in 2000 to guide government agencies and the regional community in the management of this area (DEH 2000). One of the key strategies of the plan was the development of a detailed mapping program and database for the Ramsar site. Between July 2002 and June 2003, field based wetland assessments were carried out as part of the Coorong and Lower Lakes Mapping Program (Seaman 2003). The data compiled through the assessment of 761 representative wetland sites provided the basis for subsequent monitoring of the condition of wetland habitats and any changes in wetland characteristics such as habitat types (i.e. dominant vegetation associations), hydrological regime, fauna utilisation, threatening processes and management actions taken.

Of the 761 sites assessed in 2002/3, 185 sites were assessed within the Murray Mouth and Coorong portion of the site and given wetland classifications that fall within the focal area of this study. A full account of the wetland assessment characteristics are documented by Seaman (2003).

From the period 2006 to 2010, the region experienced a severe drought and consequently many of the CLLMM wetlands experienced unprecedented drying due to the lack of flows from the Murray River above Wellington. This caused a dramatic recession of the shorelines of Lakes Alexandrina and Albert, the Goolwa Channel, the Finniss River, Currency Creek and other associated water bodies (Thiessen 2010). During this period of drought the Coorong experienced dramatically increased salinities of >200g/L in the South Lagoon, which had negative impacts on aquatic plants, macro-invertebrates, fish and waterbirds (Kingsford et al. 2011).

In 2010, Thiessen (2010) revisited a subset of 162 of the 761 original wetland sites to assess the effects of the drought on habitat condition and vegetation community associations as well as which wetland types were most prone to such extreme and extended drought conditions. Thiessen (2010) aimed to broadly identify:

- Changes in water regime
- Changes in habitat condition
- Changes in habitat community/vegetation association

- Response of different landforms types to increased water flows/levels
- Impact on range of Ramsar Wetland types

A full description of the definitions and categories of assessment components are provided in Seaman (2003).

Thiessen's assessments focussed mostly on the wetlands of the Lower Lakes of the Murray River, with only a relatively small number of sites assessed within and around the Murray Estuary. In 2014, following the break of the drought in late 2010, NGT Consulting were engaged to undertake repeat assessments of those carried out by Thiessen in 2010. Similarly, Billows et al. (2014) focussed on:

- Changes in water regime;
- Changes in habitat condition;
- Changes in habitat community/vegetation association;
- Response of different landform types to increased water flows/level; and with the addition of,
- A more detailed and quantitative assessment of threatened species sites

Billows et al. (2014) found the survey confirmed the close relationship between habitat community and condition, and site hydrology (water regime). As these sites were predominantly situated around the perimeter of the Lower Lakes, they were strongly influenced by the River Murray and barrages. In many cases wetland assessment sites returned to a state that resembled their former state (as recorded in 2003) prior to the 2006-2010 drought. The more detailed site assessments undertaken at known threatened species sites revealed that between 2003 and 2014 sites had maintained their condition and encouragingly 27% of sites had improved in condition. An important discussion point from the 2014 survey was the inherent difficulties for observers associated with the subjective assessment categories and condition classes that the assessment relies upon, but is an unavoidable consequence of repeating the original methodology.

Further details on the history of the Coorong and Lakes Alexandrina and Albert Ramsar Wetlands, and background to the wetland habitat assessment program, are provided by Seaman (2003), Thiessen (2010) and other reference material cited in this report.

1.2 Project Scope

In April 2015, NGT Consulting was engaged by DEWNR to repeat field habitat condition assessments for 96 wetland sites within the Coorong portion of the CLLMM region. One site proved inaccessible, so after negotiation with the Project Manager it removed from the list, giving a final number of sites (referred to throughout this report) of 95. Of particular interest to DEWNR is how the selected wetlands have changed over the 12 to 13 year period, which included the five-year long period of drought between 2006 and 2010 and the subsequent return of a hydrological regime more typical of recent prior conditions to the Coorong portion of the CLLMM region.

This report details the 2015 wetland habitat monitoring survey results. It focusses on a comparative analysis of 95 wetland sites against the 2002-03 original field assessment.

1.3 Project Objectives

The specific objectives of the project included:

1. Revisit 95 sites visited by Seaman (2003) in (and surrounding) the Coorong National Park to conduct wetland condition assessments
2. Update the Ramsar habitat database to reflect current condition
3. Assess wetlands to capture information on:
    a. Changes in water regime
    b. Changes in habitat condition
    c. Changes in habitat community/vegetation association
    d. Response of different landforms types to increased water flows/levels
    e. Impact on the range of Ramsar wetland types
4. Provide data to support development of the site's Ecological Character Description (ECD)

2 METHODS

2.1 Study region and site selection

This study was undertaken within the Coorong portion of the CLLMM region, with most wetland sites located within the Coorong National Park (Figure 1) covering an area between the Murray Mouth and the southern Coorong National Park boundary near Kingston South East. In total 95 sites were assessed during the 2015 study. These sites had previously been assessed in the field by Seaman (2003) between July 2002 and February 2003 to verify, map and assign attributes to the habitat mapping data set for the CLLMM region. One additional site (coastal dune shrubland) originally designated for assessment for the current study was not assessed due to its relative isolation and associated access restrictions caused by physical and visual barriers. Hence, this site was removed from the original 2015 sample set and therefore was not included in this study's comparative analysis with the 2002-03 baseline data.

A selection of several wetland polygons were chosen by DEWNR for the 2015 re-assessment period as being a representative sample of the types of wetlands found within the Coorong. Table 1 shows the number of Ramsar wetland types reassessed in 2015.

Table 1. Number of Ramsar Wetland Types assessed in 2015

Ramsar Wetland Classification	Primary	Secondary	Broad Ramsar category
Rocky marine shores (D)	11	-	Marine/coastal
Sand, shingle or pebble shores (E)	26	-	Marine/coastal
Intertidal mud, sand or salt flats (G)	11	-	Marine/coastal
Coastal brackish/saline lagoons (J)	2	-	Marine/coastal
Coastal freshwater lagoons (K)	9	-	Marine/coastal
Permanent rivers/streams/creeks (M)	1	-	Inland
Seasonal/intermittent freshwater lakes (P)	1	-	Inland
Seasonal/intermittent saline/brackish/alkaline lakes and flats (R)	9	-	Inland
Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss)	16	-	Inland
Shrub-dominated wetlands (W)	4	2	Inland
Freshwater, tree-dominated wetlands (Xf)	5	-	Inland
Freshwater springs (Y) - Secondary listing only	0	7	Inland
Total wetland types assessed	95	9	

Figure 1. Map of the study area within the Coorong, Lower Lakes and Murray Mouth (CLLMM) region showing the locations of the 95 wetland assessment sites

2.2 Data Collection

Between 13th April and the 22nd April 2015, a total of 95 wetland sites (repeated from a sample of the 2002-03 assessment sites) that are representative of the 2002-03 mapped wetland polygons, were visually assessed following a slightly abbreviated methodology developed by Seaman (2003) and repeated by Thiessen (2010) and Billows et al. (2014). To minimise the possibility of assessor variability impacting the scoring of habitat condition, as could reasonably be expected with individual interpretations of visual observations over the three assessment periods (i.e. between 2003, 2010, 2014 and 2015), field assessor Cath Dickson underwent peer to peer training with Craig Billows (2014 field assessor) during their first day in the field. The Habitat Condition Datasheet used in 2015 was a modified version of Thiessen (2010), and provided for use by DEWNR at the start of the contract. A copy of the Habitat Condition Datasheet is shown in Appendix A.

Data was collected using two methods. In-situ assessments were carried out where sites were accessible by the assessment team (on foot or by boat). Alternatively, sites were assessed remotely, assisted by a Kowa spotting scope or Minolta Weathermatic 7 x 42 binoculars, as required. Sites were assessed either from within the polygon, or just outside the polygon, on the basis of safe access (i.e. the reasonable physical limitations of field staff negotiating impenetrable vegetation or deep water) or permission, in the case of private-land. Where access was restricted (particularly where wetlands occurred on private property) some sites were assessed from roadsides or other adjacent or nearby land or from a boat where clearest possible views of the wetland could be obtained. Noting that there were less than ten of the 95 sites were this was the case.

Most sites on the Younghusband Peninsula were accessed by boat whilst a very small number were assessed from the boat (where water was too shallow and distance and deep mud rendered options for proceeding on foot unfeasible).

A series of one or more photographs depicting each wetland site was taken from a location that was considered a suitably accurate representation of the surrounding wetland habitat. In some cases more than one photo-point was created to provide a more comprehensive visual depiction of the site. Images were recorded with a 5 megapixel digital camera built into a Garmin Montana GPS receiver. All images were automatically geotagged and saved to the internal memory of the device. The direction of each image was recorded using the Garmin's internal compass function and the bearing recorded to the nearest 5°.

Although the unlabelled photographs of wetland sites were provided for the 2002-03 photo-point, the wetland site number and details of the location and direction were unable to be located and provided. Attempts were made to visually identify wetlands from the 2002-03 photographs. However, direct visual comparisons of wetland sites between 2002-3 and 2015 could not be reliably achieved.

The condensed version of Seaman's original Habitat Classification Survey Template (Seaman 2003) is shown in Appendix A in the form of a Habitat Condition Datasheet, designed for rapid field-based assessment of wetland sites. The Habitat Condition Datasheet has provision for recording observations and data on:

- Wetland site location;
- Photo-point (yes/no, photo number, direction);
- Wetland type (both Ramsar and the Directory of Important Wetlands in Australia (DIWA));
- Wetland Association (Wetland system, landform, micro relief, substrate surface type, sediment size, water regime, tidal class and water depth);

- Vegetation Association (description of vegetation type (Murray Mallee MU50 or South East MU250), cover/abundance score, life forms, microhabitats, aquatic vegetation);
- Fauna (surface fauna, opportunistic observations, reliability);
- Recreation (list of common recreational activities or structure or other);
- Land degradation/disturbances (range of listed disturbances and comments); and,
- Habitat Condition (qualitative assessment of overall wetland site on a scale from pristine, excellent, very good, good, degraded or completely degraded, with comments).

Descriptions and definitions for these assessment components are detailed in Seaman (2003).

In the field it became clear that some polygons were mapped at a very fine scale, while others contained different or multiple Ramsar wetland types, often with a mosaic of different vegetation types. Notes were taken regarding sites that may require re-mapping or to be re-identified as another Ramsar wetland type. The assessment of Ramsar wetland type was done in the field based on the Ramsar definitions and then additionally cross verified with aerial photography to ensure that the whole site was considered.

2.3 Data Analysis

The following qualitative habitat measures were used to draw comparisons of wetlands characteristics previously reported in 2003:

a) Ramsar wetland types;
b) Directory of Important Wetlands in Australia types;
c) Water regime;
d) Habitat condition; and
e) Habitat community change by:
    a. vegetation community; and
    b. landform.

These habitat measures are described by Thiessen (2010) after Seaman (2003). See Appendix B for descriptions.

This information will assist in determining the current number of wetland types present in the Coorong, Lakes Alexandrina and Albert Wetlands System and provide an assessment of whether the condition of particular wetland types have changed over time.

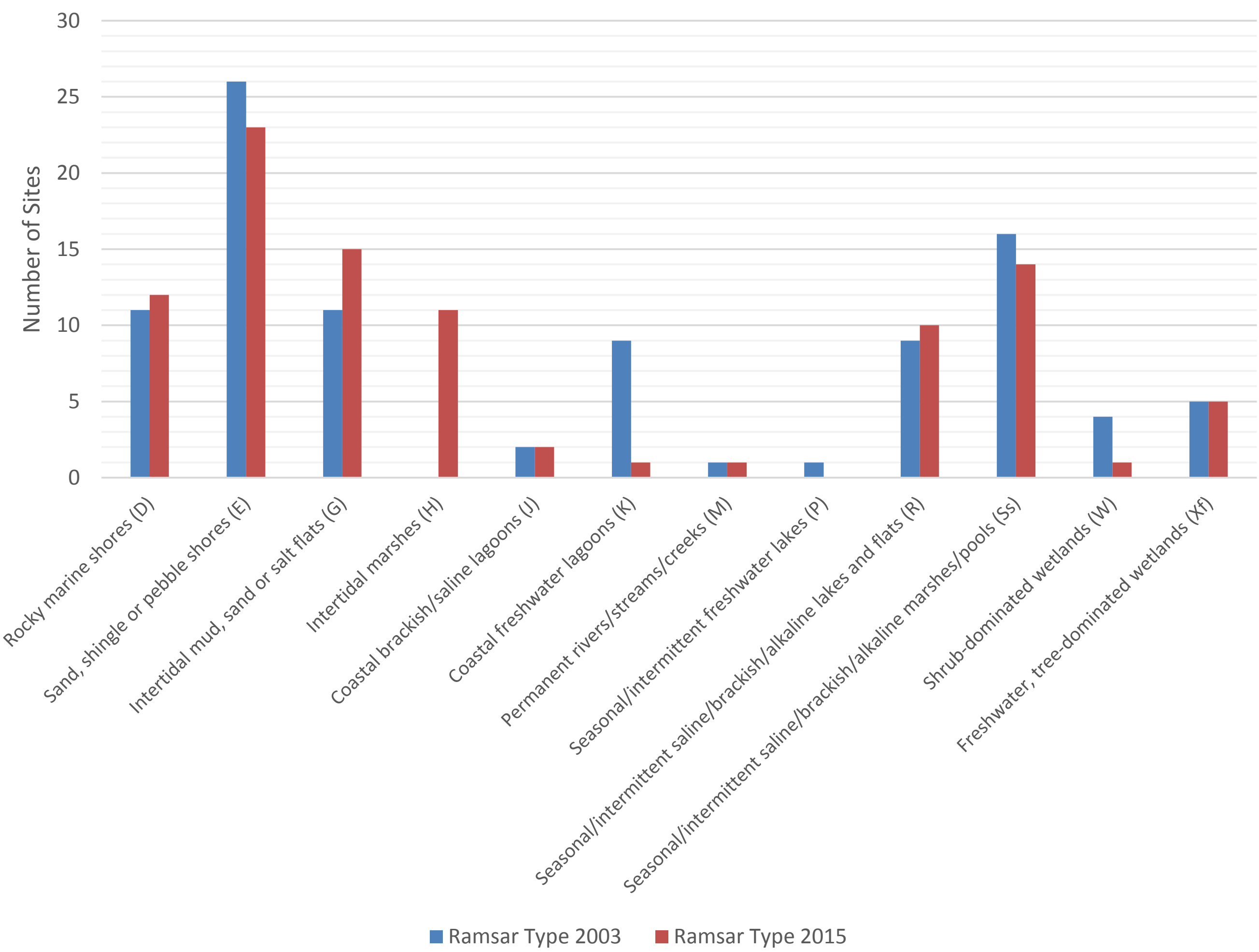
Additional information as per the Habitat Condition Datasheet (See Appendix A) was also collected to populate the CLLMM wetland database. The full data set was entered into a Microsoft Excel Spreadsheet and saved to a digital storage media (Appendix D) for subsequent entry into the DEWNR CLLMM Wetland Database.

3 RESULTS

3.1 Change in Ramsar wetland types

In 2015, 95 habitat condition sites were reassessed across the Coorong National Park, having first been assessed in 2002/2003 (Seaman 2003). As each polygon was assessed, a critical assessment of the wetland type as defined under the Ramsar Convention 1975 was also undertaken, which was cross-verified with aerial photography. Thirteen different Ramsar wetland types were identified across the 95 sites, of which Intertidal marshes (H) was recorded for the first time at 11 sites (Figure 2; Table 2). Noticeable decreases in occurrence were recorded in Coastal freshwater lagoons (K), Sand, shingle or pebble shores (E), Seasonal/Intermittent freshwater lakes (P) and Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss).

Figure 2. Changes to Ramsar wetland type at the Coorong National Park between 2003 and 2015



The 2015 assessment recommends 26 changes to the Ramsar wetland type across the 95 sites, or changes to 27% of sites (Table 2). The largest change occurred with the addition of Intertidal marshes (H) category, which was identified at 11 sites in 2015. Sites in this category had previously been assessed as Coastal freshwater lagoons (K) (7 sites) or Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss) (4) in 2003 (Table 2). Conversely four sites were newly described as Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss), which had previously been described as Shrub-dominated wetlands (W) or Freshwater, tree-dominated wetlands (Xf). The changes are unlikely to be reflecting a hydrological change, but rather the ambiguity of the description, discrepancies in mapping, site assessment location and/or how the Ramsar types were applied.

No change was observed in the Ramsar categories with the lowest numbers of representative sites, which included Coastal brackish/saline lagoons (J), and Permanent rivers/streams/creeks (M) (Table 2). However, the Seasonal/ intermittent freshwater lakes (P) was changed to Seasonal/intermittent saline/brackish /alkaline lakes and flats (R), which also concurs with the Ecological Character Description for the site, which does not record Type P in the Coorong system.

Table 2. Comparison of Ramsar wetland type assessments over 95 sites between 2003 and 2015.

		Ramsar categories in 2015												**Wetlands Assessed**	**Change in area (Ha)**
		D	**E**	**G**	**H**	**J**	**K**	**M**	**P**	**R**	**Ss**	**W**	**Xf**		
Ramsar categories in 2003	Rocky marine shores (D)	10		1										11	-16.3
	Sand, shingle or pebble shores (E)	2	21	2									1	26	-170.6
	Intertidal mud, sand or salt flats (G)			11										11	541.3
	Intertidal marshes (H)														68.1
	Coastal brackish/saline lagoons (J)					2								2	0.0
	Coastal freshwater lagoons (K)		1		7		1							9	-52.7
	Permanent rivers/streams/creeks (M)							1						1	0.0
	Seasonal/intermittent freshwater lakes (P)									1				1	-278.1
	Seasonal/intermittent saline/brackish/alkaline lakes and flats (R)			1						8				9	-65.4
	Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss)		1		4					1	10			16	-20.6
	Shrub-dominated wetlands (W)										3	1		4	-14.2
	Freshwater, tree-dominated wetlands (Xf)										1		4	5	8.53
Wetlands Assessed		12	23	15	11	2	1	1	0	10	14	1	5	95	0

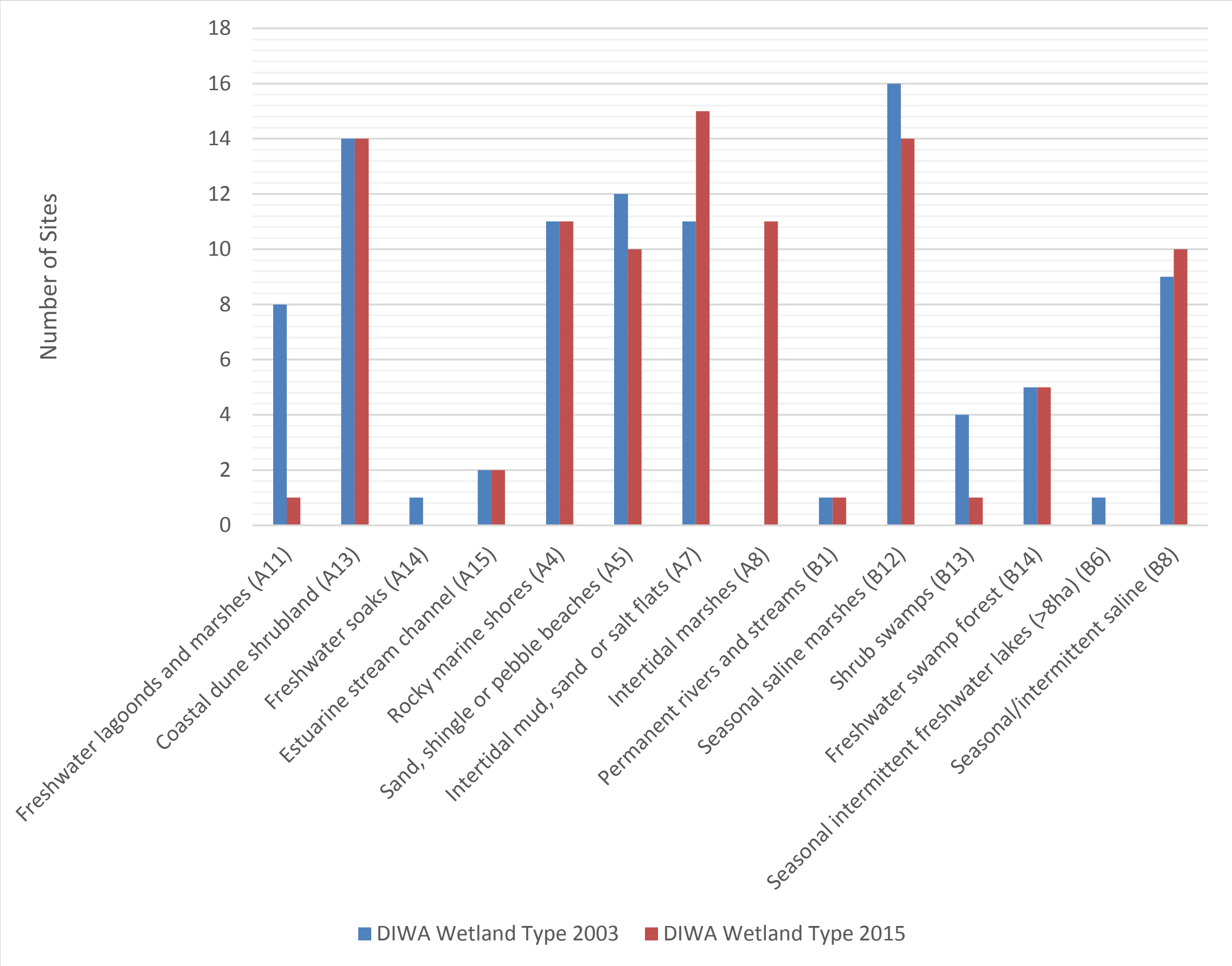
In 2003 Shrub-dominated wetlands (W) and Freshwater springs (Y) were recorded as a secondary Ramsar wetland type at two and seven of the polygons, respectively. In 2015 Shrub-dominated wetlands were not considered to be a secondary type, however, Intertidal marshes (H) was at one site. Freshwater springs (Y) were rerecorded at seven known sites along Younghusband Peninsula in 2015 and confirmed at an additional three sites that had been aerially surveyed in 2003 and required ground-truthing.

3.2 Change in the Directory of Important Wetlands in Australia (DIWA) type

The DIWA type was also assessed during the 2015 surveys, with twenty-five sites assigned different categories, or just over 26% of sites (Figure 3). This was not unexpected given that the sites recorded a similar change in the relevant Ramsar wetland type. In 2003 the most commonly recorded wetland type was Seasonal saline marshes (16 sites), followed by Coastal dune shrubland (14 sites), and Sand, shingle or pebble beaches (12). However, in 2015 the most commonly recorded wetland types were slightly different, with

Intertidal mud, sand or salt flats (15), Coastal dune shrubland (14) and Seasonal saline marshes (14) the three most common types.

Figure 3. Change in the Directory of Important Wetland in Australia (DIWA) type in the Coorong NP between 2003 and 2015.



In 2003 no wetlands were described as Intertidal marshes (A8), however, in 2015 11 sites were considered an Intertidal marsh (Figure 3). Consequently there was a decrease in the number of identified Freshwater lagoons and marshes (A11) and Seasonal saline marshes (B12) (Figure 3). The sites that had very clear descriptions, such as Estuarine stream channel (A8), Permanent rivers and streams (B1) and Seasonal intermittent freshwater lakes (B6), which also had low number of occurrences, did not change type. However, the clearly described Coastal dune shrubland (A13) had one recommended change to Freshwater swamp forest (B14), which may have been due to the point of assessment and the fact that it is a large polygon with two clear DIWA (or equally Ramsar) types.

Table 3: Comparison of Directory of Important Wetland in Australia (DIWA) wetland type assessments over 95 sites in the Coorong NP between 2003 and 2015.

		DIWA wetland type 2015													Wetlands Assessed
		A11	A13	A15	A4	A5	A7	A8	B1	B12	B13	B14	B6	B8	
DIWA wetland type 2003	Freshwater lagoons and marshes (A11)	1	1					6							8
	Coastal dune shrubland (A13)		13									1			14
	Freshwater soaks (A14)							1							1
	Estuarine stream channel (A15)			2											2
	Rocky marine shores (A4)				10		1								11
	Sand, shingle or pebble beaches (A5)				1	9	2								12
	Intertidal mud, sand or salt flats (A7)						11								11
	Permanent rivers and streams (B1)								1						1
	Intertidal marshes (A8)														0
	Seasonal saline marshes (B12)					1		4		10				1	16
	Shrub swamps (B13)									3	1				4
	Freshwater swamp forest (B14)									1		4			5
	Seasonal intermittent freshwater lakes (>8ha) (B6)												0	1	1
	Seasonal/intermittent saline (B8)						1							8	9
Wetlands Assessed		1	14	2	11	10	15	11	1	14	1	5	0	10	95

3.3 Changes in Water Regime

The repeat assessment of 95 wetland sites in 2015, found that there was a slight shift in the water regimes between the two years (Table 4). In 2015 there were marginally more wetlands that were considered permanently flooded and semi-permanently flooded, with a predictable associated shift of there being less wetlands considered to be seasonally or intermittently flooded. The most noticeable change across the categories over the 12 years was of sites with no data in 2003 and sites considered to be terrestrial and without a water regime in 2015 (Table 4). Of the 13 wetland polygons with no water regime data in 2002-3, seven were assessed by air and recommended field verification. All 13 wetlands with no data in 2002-03 now have a recommended water regime, which varies from permanently flooded to intermittently flooded. Those wetlands that were considered to have no water regime and be terrestrial in 2015 were observed to be consolidated dunes (with no obvious wet depressions) or rocky cliffs, which were predominantly described as seasonal or intermittent in 2003.

Table 4. Number of wetlands characterised by wetland regime in 2003 and 2014

Water regime	2003	2015
Permanently flooded	3	4
Semi-permanently flooded	19	23
Seasonally flooded	41	35
Intermittently flooded	19	15
Terrestrial	0	18
No data	13	0
Total no. wetlands assessed	95	95

Of the 95 sites assessed across the Coorong National Park in 2015, 57% did not record a change in the water regime since 2003 and a further 10% had no data in 2003 (Figure 4). Three percent were recorded as having a slightly greater period of inundation in 2015 than 2003, which represented sites changing from seasonally or intermittently flooded to semi-permanent or permanently flooded. Twelve percent of sites considered to be receiving less inundation generally only experienced changes of one water regime class.

The proportion of sites that were reclassified as terrestrial in 2015, or without a water regime, represented the second most commonly recorded class, of 18%. As previously described, these sites generally did have water regimes described in 2003, however, they were either rocky cliffs or consolidated dunes without wet depressions present.

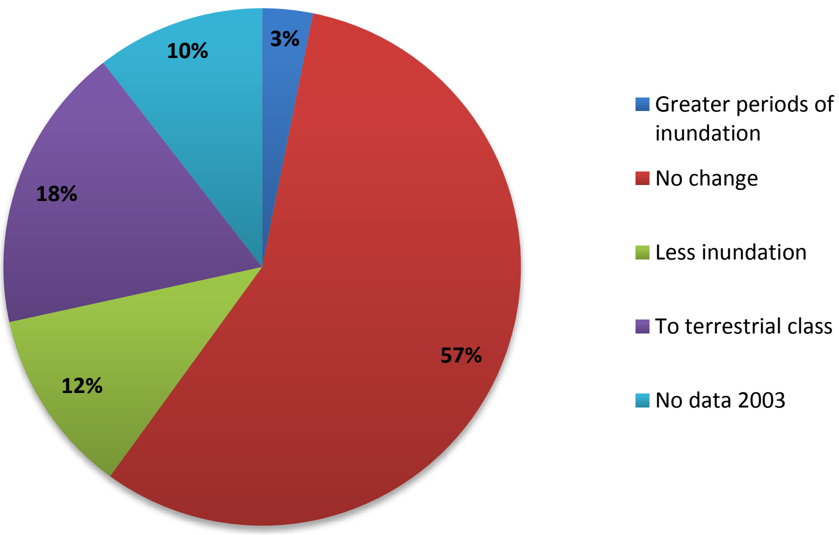


Figure 4. Percentage changes in water regime from 2003 to 2015

3.4 Changes in Habitat Condition

Assessments of the habitat condition at the 95 sites in 2015 found that 34 (36%) have improved in condition, 40 (42%) have not changed condition, and 21 (22%) have declined in condition since 2003 (Table 5, Figure 5). Table 5 details the proportion and direction of change for each condition class.

The most consistent improvement in habitat condition classes was observed at the nine sites that recorded the poorest condition scores in 2003, of Degraded or Good (Table 5). Generally wetlands with low condition scores in 2003 were recorded as having cleared or degraded buffers and associated threats. However, since 2003 revegetation has been undertaken in wetland buffers at most sites, resulting in an improved habitat condition score in 2015. Conversely the wetlands that were assessed as Pristine in 2003 experienced the highest proportion of decline, however, this only represented 8 sites and in all but one case the wetland was still considered to be in Excellent condition (Table 5). The case where a Pristine site in 2003 was considered Very Good in 2015, was not verified by a site visit during the 2003 assessment, which is a relevant consideration when interpreting this data.

Table 5. Trajectory of change in habitat condition of 95 wetland sites assessed from between 2003 and 2015 in the Coorong National Park

Habitat condition score	No of Sites with Habitat Condition score in 2003	Distribution of Change in Habitat Condition from 2003 to 2015		
		Improved (%)	No change (%)	Declined (%)
Pristine	17	0 (0.0%)	9 (52.9%)	8 (47.1%)
Excellent	49	17 (34.7%)	22 (44.9%)	10 (20.4%)
Very good	20	10 (50.0%)	7 (35.0%)	3 (15.0%)
Good	6	5 (83.3%)	1 (16.7%)	0 (0.0%)
Degraded	3	2 (66.7%)	1 (33.3%)	0 (0.0%)

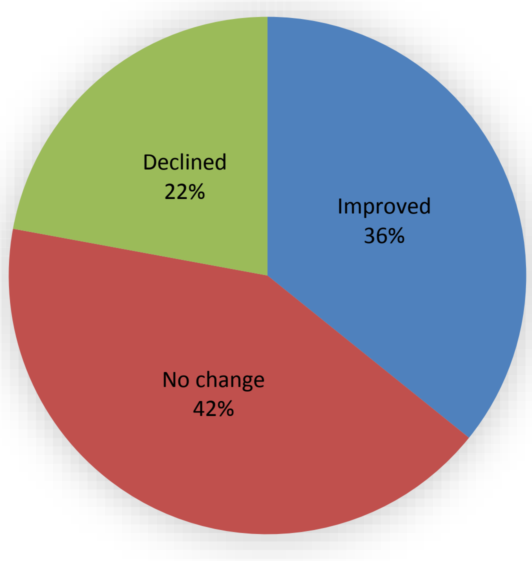


Figure 5. Habitat condition change of the same sample of 95 wetlands assessed from 2003 to 2015

3.5 Change in Condition by Ramsar Wetland Type

To ensure the comparison was of the maximum benefit to land managers the change in condition by Ramsar wetland type was considered under the 2002-03 type for analysis. The change in condition of Ramsar wetland types (as described in 2003) between 2003 and 2015 was variable, with most wetlands across the types remaining stable or improving in condition (Table 6). The greatest improvements in condition were seen at sites classified as Intertidal mud, sand or salt flats (G) (55%), Sand, shingle or pebble shores (E) (46%), and Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss) (44%). Declines in condition class were most often recorded at Shrub-dominated wetlands (W) (50%), Freshwater springs (Y) (50%), Permanent rivers/streams/creeks (100%, note n = 1) and Coastal freshwater lagoons (44%).

Table 6. Change in habitat condition of Ramsar wetland types between 2003 and 2015

Ramsar Wetland Types	No. Sites Assessed	Habitat Condition Change		
		Improved (%)	No change (%)	Declined (%)
Rocky marine shores (D)	11	18	45	36
Sand, shingle or pebble shores (E)	26	46	38	15
Intertidal mud, sand or salt flats (G)	11	55	36	9
Coastal brackish/saline lagoons (J)	2	0	100	0
Coastal freshwater lagoons (K)	9	11	44	44
Permanent rivers/streams/creeks (M)	1	0	0	100
Seasonal/intermittent freshwater lakes (P)	1	0	100	0
Seasonal/intermittent saline/brackish/alkaline lakes and flats (R)	9	33	56	11
Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss)	16	44	31	25
Shrub-dominated wetlands (W)	4	25	25	50
Freshwater, tree-dominated wetlands (Xf)	5	40	60	0
Freshwater springs (Y) – Secondary	10	20	30	50

At the majority of sites where a change in condition was observed (47 of 55), the change was only up or down one level, for example good to excellent, or pristine to excellent. However, at three sites the condition improved by two classes, at four sites the condition class reduced in condition by two classes and at one site by three classes. The Ramsar wetland type that recorded the largest changes in condition most often was the Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss, four sites). However, it is worth noting that three of the eight sites with large condition changes were previously only assessed from the air, which included only one Seasonal/intermittent saline/brackish/alkaline marshes/pool.

3.6 Change of Condition of Landform Type

Twenty-two Landform types were recorded in 2003 across the 95 sites, with up to 15 sites per category (Table 7). The Landform was observed to have changed since 2003 at some wetlands and is presented and discussed in Section 3.7.2 and Appendix C. However, for comparison of condition between 2003 and 2015, the 2003 Landform type has been used as it was likely that it was not an ecological change, but one determined by mapping or assessment. Of the Landforms that had over four representative sites, the greatest proportion of site improvement was observed at Consolidated dunes (75%), Mud flats (57%), Open depressions (57%), Dunes (50%) and Rocky shores (50%) (Table 7). Conversely Closed depressions, Reef/Rocky Reef and Vegetated bed sediments had the highest proportion of sites decrease in condition, with decline of 50%, 50% and 44% respectively.

Large changes in condition scores of two classes or greater were observed at Vegetated islands (2 declines, 1 improvement), Floodplain (1 improvement and 1 decline), Shoreline (1 decline), Closed depression (1 improvement and Mudflats (1 improvement). The discrepancy in the condition of Vegetated Islands was particularly pronounced for all sites in this category, with scores moving from Pristine, Excellent and Very Good to Very Good, Good and Degraded, respectively. Observations made during the 2015 survey of the Vegetated islands, having a very high presence of weeds with little or recovering native vegetation, suggest that these sites are likely to have been in this condition for a considerable period of time or that previously minor weed outbreaks, in the absence of competition, have dramatically increased.

Table 7. Habitat condition responses of landform types between 2003 and 2015 in the Coorong National Park

Landform (2003)	**No. Sites Assessed**	**Habitat Condition Change**		
		Improved (%)	**No change (%)**	**Declined (%)**
Floodplain	15	33	60	7
Dune	10	50	40	10
Vegetated bed sediments	9	11	44	44
Mud flat	7	57	29	14
Open depression	7	57	14	29
Salt lake	7	29	71	0
Reef/Rocky reef	6	0	50	50
Rocky shore	6	50	50	0
Closed depression	4	25	25	50
Consolidated dune	4	75	25	0
Vegetated island	3	0	0	100
Beach	2	100	0	0
Channel	2	0	100	0
Cove	2	0	100	0
Rocky ridge	2	0	50	50
Sandy beach	2	50	50	0
Shoreline	2	50	50	0
Flat	1	0	0	100
Lagoon	1	0	0	100
Rocky cliff	1	100	0	0
Sand bar	1	100	0	0
Stream channel	1	0	0	100
Total	**95**	**36**	**42**	**22**

3.7 Changes in Habitat Community – Vegetation Associations

In 2015 the vegetation associations were recorded using the South Australian pre-European MU50 or MU250 vegetation community descriptions, in comparison to 2002-03 which used free text and described the two most dominant species or gave a generic description of unidentified shrubs. The location and scale of the assessments, meant that Murray Mallee MU50s, South East 250s and in one case the Southern Lofty MU50s were required to accurately describe the vegetation, however, where possible the more detailed Murray Mallee Mu50s were used. Fifteen different vegetation communities were recorded at 72 of the 94 sites, eight from the Murray Mallee MU50, six from the South East MU250 and one from the Southern Lofty MU50 (Table 8). Of the 72 sites with a recorded vegetation community, 29 recorded a secondary vegetation community.

Table 8. Recorded vegetation communities across the assessed Coorong habitat condition assessment sites 2015

MU 50 or 250 Veg Comm.	Vegetation community description	Primary	Secondary
MM 3202	*Sarcocornia* sp., *Halosarcia* sp. Low shrubland	27	3
MM 2001	*Leucopogon parviflorus, Acacia longifolia* ssp. *sophorae, Olearia axillaris* +/- *Myoporum insulare* Tall Shrubland	15	2
MM 3201	*Sarcocornia quinqueflora, Suaeda australis* Low Shrubland	11	2
MM 2901	*Melaleuca halmaturorum* Tall open shrubland over *Sarcocornia quinqueflora*, +/- *Frankenia pauciflora var., Halosarcia pergranulata, Hemichroa pentandra, Tetragonia implexicoma*	6	2
MM 3601	*Gahnia filum, Samolus repens* Sedgeland	3	7
MM 2002	*Myoporum insulare, Acacia longifolia* ssp. *sophorae, Leucopogon parviflorus* Tall Shrubland	3	0
SE 41	*Phragmites australis, Typha domingensis* Grassland	3	4
SE 28	*Acacia longifolia* ssp. *sophorae* Tall closed shrubland	1	0
SE 17	*Allocasuarina verticillata* Woodland	1	1
SE 42	*Poa* spp. *Stipa stipoides* Tussock Grassland	1	0
MM 1001	*Eucalyptus diversifolia* Mallee over *Lepidosperma congestum/laterale/viscidum, Hibbertia riparia, Xanthorrhoea caespitosa/semiplana*	0	1
SL 50.01	*Gahnia* sp. &/or *Juncus* sp. Open Sedgeland	0	2
SE 22	*Melaleuca lanceolata, Allocasuarina verticillata* Low woodland	0	1
MM 3101	*Duma* syn. *Muehlenbeckia florulenta* Shrubland	0	1
SE 43	*Spinifex sericeus, Ficinia nodosa* Tussock grassland	0	3
Total		72	29

The most commonly recorded primary vegetation community in 2015 was samphire low shrubland, which consisted of two mapped vegetation communities (MM 3202 and MM 3201). Specifically the most common communities included the *Sarcocornia* sp., *Halosarcia* sp. Low shrubland (27), *Leucopogon parviflorus, Acacia longifolia* ssp. *sophorae, Olearia axillaris* +/- *Myoporum insulare* Tall Shrubland (15), and *Sarcocornia quinqueflora, Suaeda australis* Low Shrubland (11) (Table 8). It is important to note that often the vegetation community formed a very small part of the site polygon, forming fringing vegetation at the side of an open wetland. Of the 72 sites with a recorded vegetation type, 17 sites (24%) only recorded the vegetation community over <5% of the polygon.

A manual assessment was undertaken to compare the two vegetation communities at each site between 2003 and 2015, finding that 70 sites (74%) retained the same vegetation community (47 sites) or maintained no vegetation community (23 sites) (Figure 6). Of the 26% that had changed vegetation community, 17 sites had a vegetation community recorded where previously there was none, noting the 11 of these sites had an overall cover of <5%. Only two sites had a change of vegetation community, one from a *Eucalyptus diversifolia* Mallee (which was outside the polygon) to G*ahnia filum, Samolus repens* Sedgeland and one from an *Olearia axillaris, Leucopogon parviflorus* Coastal shrubland to *Melaleuca halmaturorum* Tall open shrubland. Of the 74% of sites that exhibited no change in the vegetation community or lack thereof, 8 sites (8.4%) had a change in overall cover class across the polygon, however, generally this was only one class of 25%.

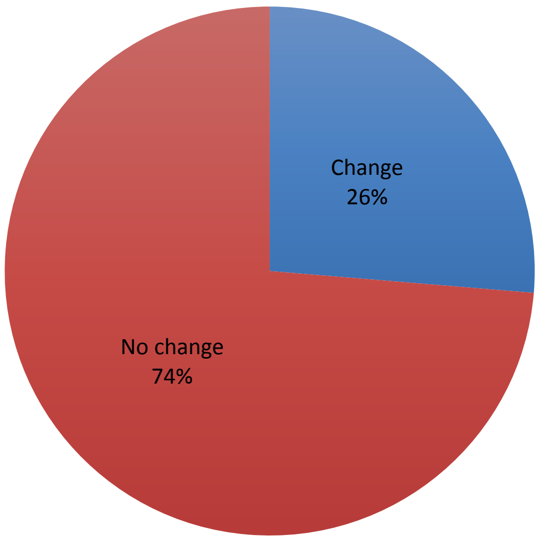


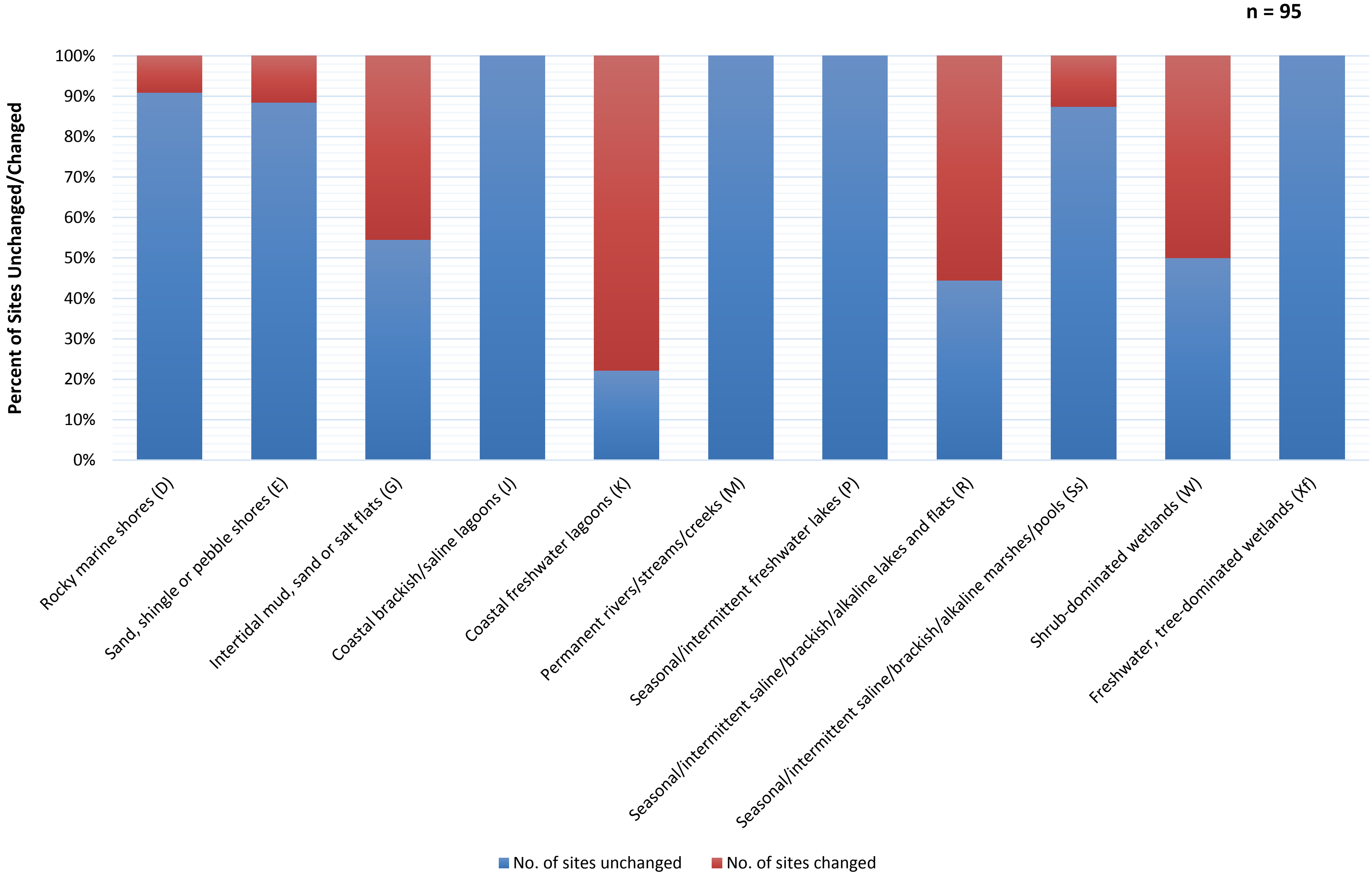
Figure 6. Habitat Community – Vegetation Association Change between 2003 and 2014

3.7.1 Habitat Change as a function of Ramsar Wetland Type

The change to the vegetation association or addition of a vegetation association, which was considered a habitat change for the purposes of this report, was assessed in 2015 in comparison to 2003. There was a variable response across the Ramsar wetland types, with seven of the eleven Ramsar types recording a habitat change at between one to 11 sites (Figure 7).

The highest variation in the recorded vegetation community was in the Coastal Freshwater Lagoons (K), Intertidal mud, sand or salt flats (G) and Seasonal/intermittent saline/brackish/alkaline lakes and flats (R) (Figure 7). However, it should be note that some of these changes could have been quite minor, such as the inclusion of a vegetation community with <5% cover (usually at the buffer) at 11 sites where previously there had been no vegetation recorded.

Figure 7. Change in vegetation community across Ramsar wetland types in the Coorong National Park between 2003 and 2015



3.7.2 Habitat Change as a function of Landform

During the 2015 assessments, 29 of the 95 sites (31%) were considered to be represented by different landforms (see Appendix D for what landforms changes were made). Landform variation was highest in the Open Depressions class, with six sites suggested to be reclassified as a Closed Depression or Salt Lake and Vegetated bed sediments, with six sites suggested to be reclassified as Shoreline and as Closed Depression (Table 8). The five changes recommended to the Floodplain Landform were highly variable, ranging through Closed Depression, Dune, Inter-dune corridor, Vegetated bed sediments and Shoreline (see Appendix D)

Unlike 2003 where only one Landform was recorded per site, in 2015 15 sites were assessed to have two Landforms present, of which nine sites had two landforms that could be considered to be related habitats, such as Shorelines and Vegetated Bed Sediments. However, six sites contained two very distinct Landforms such as Dune and Vegetated Bed Sediments or Dune and Drainage Depression, suggesting that the mapping units need to be refined. This is important because an inaccuracy in the mapping may mask any real changes in landform due to hydrology or system health.

Table 8. Habitat Changes responses of Landforms in the Coorong NP between 2003 and 2015 following the return of flows to CLLMM region

Landform	No. Sites Assessed	Change	Change in Landform (%)
Open depression	7	6	86
Vegetated bed sediments	9	6	67
Floodplain	15	5	33
Beach	2	2	100
Dune	10	2	20
Stream channel	1	1	100
Sandy beach	2	1	50
Reef	3	1	33
Closed depression	4	1	25
Consolidated dune	4	1	25
Rocky shore	6	1	17
Mud flat	7	1	14
Salt lake	7	1	14

4 SURVEY LIMITATIONS

4.1 Timing of survey

Wetlands are dynamic ecosystems driven primarily by the availability of water, with seasonal variations in the amount and timing of inundation having a major influence on the physical and biological characteristics of these systems. This series of wetland habitat assessments was carried out over a 2 week period during the latter part of autumn 2015. This period coincided within a seasonal transition stage in an annual hydrological cycle for wetlands in a southern Mediterranean climate where wetlands generally experience rehydration and often a rise in water levels in response to increased inputs from stream flows, local rainfall and rising water tables associated with the onset of winter.

Therefore results from a single snapshot of a wetland's condition at this time of year may vary depending on the volume and timing of this available water and other factors at the time of assessment. For example of the 58 wetland sites with data in 2002-03, in 2015 12% of sites were assessed under a higher level of inundation, 25% with less inundation and 14% were at a similar level of inundation. Multiple assessments reflecting each seasonal change throughout the wetting and drying cycle would provide a better way to monitor changes in wetland type, vegetation association, habitat condition and hydrological state. If this is not possible, then repeating future assessments at a similar time in the annual hydrological cycle is recommended.

4.2 Access to Wetland Sites

Of the 95 wetland sites chosen from the 2003 assessment period for re-assessment in 2015, seven sites were unable to be accessed due to the physical and/or visual barriers to accessing or viewing sites. These included dense and/or tall vegetation (e.g. Melaleuca Tall Shrublands/Woodlands) and shallow water or deep mud that was impassable safely on foot or by boat (e.g. two islands in the Southern Lagoon of the Coorong). Also two sites on private property were assessed from 'over the fence' making assessment difficult from a distance. Surveying remotely may have led to important wetland features not being identified that could affect some of the assessment criteria (e.g. the presence and amount of small or submerged vegetation obscured by dominant vegetation, the level of pest plant infestation or signs of pest animal presence) and potentially in some cases the overall habitat score.

4.3 Assessment method

The rapid wetland method employed during this study follows, in part, the descriptive assessment methodology designed by Seaman (2003) which employs a qualitative ranking of wetland habitat condition. Whilst the peer to peer training assists in reducing assessment variability between assessors, it is perhaps unrealistic to suggest that entirely accurate calibration of the qualitative method can be maintained over a two week assessment period without the provision of other reference aids such as site photographs from previous assessment events in 2003 and descriptions and definitions of wetland typology, habitat condition classes and other assessment criteria.

Whilst 2003 assessment data were provided prior to the fieldwork, the use of this previous site information as a comparative reference for the current assessment may also have an unwanted side-effect of biasing the current assessor whilst judging and scoring the various components of each site. This potential side-effect was a constant consideration for the 2015 assessors and every effort was made to assess each site afresh on its current merits, whilst understanding that the aim of comparative assessment requires the use of, and reference to, the previous information at hand.

One of the difficulties with maintaining repeatability using the qualitative assessment method is the variation in the assessor's interpretation of brief and sometimes vague, insufficient and/or contradictory definitions and descriptions of assessment criteria such as the DIWA and Ramsar wetland classifications or habitat condition levels. This, along with the potential misidentification of wetland typology based on inaccurate or poor mapping of wetland polygons (see Section 4.5), poses an additional challenge in determining direct temporal comparisons of wetlands at the site scale.

4.4 Sample size of representative wetland types, water regimes and other characteristics

The 2015 assessments surveyed approximately half of the sites in and immediately adjacent to the Coorong National Park surveyed by Seaman in 2002-03. However, the sample sizes for several of the wetland types, habitat conditions, water regimes ultimately determined/selected in 2002-03 were often very small – generally due to the rarity of the type. The small sample size has limited the opportunity to make robust comparisons between the wetland types, landforms and water regimes available, across the two assessment events.

4.5 Mapping

Based on the observation of the 2013 aerial imagery overlaid by the wetland polygons provided by DEWNR, it is evident that the scale and detail of wetland mapping presents some significant but understandable inconsistencies, given the likely evolution of the mapping itself through previous projects. Some polygons are tiny and specific, while others are so large they often contain multiple wetland vegetation types (or other features/disturbances that impact upon condition rating) clearly defined by the aerial imagery. This likely occurred by necessity as the Coorong and Lower Lakes Ramsar Habitat Mapping Program (Seaman 2003) occurred across a very large number of sites (761) in a short period of time. It is likely that while some sites received individual attention (with specific mapping) most required to be treated at a large (more generic) scale, with as much accuracy as was feasible given the time available.

This is in contrast to the current assessment in 2015, where the assessors had time to focus only on 95 sites which were assessed onsite. Many of the large sites assessed during this study contained multiple vegetation associations, meaning on-site decisions were often required for these wetlands on how far the assessment should range (to be representative of the wetland from the assessment point), to enable a fair comparison to previous assessments.

Assessment locations for this study were chosen as practically as possible, given difficulties with access in some cases, to represent the most spatially dominant wetland type, based on vegetation type/association, landform, water regime or depth and any other distinguishable features. The 2013 aerial imagery overlain with the 2002-03 wetland polygon layer was often used to confirm or indicate this spatial dominance of the wetland type being assessed and inform the decision of assessment location before proceeding.

Many of the larger wetland polygons extended beyond the reasonable range of assessment from the viewing point or were obscured by other landscape features (e.g. elevated landmass, tall vegetation, dune or island).

Again, the use of the combination of aerial imagery with the wetland polygon layer assisted in characterising the wetland polygon as a whole.

This observed discrepancy between wetland polygon extent and that observed from aerial imagery for many of the assessed wetland sites may be in a very small part explained by actual temporal changes associated with highly dynamic wetland substrates, or vegetation (e.g. Phragmites reed beds, sand bars and mobile sand dunes) that may have occurred over a 10+ year period. As the 2003 polygons were mapped over pre-2003 aerial imagery, any real on-ground changes can be established by comparing this with the 2013 imagery.

However, it is considered that many wetland sites may have been incorrectly or inaccurately mapped as it is unlikely that such a high proportion of the 95 wetland sites or Ramsar types would have changed to this extent over the 10+ year period. Many of these sites are located on relatively stable geophysical landforms and often support well-established vegetation. Again, comparing the pre 2003 and 2013 aerial imagery may help explain and resolve the true magnitude of this discrepancy. Plates 1 and 2 provide an example where 2015 wetland assessments differ substantially from those undertaken on 2003 due to course mapping units, contrasting interpretations of field observations (particularly of vegetation associations) and aerial imagery.

Plate 1. Photo-point image of vegetated island (polygon 458), a relatively stable geological feature east of Parnka Point, taken in 2015. It shows the occurrence of low samphire shrubland (left of view) and the dominance of introduced terrestrial vegetation (centre and right of view), verified using a spotting scope.

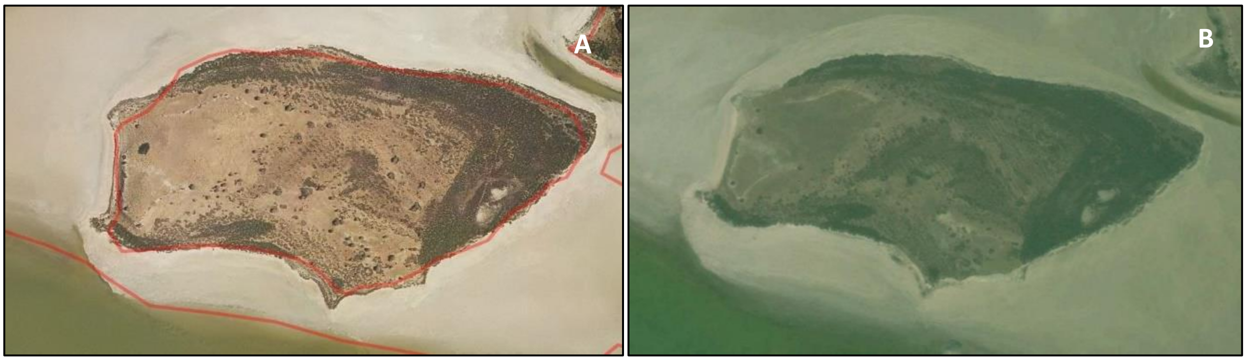


Plate 2. Illustrates the level of accuracy of the 2003 wetland mapping of the island over 2013 aerial imagery (left A) and the same area in 2005 (right B).

Plate 2A shows the deviation of the polygon perimeter from the island shoreline at several locations. The 2003 assessment identifies the *Tecticornia, Sarcocornia* shrubland as the primary vegetation association ahead of an *Acacia longifolia* - introduced grasses association, whereas 2015 observations recognise the terrestrial open shrubland of African Boxthorn **Lycium ferocissimum* over *Euphorbia* spp. on higher elevations as the primary vegetation association due to its greater cover of the island compared with the extent of low samphire shrubland. For comparison 2005 imagery has also been provided of the island, showing very little change in vegetation cover or type between 2005 and 2015 (Plate 2B). Whilst geographically it is understandable to map the entire island as one polygon, particularly when assessing the whole Coorong, Lakes Alexandrina and Albert Ramsar site, there were inconsistencies in the level of mapping detail for different sites. In some cases sites were very small and split on much less detail than that given as an example for polygon 458 (Plate 1 and 2). Hence based on the 2015 observations in the field and of 2013 aerial imagery, recommended that the mapping units be reassessed and in this case the two visibly distinct areas of the island are separated into two polygons to identify two distinct Ramsar wetland types.

Some of the 2003 assessments were conducted from an aircraft and this may have contributed to additional uncertainty associated with sites assessed by this method. Hence ground-truthing of several polygons was recommended within the comments section of the 2003 CLLMM database, which was done in the current study. An example of where ground-truthing has increased the level of detail and provides support for remapping is the long skinny wetland polygon 1640, which occurs along 2.93km of the shoreline of the Northern Lagoon adjacent to the Younghusband Peninsula (Plate 3).

Plate 3. Coorong wetland polygon 1640, between the Younghusband Peninsula and North Lagoon.

This wetland polygon (1640) was assessed from the air in 2003 with the following characteristics:

- Ramsar wetland type: Coastal freshwater lagoon (K)
- DIWA wetland type: Freshwater lagoons and marshes in the coastal zone. Reed beds and vegetated bed sediments (A11)
- Vegetation Association: *Phragmites australis, Typha domingensis* reed bed
- Habitat Condition: Excellent

A small portion of the same wetland photographed from open water in 2015 (Plate 4A). Note the *Phragmites australis* reed bed (centre left of Plate 4A) which may have influenced the characterisation of polygon 1640 (as above) in 2003. The occurrence of the reed bed is most likely due to a localised freshwater soak associated with the dune in the background. However it was observed during the current assessment period that the *P. australis* reed bed occurred within only a short section of the shoreline. As can be seen at centre right, vegetation changes to low samphire shrubland.

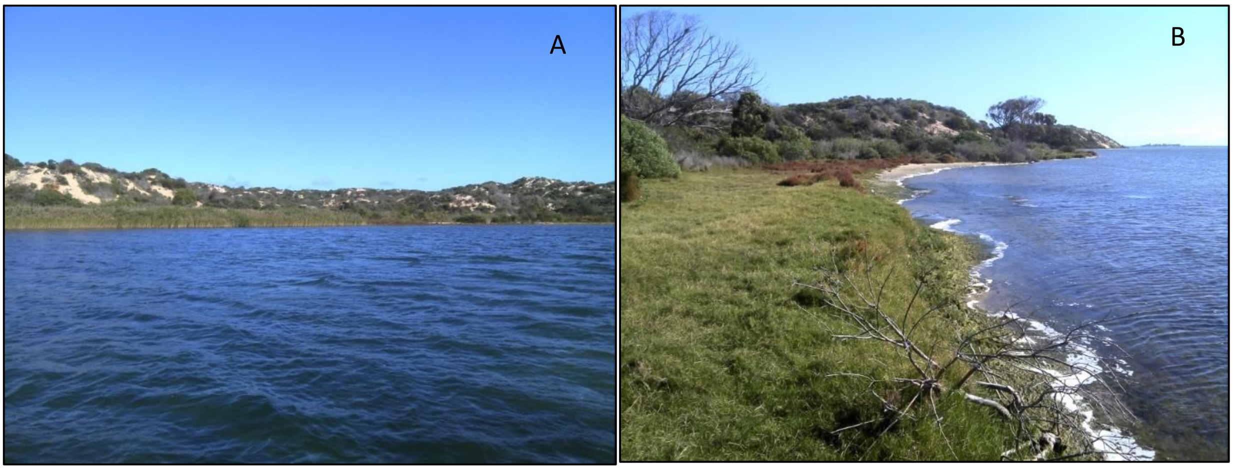


Plate 4. Coorong wetland polygon 1640 from the water and within the polygon.

Plate 4B shows typical vegetation along the shoreline within polygon 1640 in 2015. The vegetation varies from *Sarcocornia quinqueflora, Suaeda australis* low shrubland (background) to areas invaded by the introduced amphibious grass **Paspalum distichum*. Recommended changes to the wetland polygon 1640's characteristics/condition assessment and mapping is based on the 2015 on-ground observations:

- Ramsar wetland type: Intertidal marshes, incl. saltmarshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes and vegetated shorelines (H)
- DIWA wetland type: Intertidal marshes, incl. as per Ramsar description (A8)
- Vegetation association: *Sarcocornia quinqueflora, Suaeda australis* low shrubland
- Habitat condition: Very Good (reduced from Excellent due to weed cover)

The observed reed bed (Plate 4B) suggests the occurrence of a freshwater spring and was recognised as a secondary Ramsar wetland type, Freshwater Spring (Y), within the polygon. On closer inspection of the wetland polygon layer over the 2013 aerial imagery revealed other significantly different vegetation and landscape features within the 1640 polygon, thus leading to the 2015 recommendation to remap this polygon to isolate and more accurately reflect the wetland types recorded.

It is recommended that mapping of wetland polygons in the CLLMM region be updated to:

a) refine spatial differences in vegetation associations (or other clearly defining features of a wetland area such as open water, mud flats, sandy beaches or other) using the 2013 aerial imagery as a basis;
b) record spatial changes in the extent of wetland areas and;
c) map any previously unmapped wetlands.

The level of expertise in identifying spatial changes in vegetation or wetland types from aerial imagery is crucial and intimately linked to the accurate mapping of wetland polygons.

4.6 Photo-point Images

Photographs depicting each wetland site were taken at locations and from a point of perspective considered to best represent the wetland type. Whilst photographs from 2003 were provided for comparison, their identity and location details were not provided at the time of this report's publication. Therefore photo-point images could not be captured from similar locations to 2003. As a result, unfortunately visual records of wetlands between 2002-03 and 2015 (which may have been revealing) could not be compared. As occurred in the current study (aided by major technological advances since 2003), it is recommended for future assessments that bearings and geographic locations be recorded for each photograph taken to improve the accuracy and repeatability of recording visual characteristics of wetlands to compare temporal changes.

5 DISCUSSION

5.1 Post-drought water regime

The primary aim of the 2015 survey was to assess how the wetlands and/or habitats within and immediately adjacent to the Coorong National Park had responded following a considerable change in hydrology during the 'Millennium Drought'. Between 2002 and 2003 habitat condition assessments were undertaken at 761 sites in the Coorong and Lower Lakes, as part of the Coorong and Lower Lakes mapping program (Seaman 2003), including 185 in the Coorong region. The initial survey was undertaken near the start of the Millennium Drought which occurred from 1997 to 2009, when South-eastern Australia received below 12.4% of the annual average rainfall (CSIRO 2011). The Northern Lagoon was considered to have one of the highest recorded salinities in January 2003 (Phillips & Muller 2006), which coincided with the initial study, indicating the Coorong system was already under great stress. However, regionally this is still considered to be pre-drought, as the Millennium Drought didn't reach its peak until 2006-2009. No wetland condition assessments were undertaken at the sites following the peak of the drought in 2008-2010 (but before the drought broke) to make assessments against, however, it is likely and reasonable to assume that there was a also a decline in habitat condition, based on the knowledge that water levels were significantly reduced resulting in dramatically increased salinities (Kingsford et al. 2011).

The current study repeated a subset of 95 sites following the return to average rainfall years and flows down the River Murray, which in turn helps maintain an open River Mouth (currently only again with dredging) and providing flows to the North Lagoon of the Coorong. As to be expected in a diverse wetland system, the Coorong had a diverse spread of sites with different water regimes, from Permanent to Intermittent, which was similar to the spread of water regimes and hence habitats in 2003. Of the assessed sites, 57% maintained their water regime and a further 3% had greater periods of inundation recorded. Following the drought period it appears that 12% of sites have a decreased level of inundation present at the site. However, this was generally by only one water regime 'class', which (given the method) could simply fall within the likely error margin of the observer.

One of the largest changes brought about by the current survey was the addition of a Terrestrial class in the water regime, which accounted for 18% of sites. The terrestrial class was given to sites which were not likely to receive inundation at any time during the year. Sites that were included in this category generally had a Landform class of Consolidated Dune (with no evidence of swales on site) or as a Rocky Cliff in 2003. These sites were classed as having intermittent or seasonal water regimes in 2003, however, the observed vegetation communities and landform present suggest that rather than being terrestrialised as a result of altered hydrology (as may otherwise be assumed), it may be simply a reflection of the accuracy and consistency of the mapping.

As discussed by Billows et al. (2014) water regime can fluctuate and easily be misrepresented by a 'snapshot' survey, as it may capture an extreme rainfall event, drought or higher than average rainfall event. Therefore it is important for the nominated water regime to be clearly supported by additional observational data such as vegetation type and habitat condition, and for monitoring ideally to be undertaken at a frequency that can overcome this limitation. Consequently, despite the appearance of relative 'stability' of the current water regime at most of the surveyed sites between 2003 and 2015, the water regime and monitoring its changes remains a very high management priority for the whole Coorong system. This is particularly relevant given the knowledge about the role of barrage flows on both Lagoons of the Coorong, with:

a) Salinity levels in the North Lagoon directly influenced (by slow mixing) with barrage flows; and,
b) Inundation depth and duration in both the North and South Lagoons directly influenced by the magnitude and timing of barrage flows, by preventing premature discharge of water from the Coorong.

Additionally, the impact of more recent discharges into the South Lagoon from drains in the Upper South East via Morella Basin and Salt Creek, is also a factor in the future management of the eco-hydrology of the site. The potential role and importance of those flows is likely to gain more attention with the implementation of the South East Flows Restoration Project.

The factors described all highlight the need for sound site monitoring to inform the future hydrological adaptive management of the site.

5.2 Post-drought habitat condition

Following the initial survey in 2003 and the Millennium Drought 78% of the sub-set of sites surveyed in 2015 either maintained or improved their habitat condition classification and an additional 10 sites considered pristine. Ramsar wetland types that were dominated by large areas of water or regularly inundated exposed substrate recorded the greatest improvement of habitat condition, suggesting that the change and subsequent improvement of water regime and quality since 2003 is having a positive influence on aquatic habitats. This trend was also evident in the Landform category where similar open, un-vegetated habitats, such as Mudflats, Open depressions and Rocky Shores were most likely to improve in condition.

The CLLMM Project team are undertaking a landscape scale revegetation project, which has planted over one million tubestock seedlings across the Coorong and Lower Lakes region. The Project focuses on restoration and building ecological resilience throughout the region (Tuck & Bachmann 2014). During the survey period for this current project, the amount of revegetation works that have been conducted are clearly observable, with regular revegetation encountered that is between 1 and 10 years old from a variety of projects. Although there was a number of contributing factors to the improvement of condition scores across the Coorong, sites with an improved condition score and a reasonable proportion of native vegetative cover were most likely to be those sites where revegetation had been undertaken within the site or around the buffer. At five sites, the revegetation was considered to be improving the buffer, often contributing to changing scores by up to two condition classes, for example degraded to good or very good to pristine.

Ramsar wetland types that had the highest amount of decline across the survey period were generally those that had a comparatively high proportion of vegetation cover, such as Shrub-dominated wetlands (W), Freshwater springs (Y) and Coastal Freshwater Lagoons (K) or Rocky marine shores (D). This most likely reflected the higher likelihood of having a degraded buffer (through proximity to the edge), a high cover of woody and herbaceous weeds and to a lesser extent vertebrate pests. The most commonly recorded high threat weeds included African Boxthorn (**Lycium ferocissimum*) at 34 sites, Euphorbia spp. (**Euphorbia terracina* and **E. paralias*), Marram Grass (**Ammophila arenaria*) at 3 sites and Spiny Rush (**Juncus acutus*) (1).

The Vegetated Island landform had the most consistent large decrease in condition; changing from pristine to very good, excellent to degraded, and very good to degraded at 3 sites. In all cases high levels of woody weeds and **Euphorbia* spp. were evident, with little remaining native vegetation.

The majority of cases (85%) where a change in condition was reported reflected only a minor change of one condition class. In a qualitative assessment where habitat condition is described using broad categories where little quantitative information is used by different (or possibly even the same) assessors, the method may not be sufficiently robust to distinguish minor changes between similar and different types of wetlands (Billows et al. 2014) and hence may fall within the natural 'error margin' of this methodology. Despite being trained in the methodology using peer to peer training, which reduces natural variability between assessors, there is the underlying assumption that assessors will maintain or share the same common interpretation and understanding of important wetland characteristics.

To try and reduce observer bias in habitat condition assessments, it is suggested that a modified system be considered in future that incorporates some basic quantitative elements, but maintains its rapid approach. For example, a similar rapid wetland condition assessment approach is in use by ForestrySA to assist with their adaptive management approach to wetlands in plantations, giving typical native plant species richness, size and brief disturbance descriptions to guide assessors (Haywood & Horn, in prep. 2015).

5.3 Reviewing habitat community change

The vegetation communities were described using the MU250 and MU50 of primarily the South East or Murray Mallee vegetation types and also free text during the current survey, increasing the information about vegetation types across the Coorong system. The vegetation types had previously been noted in 2003 in free text, using the two most dominant species. The data was manually compared, but assumptions were required to determine which vegetation community the 2003 data was referring to. Fifteen different communities were recorded across the 72 sites and 17 had more than one vegetation community recorded.

Despite two methods being used to record vegetation communities, it was found the 70% of the sites did not change, indicating they either had remained with the same assumed coarse vegetation community or with no vegetation community. While in two cases the change was clearly due to incorrect mapping or identification, in many cases reported changes may have been due to differences in the assessors' survey location or understanding of the polygon boundaries. For example, at 17 sites that registered a change, the vegetation community only had a cover of <5%; hence it is possible that it may have been present in 2003 but not considered to have been located in the polygon.

The data did not show a clear change in vegetation community that might have been related to the change in hydrology across the site over the past 12 years. While there was not any strong data, there were some indicators that the sites might have had subtle changes in community with the encroachment of drier species, which would be consistent with the influence of the intervening drought years. Hence, it is possible that an increase in the number of sites with <5% vegetation cover might also be a genuine indicator of vegetation communities moving down the wetland profile (or elevation gradient), as these sites were dry for long periods. Also at several sites other small changes such as the encroachment of *Myoporum insulare* into Samphire low shrublands could also be observed, although not identified at the coarser analysis phase, suggesting that the site had experienced a drying phase.

As with many elements of this habitat condition assessment, change in the dominant vegetation community consists of a relatively coarse categorisation method. Each site is allocated a vegetation community regardless of how well the community meets the vegetation community description, and consequently its attributes such as structure or habitat value to fauna, which reduces the ability to comment meaningfully on habitat community change. It is recommended that vegetation communities are also given a 'health' score so that the assessors can see whether there is a trajectory of vegetation community health within this classification system, which might then enable comment about a change to the site's habitat condition.

5.4 Reviewing Ramsar wetland type and landform

Whilst 25 (26 %) of the 95 wetlands assessed in 2003 were identified as different Ramsar wetland types in 2015, it is unlikely that most are a result of actual change to the wetland type between 2003 and 2015. As discussed in Section 4, various factors may influence how wetlands are categorised and assessed based on the assessors' interpretations of the descriptions for wetland type, how accurately the wetland polygons are superimposed onto aerial imagery and whether or not the wetland was re-assessed from the same location as previously assessed.

For instance, the noticeable decreases in occurrence that were recorded in Sand, shingle or pebble shores (E), Coastal freshwater lagoons (K) and Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss) are most likely due to a combination of all or most of the above factors. For example the long, narrow wetland polygon 1640 (Plate 3) classified as a Coastal Freshwater Lagoon (K) in 2003 was observed in 2015 to exhibit features of more than one Ramsar wetland type based on on-ground observations (c.f. from the air in 2003) of vegetation that reflects hydrological and geological conditions. From the 2015 observations the assessors concurred that the dominance of stretches of low samphire shrubland and the invasive **Paspalum distichum* along most of its shoreline compared with the substantially less expansive beds of *Phragmites australis* warranted the wetland polygon as a whole to be classified as an Intertidal marsh (H) which includes "**salt marshes**, salt meadows, saltings, **raised salt marshes** and tidal, **brackish and freshwater marshes**". The assessors ruled out Coastal Freshwater Lagoon (K) as occurring, as most of the shoreline was adjacent and exposed to the main lagoon of the Coorong and its saline water. Coastal dune shrubland also occurs within the polygon (best matching Sand, shingle and pebble shores (E)). Plate 4A shows two distinctly different vegetation types the mixed raised samphire and **P. distichum* shoreline (with Coastal Dune Shrubland in the background on higher elevations) and Plate 4B illustrates the less abundant stretch of *P. australis* marsh where freshwater soaks are likely to occur. The 2013 aerial imagery for the 1640 polygon supports the field observation by showing not only the multitude of wetland/vegetation types within the polygon but also the coarse polygon perimeter mapping at the site scale. These images illustrate that if polygons are inaccurately traced in an attempt to visually isolate wetland types based on textural changes depicting changes in vegetation cover then determining the most suitable wetland type for that polygon in the field is a major challenge for assessors.

Other examples such as this can be illustrated for several wetland sites that have had their wetland typology changed throughout this study. Wetland polygon 458 is such an example where 2015 wetland assessments differ significantly from those undertaken on 2003 due to mapping inaccuracies and contrasting interpretations of field observations (particularly of vegetation associations) and aerial imagery (see Plate 1 in Section 4.6).

Based on the high percentage (26%) of wetlands that have been reclassified because of the above mentioned factors, the redrawing of wetland polygon boundaries for most wetlands within the Coorong is strongly recommended to minimise uncertainly in defining wetland type whether it be according to the Ramsar Classification System or the DIWA system.

5.5 Limits of Acceptable of Change

The Ecological Character Description (ECD) of the Coorong, Lakes Alexandrina and Albert Wetland International Importance (Phillips & Muller 2006) describes the species, communities and habitats and the processes and system drivers which characterise the Coorong, and outlines the Limits of Acceptable Change to these characters to maintain its value. The six primary determinants of the ecological character of the site are already outside their recommended limits of acceptable change (LAC) (Phillips & Muller 2006). A 'traffic light' assessment of all the key elements of the ecological character were provided to allow a quick overview of the state of the current threats and vulnerabilities. The 'traffic light' assessment ranges from red, amber, yellow to green, where red indicates urgent management attention to address a significant detrimental impact of a threatening process/es, to green which indicates management actions are currently adequately addressing all known risks or threats (Phillips & Muller 2006). Of the 13 different Ramsar types assessed during the 2015 surveys, 54% of the Ramsar types are considered to be red in 2006, requiring urgent management attention, with the remaining 46% either amber or yellow indicating strong likelihood of the presence of threatening processes or at a minimum some concern of threatening processes which warrants further investigation.

This current reassessment of 95 habitat sites is a rapid condition assessment that provides temporal information on the condition of a sub-set of Ramsar wetland types and in some cases vegetation communities that contribute to the ECD. The limits of acceptable change of extent for each of the 13 Ramsar wetland types observed range from 0% (3 types), 2% (6 types) and 5% (3 types). The suggested changes in this report to different Ramsar wetland types mean that six Ramsar types (D, E, G, H, K and R) exceed the change of extent by between 0.6% and 128.6% (refer to Table 1). However, it is important to recognise that the change of extent of different Ramsar wetland types is considered to be predominantly representative of often coarsely mapped polygons and the interpretation of the Ramsar wetland types, and not an indication that the system has undergone a significant ecological shift.

5.5.1 Type D: Rocky marine shores

Rocky marine shores are considered 'amber' under the traffic light assessment, based on the threat of smothering by sediment and that they are vulnerable due to the relatively small area of occupancy and thin tidal band that they occupy. During the current survey 11 sites were assessed, which represents 109 ha of 617 ha of the Rocky marine shores in the Coorong. Of the 11 sites, one site was considered to be incorrectly categorised and changed to Intertidal mud, sand or salt flats (G), it is possible this may demonstrate the previously mentioned threat of smothering by sediment. The sites were described as Pristine through to Good, with 63% of sites maintaining or improving their condition assessment since 2003. Thirty-seven percent of sites received a lower condition score than in 2003, including one site which was reduced from Very Good to Degraded, however, this was Woods Well Island and (being an island) it is questionable as to whether it belongs in this category. Rocky ridgelines and in some cases cliffs have also been included in this category in 2003 and 2015, hence pest plants such as African Boxthorn and vertebrate pests were the most commonly recorded threats.

5.5.2 Type E: Sand shores and dunes

The Sand shores and dunes (E) were the most commonly assessed sites (26) in 2015, however, it was recommended to change five sites to different Ramsar wetland categories, Rocky marine shores (D), Intertidal mud, sand or salt flats (G) or Freshwater, tree-dominated wetlands (Xf). As a dynamic system, this wetland type is consider under threat from wind and water erosion, destabilising recreation activities, and invasion by terrestrial weeds (Phillips & Muller 2006). Twelve of the sites assessed in 2015 were considered to be completely terrestrial in nature, despite previous descriptions of intermitted or seasonal flooding in 2003. Commonly occurring threats in 2015 included access tracks, pest plants at varying density levels (**Euphorbia* spp. and **Lycium ferocissimum*) and low level traces/scats of pest animals (Red foxes and European rabbits). Encouragingly the condition of 85% of sites improved or remained stable, with less camping sites and tracks recorded.

5.5.3 Type G: Intertidal mud, sand or salt flats

The Intertidal mud, sand or salt flats (G) are considered to be extremely vulnerable to increased sedimentation and changes to the organic carbon and sediment profiles (Phillips & Muller 2006). However, during the survey the intertidal mud and sand flats were assessed to be in Pristine or Excellent condition, with 91% of the sites maintaining or improving their condition since 2003. Very low levels of disturbance were recorded, which included old fence posts, degraded buffers or vertebrate pest traces. There was a high number of different microhabitats present at most sites, which included algal mats, detritus, open water, rocky areas, molluscs, burrows and pooling.

The number of sites where the Ramsar wetland type assessed as Intertidal mud, sand or salt flats was suggested to be increased by four in 2015. The four additional sites would increase the extent of occurrence by 541.3ha.

5.5.4 Type I: Coastal brackish/saline lagoons

Two sites were assessed as Coastal brackish lagoons (J) in both 2003 and 2015. The sites consisted of saltmarsh drainage channels on the Younghusband Peninsula, which were previously assessed from the air. The sites were considered to be Pristine in 2003 and 2015 with no threats/disturbances recorded.

5.5.5 Type K: Coastal freshwater lagoons (with secondary Type Y: Freshwater springs)

Of the nine sites previously assessed as Coastal freshwater lagoons (K) in 2003, only one site was considered to be consistent with the description, which would significantly change the area of extent. Seven sites were considered to be better described as Intertidal marshes (H), as they have tidal influence with vegetated bed sediments (generally >50% cover) and were not isolated freshwater lagoons. In most cases the sites also contained the Freshwater soaks (Y) Ramsar wetland type, with a high cover of *Phragmites australis* or *Typha domingensis* in or around the soaks. As previously explained, it is highly unlikely that suggested change in wetland type represents a significant ecological change, but rather interpretation of Ramsar wetland types and coarse mapping units.

The current survey was the first time that any of the sites were ground-truthed having previously been assessed by air in 2003. The on-ground visits greatly improved the detail of the assessments and likely explains many changes recorded in the database. The sites (Type K) were considered in Excellent condition in 2003, however, in 2015 44% decreased in condition to Very Good or Good. Similarly, of the 10 sites to record Freshwater springs (Y), 50% decreased in condition and only 20% were considered to improve in condition. The reduction in condition was predominantly caused by the very high cover of **Paspalum distichum* 'lawn' surrounding most freshwater soaks and regularly recorded dense **Lycium ferocissimum* infestations on the drier areas of some sites. It is likely that the **P. distichum* was present in 2003, but not identified from the air. Very little human disturbance was observed, with only very occasional campsites or boat landings recorded. Despite the high level of weed cover the sites continued to retain their high ecological importance, maintaining a high diversity of fauna, flora and microhabitats.

Ramsar wetland types (K, Y, or H) are all considered to be red under the traffic light assessment in 2006, which was consistent with what was observed in 2015. Given their dependence on freshwater expression, the sites are particularly threatened by recharge-discharge processes and consequent declining water quality (Phillips & Muller 2006). Freshwater soaks were still present and maintaining a vegetation community consistent with varying levels of water expression at all seven previously recorded sites. Three additional sites were identified in 2015 within other Type K (or H) sites. Very few sites were observed to have open water, rather soaks or seepages. The sites are all affected by high levels of weed infestation and weed control is recommended.

5.5.6 Type M: Permanent rivers/streams/creeks

Only Salt Creek was assessed in 2003 and 2015 as a Permanent creek (M) across the surveyed sites. The site remained well utilised by a good diversity of water fowl, waders and small-bodied fish. It is a high use site, which has walking trails, bitumen and dirt roads, bridges and picnic areas within or immediately adjacent to the polygon. The condition was recorded as Very Good in 2015, which was reduced from Excellent in 2003, primarily due to the observed water quality, low levels of aquatic plants and high levels of algae. The buffer of *Gahnia filum* remained in very good condition, with low levels of woody weeds on the higher ground. The system is still highly dependent on the regulated flows from the Morella Basin, and as such is still considered to be extremely vulnerable (red) to degradation (Phillips & Muller 2006).

5.5.7 Type P: Seasonal/intermittent freshwater lakes

In 2003 one wetland located south of 42 Mile Crossing near the Southern Lagoon, was described as a Seasonal/intermittent freshwater lake, likely due to its very large size. However, the site (polygon 266) is a large saline lake system, hence it is recommended that it is remapped as Type R, Seasonal/intermittent saline/brackish/alkaline lakes and flats. This change is consistent with the ECD which does not refer to any freshwater lakes in the Southern or Northern Coorong lagoons (Phillips & Muller 2006).

5.5.8 Type R: Seasonal/intermittent saline/brackish/alkaline lakes and flats

The Seasonal/intermittent saline/brackish/alkaline lakes and flats (R) surveyed in 2015 predominantly maintained (56%) or improved (33%) their condition since the initial assessment in 2003. Of the nine sites, one site was recommended to be changed to Intertidal mud, sand or salt flats (G) and one brought into Type R, which would reduce the extent of occurrence by 65.4ha. The sites generally a good diversity of micro-habitats for fauna, which included mudflats, rocky areas, pooling, perching, molluscs, and detritus. Most sites were dry at the time of survey, however, small waders were observed at the two sites which retained a very low level of inundation.

There was a low level of disturbance or threats at all sites, with many sites having a walking trail or access track bordering the site or a degraded buffer surround part of the polygon. Tracks and scats of vertebrate pests, such as European rabbits, Red foxes or deer species were observed at half of the sites.

5.5.9 Type Ss: Seasonal/intermittent saline/brackish/alkaline marshes/pools

There was a recommended reduction in the number of sites described as Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss), with only 10 of the 16 sites remaining in the category. In one case a vegetated island was recorded in this category, providing a good example of where coarse mapping units has been used. However, other sites from different categories were recommended to be changed into the Ss Type, which meant that there would only be a net reduction of 20.6ha. Similar to Type R, Type Ss was well represented in the survey and across the Coorong system as a whole. However, Type Ss is still considered vulnerable (yellow) given its dependence on maintaining a good habitat connectivity within a matrix of different types (G, W, R and Xf) (Phillips & Muller 2006).

Of the 16 sites assessed in 2015, three quarters were considered to have maintained or improved their condition since 2003. Similar to nearly all sites in the Coorong National Park there was a very good diversity of micro habitats, in particular pooling, small mudflats, perching, structural diversity and roosting habitat. Regularly occurring disturbances or threats included degraded buffers, introduced grasses, woody weeds and vertebrate pests. This Ramsar wetland type was also most likely to record a recovering buffer through revegetation, and often consequently received a better condition score in 2015.

5.5.10 Type W: Shrub dominated wetlands

Four sites were classified a Shrub dominated wetlands (W) in 2003, three of which are recommended to be included in the previous category, Seasonal/intermittent saline/brackish/alkaline marshes/pools (Ss), in 2015. Of the four sites, one half maintained or improved their condition since 2003. The habitats within the four sites were highly variable, both in composition and condition, with many appearing to be recovering from disturbance. *Gahnia filum* still dominated some of the lower lying areas, grading to Samphire Shrublands and *Melaleuca halmaturorum* Tall Shrubland on the rises. There was a high diversity of micro-habitats for fauna and flora at the four sites, in particular providing roosting, nesting, sheltered and structurally diverse areas. Vertebrate pests (high levels of European Rabbits), weeds and access tracks were the most commonly recorded threats.

This habitat type is considered to be vulnerable due to its reliance on freshwater inflows to prevent it drying out and converting to Type Ss (Phillips & Muller 2006). The recommendation of this report to change three of the four surveyed Type W wetlands to Type Ss suggests that this threat is being realised. Further assessments of this habitat type is recommended to determine whether this is a trend across all Type W sites in the Coorong system.

5.5.11 Type Xf: Freshwater, tree-dominated wetlands

Freshwater, tree-dominated wetlands were represented at five *Melaleuca halmaturorum* Tall Shrubland sites. It is suggested to change one 2003 Freshwater, tree-dominated wetland site to Type Ss, and add one site previously described as Sand, shingle or pebble shore (Type E – note: also representing sand dunes), which would result in a net increase of 8.53ha. The suggested change of a site from Type E to Type Xf demonstrates the variability represented within some of the large site polygons. In that particular case the site polygon extended from the edge of the Southern Lagoon up into the sand dune, however, Type Xf represented a greater proportion of the site.

Freshwater, tree-dominated wetlands occur in large bands around the Southern Lagoon and provide important ecosystem services, including protective physical buffers, long term biomass sinks, sheltered roosting and feeding habitat (Phillips & Muller 2006). However, they are considered vulnerable to water and land use development (yellow). The surveyed sites recorded a high level of disturbance, which included degraded or cleared buffers, potential stock grazing, vertebrate pests and woody weeds (**Lycium ferocissimum*). However, the five sites assessed all either maintained (60%) or improved (40%) their condition to Very Good (4) or Excellent (1) since 2003. High numbers of micro-habitats were recorded at all sites, including structural diversity, nesting habitat, roosting, undulations, hummocks, detritus and rocky areas. Ongoing weed control and buffering of remnant sites is required in the future.

6 CONCLUSION

The current study conducted wetland condition assessments across the Coorong, revisiting 95 sites first assessed by Seaman in 2003. The study focused on capturing information about the changes in water regime, habitat condition, community/vegetation association, response of different landform types to increased flows and the impact on the range of Ramsar wetland types. In particular the study focussed on how the wetlands and/or habitats within and immediately adjacent to the Coorong National Park had responded to the considerable change in hydrology (low flows) associated with the 'Millennium Drought'.

The 2015 study found that since 2003, 57% of the 95 assessed sites maintained their water regime, 3% increased their period of inundation and 12% had a decreased level of inundation. The largest change occurred through the addition of a 'terrestrial' class in 2015, which accounted for 18% sites. Sites assessed to be terrestrial were unlikely to have terrestrialised in the past 12 years, as often the sites were described as rocky cliffs or sand dunes, indicating inaccuracies in the original mapping.

Following the initial survey in 2003 and the Millennium Drought, 78% of the sub-set of sites surveyed in 2015 either maintained or improved their habitat condition classification and an additional 10 sites were considered pristine. Only two sites were downgraded to the poorest condition category of Degraded, which was predominantly relatedly to the increased presence of weeds across a terrestrial system (vegetated island). The majority of cases (85%) where a change in condition was recorded, it reflected only a minor change of one condition class. As a qualitative assessment with broad categories, it may not be sufficiently robust to distinguish minor changes between similar and different types of wetlands (Billows et al. 2014) and hence may fall within the natural 'error margin' of this methodology. To try and reduce observer bias in habitat condition assessments, it is suggested that a modified system be considered in future that incorporates some basic quantitative elements, while maintaining its rapid approach.

The assessment of habitat/vegetation community, Ramsar wetland type and landform revealed subtle levels of change and often inconsistencies in the mapping and feature assignment across the Coorong. There was a slight indication that vegetation communities were moving down the wetland basin profile during the drier period, with a trend of vegetation communities increasing of 0% to <5% cover around the sill and it is possible that the change of some Ramsar wetland types (W to Ss), demonstrate a drying system. However, in general the largest changes could be attributed to inconsistencies in the mapping resolution and assigning of features or landforms. In some cases polygons contained multiple vegetation/habitat types or were assigned landforms or Ramsar wetland types that did not represent the current (or past based on aerial photography) situation.

Whilst 25 (26 %) of the 95 wetlands assessed in 2003 were identified as different Ramsar wetland types in 2015, it is unlikely that most differences are a result of actual change to the wetland type between 2003 and 2015. As discussed in Section 4 and above, various factors may influence how wetlands are categorised and assessed based on the assessors' interpretations of the descriptions for wetland type, how accurately the wetland polygons are superimposed onto aerial imagery and whether or not the wetland was re-assessed from the same location as previously assessed. This is particularly important in consideration for interpretation of the Limits of Acceptable Change (Section 5.5) of Ramsar wetland types across the Coorong system. In theory, the recommended changes to Ramsar type would move 6 of the 13 types outside the acceptable limits of change. However, in nearly all cases these changes are representative of coarsely mapped polygons within the original data set, not an indication that the system has undergone a significant ecological shift.

On this basis, the project has highlighted an important information gap requiring future attention in some of the spatial datasets that underpin the ecological character description for the site.

6.1 RECOMMENDATIONS

Based on the findings of the project, key future recommendations proposed for consideration include:

1. Updating mapping of wetland polygons in the CLLMM region to:
    - consider reassigning Ramsar wetland types as required;
    - refine spatial differences in vegetation associations (or other clearly defining features of a wetland area such as open water, mud flats, sandy beaches or other) using the 2013 aerial imagery as a basis;
    - record spatial changes in the extent of wetland areas and;
    - map any previously unmapped wetlands.
2. Repeating the habitat assessment process in the Coorong at semi-regular intervals (every 2-4 years at the same time of year).
    - A range of monitoring methods (and their target subjects) are required to help inform the future adaptive management of releases of water into the South Lagoon from the Upper South East via Salt Creek, and for better understanding the ongoing dependence of Coorong wetland habitats upon barrage flows.
3. To try and reduce observer bias in habitat condition assessments, it is suggested that a modified system be considered in future that incorporates some basic quantitative elements, but maintains its rapid approach.
    - For example, it is recommended that vegetation communities are also given a ‘health’ score so that future assessors can see whether there is a trajectory of vegetation community health change within the existing classification system.
    - In this regard, the rapid wetland condition assessment method developed by ForestrySA may provide a useful reference.

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8 APPENDIX A. Habitat Condition Datasheet

Government of South Australia
Department of Environment, Water and Natural Resources

Object ID	
Date	
Observers	

Location	Zone:	Easting:	Northing:
Locality Description (Vegetation/ Topo)			

Site Photos Taken	Yes	No
Photo Number and Direction	Photo Number and Direction	Photo Number and Direction
Photo Number and Direction	Photo Number and Direction	Photo Number and Direction

Wetland Type

DEWNR		**Ramsar**	

Wetland Association

Wetland System	
Marine	Lacustrine
Estuarine	Palustrine
Riverine	

Landform		
Beach	Channel	Cliff
Closed depression	Consolidated dune	Cove
Drainage depression	Dune	Flat
Floodplain	Hill footslope	Interdune corridor
Island	Lagoon	Lake
Mudflat	Open depression	Reef
Ridge	Rocky cliff	Rocky outcrop
Rocky reef	Rocky ridge	Rocky shore
Salt lake	Sand bar	Sandy beach
Shoreline	Stream bank	Stream channel
Undulating plain	Un-vegetated bed sediments	Vegetated bed sediments
Vegetated Island	Other	

Micro relief (up to 2 categories)		
Structural relief	Crabhole	Undulating surface
Hummock	Mounds	Depressions
Terrace	Slopes	Banks

Substrate surface type		
Mud (silt and clay)	Sandy mud	Shelly mud
Shelly sand	Shells	Muddy sand
Sand	Loams	Gravel
Cobbles	Stones	Boulders
Bedrock	Reef	Sand
Sandy loam	Light Clay	Heavy clay

Sediment Size	
Coarse sediment (high sand content 0.02-2.00mm	Fine sediment (low sand content, <0.02mm)

Water regime	
Permanent	Seasonal
Intermittent	Artificially flooded
Temporarily	

Tidal class	
Intertidal	Stranded tidal
Supratidal	Intermittent tidal
No tidal	

Water depth	
Damp	10cm -0.5m
Film	Open water
<3cm	Not present
3-10 cm	

Vegetation Association

Dominate vegetation type	
Forest	Coastal shrubland
Woodland	Sedgeland
Shrubland	Sea grasses
Comments and matching against dominant vegetation association list	

Cover/abundance	
Not many, 1-10 individuals	Any number of individuals covering 25 -50% of the area
Sparsely present, cover very small <5%	Any number of individuals covering 50 -75% of the area
Plentiful, but of small cover <5%	Covering more than 75% of the area
Any number of individuals covering 5 -25% of the area	

Life form		
Trees > 30m	Trees 15 – 30m	Trees 5 – 15m
Trees < 5m	Mallee (>3m)	Low mallee (<3)
Shrubs > 2m	Shrubs 1.5 – 2.0m	Shrubs 1 – 1.5m
Shrubs 0.5 – 1.0m	Shrubs 0 – 0.5m	Mat plants (single plant)
Hummock grass	Grasses > 0.5m	Grass < 0.5m
Herbaceous spp.	Sedges > 0.5m	Sedges < 0.5m
Vines	Mistletoes	Ferns
Mosses, liverworts	Lichens	Aquatic/algae

Microhabitats		
Algae mat	Banks with hollows	Burrows
Detritus	Freshwater soak	Hollows (trees)
Hummocks	Lignum	Molluscs
Mounds	Mud flat	Nesting areas
Open water	Perches	Pooling
Rocky areas	Roosting area	Sandy areas
Sheltered areas	Snags	Structural diversity
Surface aquatics	Undulations	Worm reefs

Aquatic Vegetation		
Algal	Aquatic moss	Unknown submergent
Floating leaved	Rooted floating leaved	Other
Unknown surface	Moss/Lichen	

Fauna

Substrate surface fauna		
Molluscs	Crabs	Worms
Ants	Other insects	Other crustaceans
Opportunistic **(free text – all species):**		

Reliability for opportunistic sightings		
0 – 5m	>50 – 100m	>250 – 500m
0 – 50m	>100 – 250m	>500m – 1km
		>1km – 10km

Recreation		
Bird watching	Boating area	Fishing
Shacks	Other:	

Land Degradation/Disturbance

Access tracks	Altered flow	Clearance
Degraded banks	Degraded buffer	Erosion
Excavated	Fence line	Grazing
Introduced grasses	Introduced plants	Introduced trees
Jetty	Mowing of aquatics	Pest plants
Pest vertebrate presence	Rubbish	Salt intrusion
Sand extraction	Walking tracks	Water extraction
Fire scars	Altered flows	Access road
Boat launch area	Camping sites	Clearance
Cleared buffer	Degraded buffer	Fence lines
Grazing	Introduced grasses	Rubbish
Vertebrate pests	Walking trail	Woody weeds
Comments:		

Habitat Condition

Condition scale	Description
Pristine	Pristine, or nearly so, no obvious signs of disturbance. Indigenous flora dominant and abundant, 100% ground cover. Structural diversity present, if applicable, and microhabitats present. Surrounding ecosystems intact with high connectivity. Habitat integrity is high. Reflects pre-European vegetation.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species limited to 5 – 20% coverage. Diverse species, stable fauna habitat. Structural diversity present, if applicable. Habitat buffered by and linked to remnant vegetation with ecosystem stability.
Very Good	Vegetation structure altered, Indigenous and exotics together, 20-50% weed invasion, obvious signs of disturbance (e.g. disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback and grazing). Core habitat areas exist buffered by remnant vegetation. Obvious signs of use by fauna, areas of structural diversity might exist with some microhabitats.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances (as above). Retains basic vegetation structure or ability to regenerate it (e.g. disturbance to vegetation structure caused by very frequent grazing). Presence of aggressive weeds at high density (50-70%). Core habitat areas exist that are buffered by scattered remnants. Species use of habitats is likely to be opportunistic. Structural diversity limited to isolated patches if all, micro-habitats presence low.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by cropping, grazing or clearance, presence of very aggressive weeds, partial clearing, dieback and grazing damage. Weed presence greater that 70%. Habitats are impacted by disturbances and are not connected with remnant buffers.
Completely degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. Habitats do not exist, although areas might be used as opportunistic habitats or 'stepping stones' to desirable habitat areas. Weed presence aggressive and greater than 80%; monoculture may exist, e.g. pasture.
Comments	

Appendix B. Habitat Measures used by Thiessen in 2010 after Seaman (2003)

Habitat Measures used by Thiessen 2010 after Seaman (2003) and adopted by Billows et.al. (2014)

All information and references in this appendix see Thiessen (2010).

a) Water regime: the four Ramsar categories of permanent, semi-permanent, seasonal and dry were used to define water regime. In 2015 given the focus 'Intermittent' was also used, as had been the case with Seaman (2003), help describe the sites which are intermittently affected by tides or inflows from Salt Creek. During site visits in 2010 and 2014 water levels were determined to measure the change in water regimes.

b) Habitat Condition – Seaman's (2003) six categories of habitat condition that were used to describe sites include: completely degraded, degraded, good, very good, excellent and pristine. Habitat Condition is a subjective assessment based on field observations. During assessment certain ecological values were considered, including hydraulic and habitat connectivity (and the interplay between); cover and abundance of native and introduced species; integrity of vegetation associations and the structure and health and vigour of the vegetation. Full descriptions of these categories are provided by Seaman (2003) and are included in full in Appendix A.

c) Habitat Community Change: Habitat is defined as "the place in which an organism lives, comprising physical structure, such as reef, sediments or water column properties, as well as biological structures, such as the dominant plant types" (p.161) (DEH 2010). Using this definition, a change in habitat can be determined by a change in the vegetation association which is the description of dominant and/or co-dominant overstorey and understorey species within the habitat (based on the survey of Seaman, 2003). The measure of a community change was assessed by comparing the vegetation associations mapped in ArcGIS by Seaman (2003) to the assessed vegetation association observed in 2010.

d) Ramsar wetland types: sites were assessed in relation to the 13 Ramsar wetland classifications, as previously described in Table 1

APPENDIX C. Landform change between 2003 and 2015 over 95 sites in or adjacent to the Coorong National Park

Landform (2003 rows, 2015 column)	Beach	Channel	Closed depression	Consolidated dune	Cove	Dune	Flat	Floodplain	Inter-dune corridor	Lagoon	Mudflat	Open depression	Rocky cliff	Rocky reef	Rocky shore	Salt Lake	Sand bar	Sandy Beach	Shoreline	Un-vegetated bed sediments	Vegetated bed sediments	Vegetated Island	Grand Total
Beach							1													1			2
Channel		2																					2
Closed depression			3													1							4
Consolidated dune			1	3																			4
Cove					2																		2
Dune			1			8															1		10
Flat							1																1
Floodplain			1			1		10	1										1		1		15
Lagoon										1													1
Mud flat					1						6												7
Open depression			5									1				1							7
Reef											1			2									3
Rocky cliff													1										1
Rocky reef														3									3
Rocky ridge													2										2
Rocky shore											1				5								6
Salt lake					1											6							7
Sand bar																	1						1
Sandy beach	1																	1					2
Shoreline																			2				2
Stream channel		1																					1
Vegetated bed sediments			1																5		3		9
Vegetated island																						3	3
Grand Total	1	3	12	3	4	9	2	10	1	1	8	1	3	5	5	8	1	1	8	1	5	3	95

APPENDIX D. CLLMM Raw Data spreadsheet, scanned datasheets and site photographs in digital format (See attached disk).