Peel-Yalgorup Ramsar Littoral & Fringing Vegetation Monitoring: Review

Final Report
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1. Introduction

1.1 Objectives

The Peel-Yalgorup wetland system is designated as a wetland of international importance under the Ramsar Convention. Consistent with the obligations under this convention, an Ecological Character Description (ECD) and Management Plan (MP) have recently been completed for the site.

One of the key recommendations of the ECD and actions in the MP is monitoring of critical components and processes to inform and assess against Limits of Acceptable Change (LAC). A monitoring and evaluation guide forms a part of the MP and details recommended methods and priorities for monitoring at the Ramsar site. Assessing the extent and composition of littoral and fringing vegetation was identified as a priority.

Field based monitoring of littoral and fringing vegetation within the Peel-Yalgorup Ramsar site was undertaken in 2008 (DEC 2008) and 2009 (Smith 2009). However, the methods used did not follow those recommended in the monitoring and evaluation guide, but rather were based on the methods of Monks and Gibson (2000). Concern was raised in the 2009 report about the appropriateness of the method to meet the objectives of the program with respect to detecting change in ecological character.

This report provides a critical review of recent littoral and fringing vegetation monitoring within the Peel-Yalgorup Ramsar site. The specific objectives of the project (as provided in the brief from the Peel Harvey Catchment Council) are to:

- review baseline information, collected in 2008 and 2009, about condition and extent of habitat types;
- provide a comparison with previous vegetation studies available for the Peel-Yalgorup Ramsar System;
- assesses the appropriateness of the monitoring undertaken to date in establishing a baseline, or determining change in, the ecological character of fringing and littoral vegetation in the Peel-Yalgorup Ramsar System; and
- recommend an appropriate, detailed methodology for future fringing and vegetation monitoring to determine change in ecological character.

1.2 Peel-Yalgorup Ramsar site

The Peel-Yalgorup Ramsar site comprises the Peel-Harvey Estuary, the Yalgorup Lakes and Lakes McLarty and Mealup in southwest Western Australia. In addition to the officially designated Ramsar site, the ECD, MP and the littoral vegetation monitoring includes Lakes Goegrup and Black, which are planned as extensions to the site in the near future (Hale and Butcher 2007; Figure 1).

Littoral or fringing vegetation was identified in the ECD as a critical component of the Peel-Yalgorup Ramsar site for the Peel-Harvey Estuary and Lakes McLarty and Mealup (Hale and Butcher 2007). The saltmarsh at the Yalgorup Lakes occurs in a narrow band and was not considered to be as critical to the ecological character of the site as the more extensive areas around the Peel-Harvey Estuary (Peel Harvey Catchment Council in prep.). A summary of the dominant littoral vegetation components at each of the areas in the study area is provided in Table 1. For a full description, refer to the ECD (Hale and Butcher 2007).

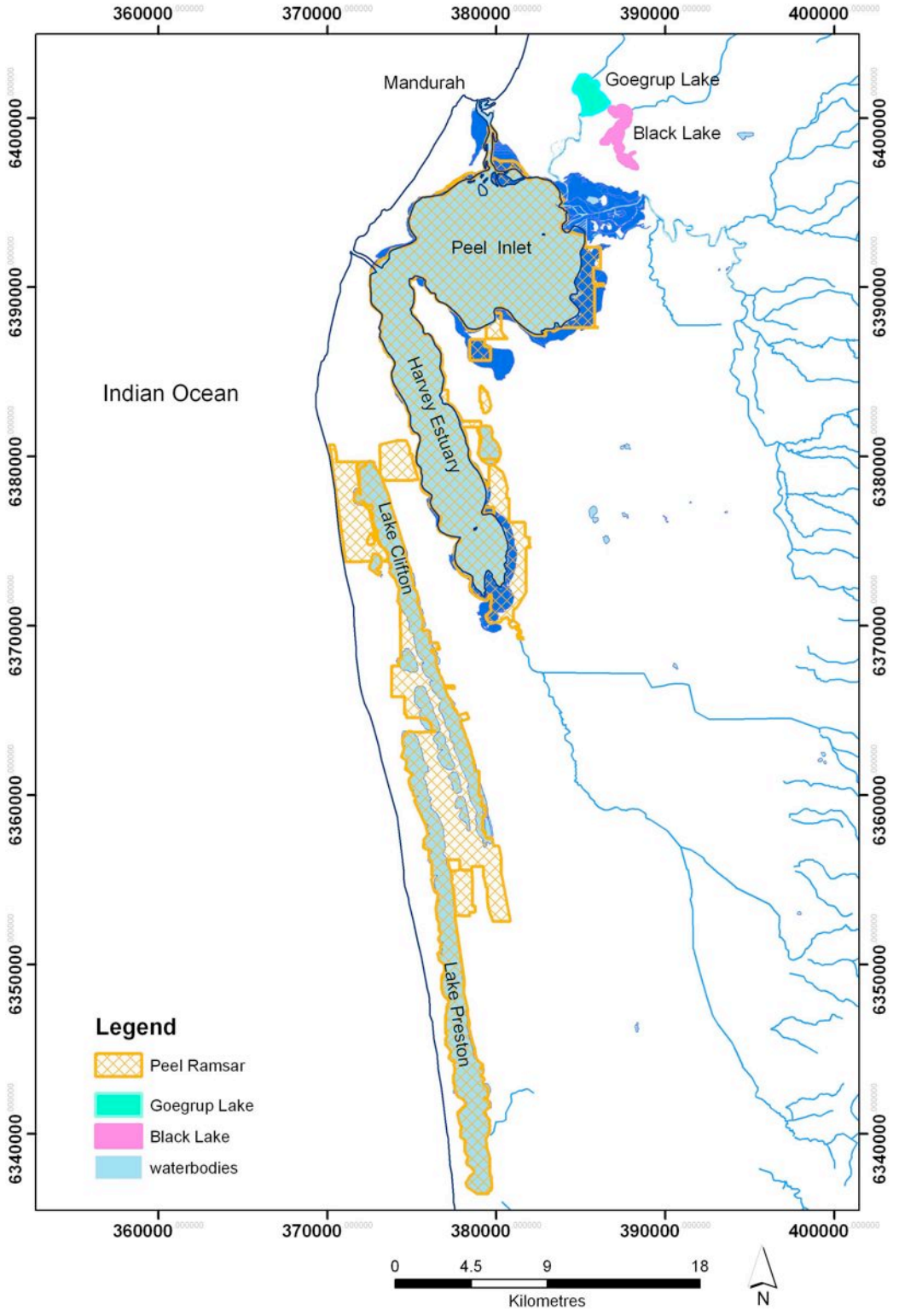

Figure 1: Peel-Yalgorup Ramsar site.

Table 1: Summary description of littoral and fringing vegetation in the study area (adapted from Hale and Butcher 2007).

Location	Critical component	Description
Peel-Harvey Estuary	Saltmarsh	Fringing the Peel Inlet and parts of the Harvey Estuary within the intertidal zone. Dominated by Samphire (*Sarcocornia quinqueflora*) with *Juncus kraussii* at higher elevations.
	Paperbark	On the landward edge of saltmarsh, Saltwater Paperbark *(Melaleuca cuticularis*) and other salt tolerant trees form a narrow band.
		Along the inflowing Harvey River, within the Ramsar site, freshwater riparian vegetation occurs, dominated by Swamp Paperbark (*Melaleuca rhaphiophylla*).
Yalgorup Lakes	Saltmarsh	Small areas around some of the lakes (data deficient).
	Paperbark	Paperbark Swamp dominated by *Melaleuca cuticularis* and *Melaleuca rhaphiophylla,* occurs around the edges of the lakes in a narrow band.
Lakes McLarty and Mealup	Freshwater emergent vegetation	*Typha* spp. and freshwater sedges were once dominant across large areas of Lake McLarty and Mealup
	Saltmarsh	Saltmarsh communities dominated by *Juncus kraussi* have replaced freshwater littoral vegetation at Lake Mealup.
	Paperbark	On the landward extent of the margins of the lakes, where inundation is less frequent, stands of *Mealueca raphiophylla* and *M. preissiana* occur.
Lakes Goegrup and Black	Saltmarsh	Samphire (*Sarcocornia quinqueflora*) at lowest elevations around lakes.
	Paperbark	Two communities – Saltwater Paperpark behind saltmarsh and freshwater paperbark at higher elevations.

1.3 Limits of Acceptable Change

The act of designating a wetland as a Ramsar site carries with it certain obligations, including managing the site to retain its 'ecological character' and to have procedures in place to detect if any threatening processes are likely to, or have altered the 'ecological character'. Central to this is the development of an ECD, which provides a detailed description of the site and sets Limits of Acceptable Change (LAC). LAC are defined as the variation within specific ecosystem components and processes that are considered acceptable for maintaining the ecological character of the site (Phillips 2006).

Most often, LAC are written for the point in time at which a site was designated as a Wetland of International Importance under the Ramsar Convention (DEWHA 2008). This was 1990 for the Peel-Yalgorup Ramsar site and current conditions for the proposed extension to include Lakes Goegrup and Black. However, the opening of the Dawesville Channel in 1994 (four years after the sites was designated under the Convention) resulted in an irreversible change in character due to increased tidal flushing. As a consequence, the LAC for this area within the Ramsar site were written to reflect the new established baseline post Dawesville Channel opening (Hale and Butcher 2007).

The ECD for the Peel-Yalgorup Ramsar site (Hale and Butcher 2007) contains a number of LAC that are relevant to the littoral and fringing vegetation (Table 2). Those related to vegetation extent are assessed by the Littoral and Fringing Vegetation Mapping Program, for which a remote sensing assessment was conducted in 2008 (Hale and Kobryn 2009). The LAC related to vegetation community health and composition are relevant to the field based vegetation monitoring that forms the basis of this review.

Table 2: LAC relevant to the fringing and littoral vegetation in the study area (Peel-Harvey Catchment Council in prep).

Location / Component	Baseline / Supporting Evidence	Limit of Acceptable Change
Peel-Yalgorup / Samphire and Paperbark	Current extent and health of samphire and paperbark communities unknown	Baseline must be set before limits can be made.
Lakes McLarty and Mealup / Littoral vegetation	Dominated by freshwater reeds, but encroachment of *Typha* sited as a problem at both wetlands. Sedges are an important habitat component for some waterbirds	*Typha* limited to < 20 % of the wetland area Freshwater sedges covering a minimum of 20% of the wetland area
Lakes McLarty and Mealup / Paperbark	Fringing freshwater paperbark community which is an important habitat for waterbirds No quantitative information	No decline in paperbark health No net loss of extent of paperbark community.
Lakes Goegrup and Black / Samphire	Approximately 83 hectares when mapped in 2006. However, there is no information on the natural variability in this community	Extent and distribution of samphire within patterns of natural variation.
Lakes Goegrup and Black / Paperbark	Fringing areas of both freshwater (47 ha) and saltwater paperbark (145 ha) communities. These perennial woody vegetation complexes would have low natural variability in extent	No change in the condition of paperbark communities. No loss of extent of paperbark communities.

It should be noted that there has been a shift in philosophy of LAC from the Australian Government since the ECD for the Peel-Yalgorup Ramsar site was written. LAC within the ECD (Hale and Butcher 2007) were designed to enable trends in components and processes to be detected with sufficient time to instigate management actions to prevent an irrevocable change in ecological character. These types of limits are now termed “management triggers” with an exceedence resulting in increased investigation and / or on ground activities to prevent a change in ecological character from occurring. LAC are now considered as the “line in the sand” at which a change in character is deemed to have occurred. An exceedence of a LAC may trigger an investigation into the causes and to determine whether the change in character needs to be reported to the Ramsar Convention. This change in the way that LAC are viewed means that most of the LAC within the Peel-Yalgorup ECD have been set at a level too low (i.e. at a point before a change in character would be considered to have occurred). This must be considered when assessing monitoring data against LAC for this site and in the use of data to refine LAC.

3. Assessment of current and historical data

The baseline for assessing change in character at the Peel-Yalgorup Ramsar site is conditions post opening of the Dawesville Channel (1994). Therefore an assessment of historical monitoring data against current data collected in 2008 (DEC 2008) and 2009 (Smith 2009) serves two purposes:

1. To compare current vegetation species composition and condition with the 1994 baseline to determine any changes to ecological character at the site; and
2. To determine if the monitoring methodology is adequate for this purpose.

3.1 Comparison of the current and historical methods

3.1.1 General method

McComb et al. 1995 (Murray et al. 1009a and b)
An extensive investigation into the samphire marshes of the Peel-Harvey Estuary was conducted in 1994 (McComb et al. 1995). Studies included (among others) saltmarsh extent (Glasson et al. 1995); composition (Murray et al. 1995a); and water regime (Murray et al. 1995b). The field based methods involved monitoring at 10 locations within the Peel-Harvey Estuary. At each of these locations, species composition was determined by measuring cover of species in quadrat based sampling, and the water regime of different saltmarsh communities investigated along transects. Water regime investigations involved recording elevation and species present at 10 centimetre intervals along the transect from lower elevations permanently inundated to higher elevations periodically inundated. Sampling was conducted in spring and autumn of 1994.

Monks and Gibson 2000
A series of studies was established in 1994 after the opening of the Dawesville Channel to monitor changes in fringing vegetation in the Peel-Harvey Estuary. This involved annual monitoring of saltmarsh at six locations, freshwater vegetation in a small wetland near Austin Bay, and riverine vegetation at 10 locations in the Harvey River.

The method was based on the transect method developed by Murray et al. (1995b). Permanent transects were established at each location perpendicular to the shoreline from the water's edge to upland terrestrial vegetation. Point intercepts of plant species in all vegetation layers (canopy, understorey and ground storey) were recorded at 10 centimetre intervals. Elevation was recorded at 50 centimetre intervals for the seaward 20 metres of each transect.

Calvert 2002
Fringing vegetation of the Peel-Harvey Estuary was assessed at 10 locations in 2001 as part of an Honours project. Transects were established at each location from the water's edge to the start of terrestrial vegetation. Soil, elevation and flora species present were recorded at 10 points, evenly spaced along each transect.

DEC 2008 and Smith 2009
Monitoring of fringing vegetation was undertaken in 2008 and 2009 at eighteen locations within the Peel-Yalgorup Ramsar site. At each location a transect from the water's edge to the beginning of terrestrial vegetation was established. Transects were permanently marked at the start and end point. Point intercepts of all vegetation layers were recorded at 50 centimetre intervals.

3.1.1 Monitoring locations

Historical quantitative data on fringing vegetation is limited to the Peel-Harvey Estuary and Lake Goegrup. The recent monitoring conducted in 2008 and 2009 was the only data that could be found for other areas within the Ramsar site such as the Yalgorup Lakes and Lakes McLarty and Mealup.

Despite the relative intensity of sampling in the Peel-Harvey Estuary, there is little overlap in the monitoring locations between the recent studies and historical studies (Figure 2). Current

(2008 / 2009) monitoring locations are similar to just three sites sampled by Monks and Gibson (2000) and an additional three sites from Murray et al. (1995a and b; Table 3).

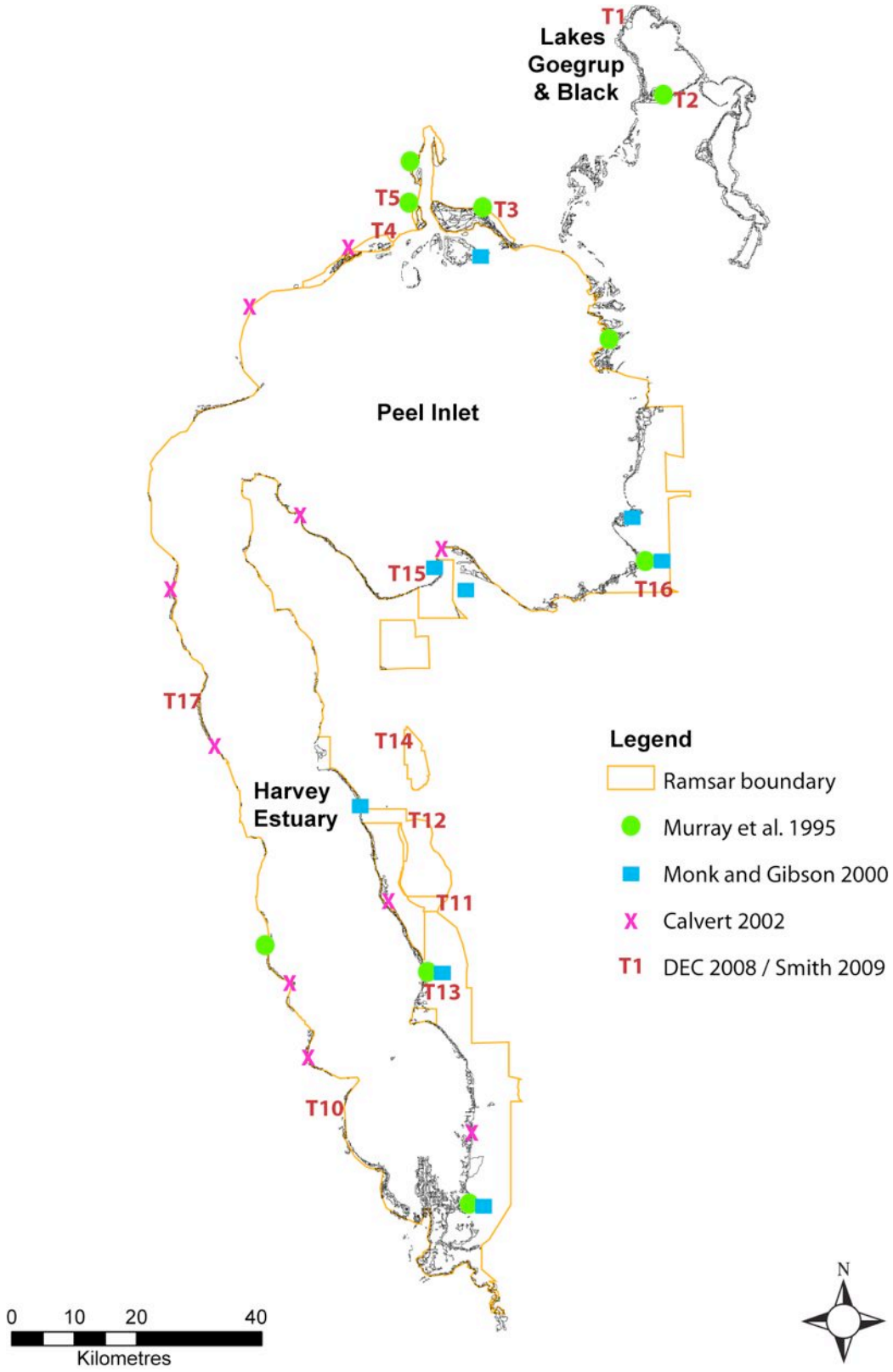

Figure 2: Location of littoral and fringing vegetation monitoring sites in the Peel-Harvey Estuary. Note that locations are approximate and sites that closely align and shown adjacent for clarity.

Table 3: Historical sites corresponding to recent (2008 and 12009) vegetation monitoring.

2008 / 2009 sites	Monks and Gibson (2000) sites	Murray et al. (1995a and b) sites
T2 Goegrup south		Site 2
T3 Creery wetland		Ste 5
T5 Samphire Cove		Site 4
T13 Kooljerrenup	North Kooljerrenup	Site 9
T15 Carrabungup	Carrabungup	
T16 Austin Bay Sth	Austin Bay B	

3.2 Results

Where possible, available data and information have been used to compare littoral vegetation community composition within the Peel-Yalgorup Ramsar site (and Lakes Goegrup and Black). However, analysis of results between studies was compounded not only by different methods, but also the fact that the raw data from Murray et al. (1995 a and b) could not be sourced.

3.2.1 Peel-Harvey Estuary

There are four locations within the Peel Harvey Estuary where there is information available from both recent and historical sites: Creery Wetlands, Austin Bay, Carrabungup and Kooljerrenup. Note that although there was a monitoring location in Samphire Cove in Murray et al. (1995a and b) there was no data or information presented in the report for this site in the historical study.

Creery Wetlands

Transect T3 from the 2008 and 2009 surveys aligns approximately with site 5 from Murray et al. (1995a). Although Monks and Gibson (2000) monitored vegetation at Creery from 1994 to 1998, their site was located on Creery Island rather than the main shoreline. The conditions at Creery Island with respect to tide and wave action are considerably different to those on the more sheltered shoreline and so vegetation data collected from the two locations are not considered comparable.

The point intercept data from the vegetation transect surveyed in 1994 is not available. However, the percentage cover of dominant saltmarsh species collected from 1 metre square quadrats was presented in the report (Murray et al. 1995a). The same five species of saltmarsh that were dominant in 1994 were also dominant in 2008 and 2009 (Table 4). In spite of this, given the markedly different sampling techniques, a quantitative comparison of cover of each species is not possible.

Table 4: Percentage cover of dominant species recorded in vegetation transects at Creery Wetlands. Note that the sampling method varied from 1994 to 2008 / 2009 and quantitative comparisons between these surveys may not reflect true changes in species composition.

Species	1994 cover (Murray et al. 1995a)	2008 cover (DEC 2008)	2009 cover (Smith 2009)
Sarcocornia quinqueflora	17	15	14
Tecticornia[1] *halocnemoides*	27	13	8
Tecticornia indica	30	22	9
Frankenia pauciflora	6	21	20
Casuarina obesa	Not reported	28	20
Bare ground	20	6	7

The 2008 and 2009 surveys also recorded significant cover of *Casuarine obesa*, which was not present in the 1994 survey. The absence of replicate samples within each of the surveys prevents any consideration of spatial variability. Therefore it is not known if *Casuarina obesa*

[1] Note taxonomic reviews of saltmarsh species have resulted in all members of the genus Halosarcia being incorporated into the genus Tecticornia.

was present in adjacent areas in 1994 or its distribution and / or extent has increased since that time.

Austin Bay

Transect 16 from the 2008 and 2009 surveys corresponds approximately with the "Austin Bay A" transect of Monks and Gibson (2000). Twenty-six species were recorded at this site from 1994 to 1998, only 12 of which were native. The 2008 / 2009 surveys recorded 20 species, of which 11 were native. Lower species numbers are expected in the 2008 / 2009 surveys as the sample density is five times lower than that in the 1990s.

In 1994 the vegetation was dominated by the introduced species *Lolium rigidum*, which declined from 27 % cover in 1994 to 11 % in 1998 and the native samphire species *Tecticornia halocnemoides* which also declined from 27 % in 1994 to 12 % in 1998 (Monks and Gibson 2000). Both of these species were present in the 2008 and 2009 surveys, but the introduced Lolium was recorded in trace amounts only, and the samphire at 10% cover (Table 5). Extensive algal mat coverage was recorded in all years from 1994 to 1998, but was very low by comparison in 2008 and 2009. The transect in 2008 and 2009 was dominated by *Casuarina obesa* and *Tecticornia indica*, both of which were recorded in the 1990s surveys, but in lower amounts.

Table 5: Percentage cover of dominant species recorded in vegetation transects at Austin Bay.

Species	Monks and Gibson (2000)					DEC	Smith
Year	1994	1995	1996	1997	1998	2008	2009
Casuarina obesa	5	5	6	5	4	16	13
* *Lolium rigidum*	27	26	22	21	11	2	0.5
Sarcocornia quinqueflora	11	11	4	7	3	6	4
Tecticornia halocnemoides	27	26	20	24	12	10	10
Tecticornia indica	2	2	2	4	4	27	22
Algal mat	32	24	34	32	36	5	7
Litter				0.5	1	10	37
Bare ground	0.5	14	14	6	6	11	7

The results at this site are somewhat consistent with predictions of the effect of the opening of the Dawesville Channel, which was predicted to decrease algal coverage in the Peel Inlet and Murray et al. (1995b) predicted a decline in *Tecticornia halocnemoides* and Sarcocornia quinqueflora and an increase in *Tecticornia indica*. However, a decline in *Casuarina obesa* was also predicted by Murray et al. (1995b), which is the opposite of the pattern observed in the data. However, the lack of replicate samples prevents any form of statistical analysis and it is not possible to determine if the differences between the 1990s surveys and the 2008 / 2009 monitoring are the result of changes in species composition or reflecting spatial variability.

The permanent transect 1994 to 1998 was 140 metres long from the water's edge to the terrestrial vegetation. By comparison, the 2008 / 2009 transect is just 104 metres in length. Whether this is the result of different transect placement (note the different bearings) or reflecting a narrowing of the littoral zone, since the opening of the Dawesville Channel is not known. The images Figure 3 and Figure 4 however, show an extensive flat littoral zone in 1994, with the Casuarina trees in the distance at the end of the transect. The 2009 image shows the beginning of the transect just metres from a relatively sharp rise in elevation.

Figure 3: Transect A at Austin Bay 1994 looking east from the water's edge to transect end (Monks and Gibson 2000).

Figure 4: Transect 16 Austin Bay 2009, looking northeast from the waters edge towards the end of transect (Smith 2009).

Carrabungup

Transect 15 from the 2008 and 2009 surveys roughly aligns with that of the Carrabungup transects A and B of Monks and Gibson (2000). Forty-eight species were recorded from 1994 to 1998 at this site, twenty-five of which were native. This is compared with only twenty species in 2008 / 2009, of which seventeen were native. Again these figures perhaps reflect the different sampling density in the two studies, rather than a decline in species richness.

Dominant species during the 1990s surveys varied between the two sites, highlighting high spatial variability (Table 6). However *Juncus kraussii* and *Sarcocornia quinqueflora* were both present in relatively high abundance in both transect A and B. *Juncus krausssii* was not present at all in the 2008 and 2009 surveys, which were dominated by algal mat, litter and the sedge *Baumea juncea*. Given the high spatial variability indicated by the two transects of Monks and Gibson (2000) it is unknown whether the differences between the 1990s results and more recent surveys is a result in a change in vegetation or different transect alignments.

Table 6: Percentage cover of dominant species recorded in vegetation transects at Carrabungup. Note that Monks and Gibson (2000) surveyed two transects at this site A and B.

Species	**Monks and Gibson (2000)**										**DEC**	**Smith**
Year	**1994**		**1995**		**1996**		**1997**		**1998**		**2008**	**2009**
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**		
Juncus kraussii	62	27	64	32	56	38	59	36	50	33	Not recorded	
Sarcocornia quinqueflora	22	42	25	41	23	32	22	36	22	33	23	21
Melaleuca acerosa	17	1	10	1	10	1	10	1	10	1	Not recorded	
Casuarina obesa	0	18	0	18	1	15	1	18	0	18	7	3
Baumea juncea	Not recorded										14	10
Algal mat	1	25	1	30	5	38	5	38	0	34	6	23
Litter	0	0	2	0	6	0	2	0	2	0	28	32
Bare ground	4	0	5	3	5	0	5	0	8	0	8	20

Photographs from the 1990s surveys (Figure 5) and 2008 / 2009 surveys (Figure 6) show similar vegetation distributions. Although the 1990s (transect B in particular) indicates a greater extension of low lying frequently inundated saltmarsh than the more recent photographs.

Figure 5: Transect A (top) and B (bottom) at Carrabungup 1994 looking east from the water's edge to transect end (Monks and Gibson 2000).

Figure 6: Transect 15 Carrabungup 2008, looking east from the waters edge towards the end of transect (Smith 2009).

Kooljerrenup

Transect 13 from the 2008 and 2009 surveys is in a similar location to the North Kooljerrenup transects A and B reported by Monks and Gibson (2000). Thirty-seven species of plant were recorded during the 1990s surveys, 22 of which were native. This is compared with 33 species in 2008 / 2009, 32 of which were native.

In the 1990s, the littoral vegetation community at this site was dominated by *Sarcocornia quinqueflora* and *Juncus kraussi*, the latter of which declined significantly from 1994 to 1998 (Table 7). *Sarcocornia quinqueflora* was still present and dominant in 2008 and 2009, but in much lower abundance. The data also indicate a possible decline in *Melaleuca cuticularis* and *Suaeda australis* and a corresponding increase in *Melaleuca pauciflora* and *Schoenus subfascicularis*.

Table 7: Percentage cover of dominant species recorded in vegetation transects at Kooljerrenup. Note that Monks and Gibson surveyed two transects at this site A and B.

Species	Monks and Gibson (2000)										DEC	Smith
Year	1994		1995		1996		1997		1998		2008	2009
	A	B	A	B	A	B	A	B	A	B		
Juncus kraussii	21	21	7	5	11	11	11	17	13	17	6	8
Sarcocornia quinqueflora	42	37	31	34	23	49	37	73	50	81	17	13
Suaeda australis	2	21	3	6	4	6	6	4	1	3	1	1
Melaleuca cuticularis	5	14	0	2	0	6	0	6	0	6	4	1
Melaleuca pauciflora	Not recorded										7	5
Schoenus subfascicularis	Not recorded										17	2
Algal mat	7	1	21	1	45	1	45	14	29	23	2	3
Litter	1	0	3	5	0	0	0	0	2	1	16	10
Bare ground	9	1	32	16	11	16	5	0	5	1	19	14

Murray et al. (1995b) predicted a decline in *Melaleuca cuticularis, Sarcocornia quinqueflora* and *Suaeda australis* following the opening of the Dawesville Channel, but an increase in *Juncus kraussii*. However, with no objective measure of spatial variability it is not possible to

know if the changes in species cover are real or an artefact of the sampling program. The transect photos from the 1990s (Figure 7) and 2008 / 2009 (Figure 8) illustrate the patchiness of the distribution of saltmarsh plants (particularly the *Sarcocornia quinqueflora* in the foreground of Transect A). It would be very easy to obtain different results with a slight realignment of the transect tape.

Figure 7: Transect A (top) and B (bottom) at Kooljerrenup 1996 looking east from the water's edge to transect end (Monks and Gibson 2000).

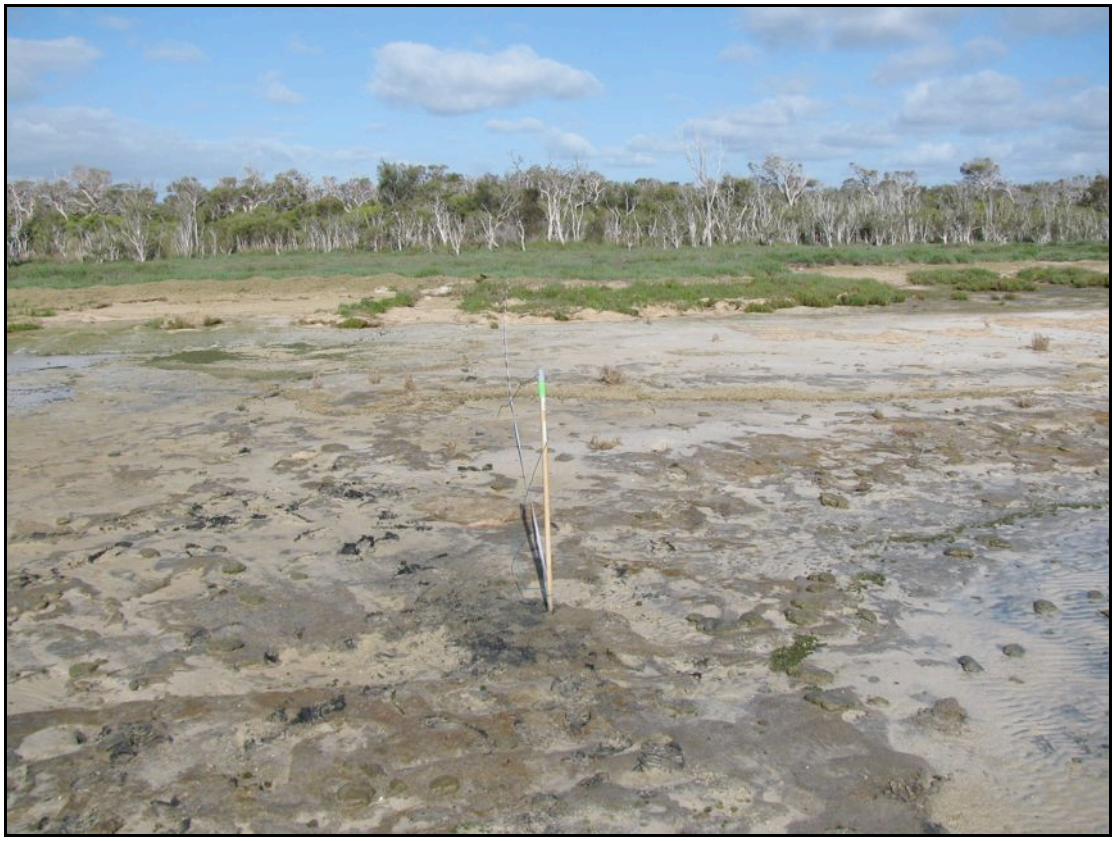

Figure 8: Transect 13 Kooljerrenup 2009, looking east from the waters edge towards the end of transect (Smith 2009).

3.2.2 Other locations within the Peel-Yalgorup Ramsar site

The only other location within the study area (if not yet the Ramsar site) with historical monitoring at a similar location to recent monitoring is Lake Goegrup, for which a single site was surveyed in 1994 by Murray et al. (1995 a and b). However, the data for this site was not presented in the report and could not be sourced.

4. Monitoring methods

4.1 Limitations of current method

The monitoring and evaluation guide within the Peel-Yalgorup Management Plan recommended a method for the monitoring of littoral and fringing vegetation. The field component called for the establishment of permanent transects extending from terrestrial vegetation to the water's edge at Lakes McLarty and Mealup, Lakes Goegrup and Black and in the Peel-Harvey Estuary. Monitoring was to follow the method of Murray et al. (1995b). That is, transects should be stratified into zones of similar vegetation in each zone percentage cover of each species should be recorded in five random quadrats (1m x 1m). The 2008 vegetation monitoring (DEC 2008) did not follow this method, but rather, followed that of Monks and Gibson (2000), with point intercepts along a transect at 18 sites including Lakes McLarty and Mealup, Lakes Goegrup and Black, the Peel-Harvey Estuary and the Yalgorup Lakes. The 2009 monitoring (Smith 2009) replicated that of the 2008 survey.

The objective of the littoral and fringing vegetation monitoring program (Peel Harvey Catchment Council, in prep.):

- To determine the extent and composition of littoral vegetation and paperbark communities at Lakes McLarty and Mealup to set a baseline against which change can be assessed;
- To determine the extent and composition of samphire and paperbark communities fringing the Peel Harvey Estuary to set a baseline against which change can be assessed; and
- To monitor the extent and composition of samphire and paperbark communities at Lakes Goegrup and Black to assess against LAC.

The major limitation of the current vegetation monitoring method, with respect to meeting the objectives, is the lack of spatial replicates, which prevents the use of statistics to assess change in vegetation community composition and cover. Comparative statistics (such as t-tests and ANOVAs) are used to answer the question "is there a significant difference between the means?" from two sets of samples. Essentially, the question becomes "is the variability within a sample greater than the variability between samples?" In order to perform these analyses replicate samples are required for each site at each point in time. Without replicate samples, there is no way of determining significant change.

In addition, the point intercept method used during 2008 and 2009 does not adequately assess vegetation cover, nor does it distinguish different vegetation communities. Meaningful comparisons between years are difficult as the position of the tape and transect strongly influence the species recorded (at 50 centimetre intervals); making it impossible to determine if any differences observed in the data are due to variability in sampling or actual change in vegetation. Monks and Gibson (2000) could find no consistent change in littoral and fringing vegetation in the Peel-Harvey Estuary from 1994 to 1998 following the opening of the Dawesville Channel, despite annual surveys at 6 paired transect locations. It is likely that the method selected for monitoring hindered the determination of vegetation patterns over time.

Smith (2009) also suggested that the 2008 / 2009 method did not allow for the detection of rare species. However, this is not part of the objectives of the program, which is focussed on ecological character and change in character, rather than species richness or presence of rare species.

Finally, the inclusion of four sites at Yalgorup Lakes for the 2008 and 2009 surveys, while informative, is not necessary to meeting the objectives of the program.

4.2 Recommended future monitoring method

To meet the objectives of the littoral and fringing vegetation monitoring program, it is recommended that the original quadrat based sampling be instigated. This will allow for more meaningful assessments of vegetation condition and community composition and allow for statistical comparisons of data collected over time. It is acknowledge that the quadrat based

sampling will incur additional costs. However, sampling frequency is recommended at 3 to 5 year intervals and the costs could be mitigated by undertaking sampling at a sub-set of sites each year on a rotational basis (with resulting efficiencies in travel and set up costs). In addition, the vegetation at the Yalgorup Lakes is not critical to the program and could be sacrificed if resources dictate.

The key aspects of the recommended monitoring method are presented below.

4.2.1 Monitoring locations

Field assessment will be based on available resources. A suggested filed schedule is provided with priority assigned to each location (Table 8).

Table 8: Suggested field schedule and priority for vegetation monitoring sites

Site (DEC 2008)	Location	Schedule	Priority
T1	Lake Goegrup North	Year 3	Medium – not yet part of Ramsar site
T2	Lake Goegrup South	Year 3	Medium – not yet part of Ramsar site
T3	Creery Wetland	Year 3	High
T4	Len Howard Reserve	Year 3	High
T5	Samphire Cove	Year 3	High
T6	Lake Preston West	Year 4	Low – not part of objectives
T7	Lake Preston East	Year 4	Low – not part of objectives
T8	Lake Clifton Nth of boardwalk	Year 4	Low – not part of objectives
T9	Lake Clifton Sth of boardwalk	Year 4	Low – not part of objectives
T10	Island Point Sth	Year 1	High
T11	Lake McLarty Sth	Year 2	High
T12	Lake McLarty Nth	Year 2	High
T13	Kooljerrenup	Year 2	High
T14	Lake Mealup	Year 2	High
T15	Carrabungup	Year 1	High
T16	Austin Bay Sth	Year 1	High
T17	Warrungup Spring	Year 1	High
T18	Black Lake	Year 3	Medium – not yet part of Ramsar site

4.2.2 Materials and equipment

A map of the monitoring locations with the position of previous transects is prepared and printed.

GPS and digital camera are required for field assessments (see below). Both are checked to ensure proper functioning and sufficient battery power. The coordinates for each of the monitoring transects are loaded into the GPS.

The following equipment and materials are required for field sampling and should be placed in the appropriate vehicle prior to departure:

- Copy of method
- Maps of sites
- GPS with spare batteries
- Digital camera and spare batteries
- Measuring tape (minimum 20m)
- Flagging tape
- Field assessment sheets
- Clipboards, pens, pencils
- Specimen bags and labels
- First aid kit
- Sunscreen

4.2.3 In the field

The following procedures are undertaken at each sampling location. Note that the order in which quadrats are assessed is dependent on the tide, with those at lower elevations completed when low tide occurs on the sampling day (to minimise damage to inundated vegetation communities).

Quadrats (1 x 1 metre) are located along transects that run perpendicular to the shoreline, through the zones of littoral and fringing vegetation (from deep water to shallow water zones). Transects were established during the 2008 assessment (DEC 2008) and as far as practicable, repeat monitoring occurs within the same transect locations (although quadrat placement can vary). A minimum of five quadrats should be randomly placed within each distinct vegetation community (based on visual assessment of dominant species). Typically this may include (as described my Murray et al. 1995a):

- *Juncus kraussi* sedgeland,
- *Tecticornia halocnemoides* dominated samphire,
- *Tecticornia indica* dominated samphire,
- *Sarcicornia quinqueflora* dominated samphire,
- Freshwater vegetation; and
- Tree dominated vegetation (Melaleuca or Casuarina).

The position of each 1 x 1 metre quadrat is determined using the GPS (GDA94) and coordinates of the centre of the quadrat are recorded. A photo-point of each end of the transect should be taken (as per DEC 2008 and Smith 2009).

The projected foliage cover (Figure 9) of each plant species within each quadrat is recorded as:

- 1% - "trace" records, where only a few individuals are present within the quadrat and total < $1m^2$
- All other estimates recorded to nearest 5%

Only record "live" species, but this should include those that are senescing, but not yet dead

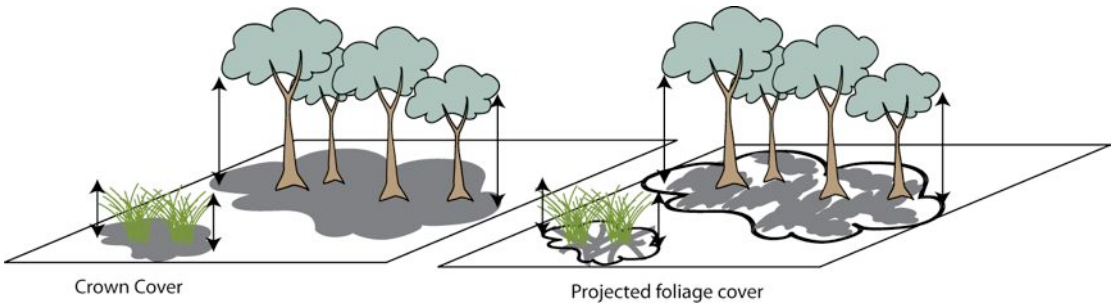

Figure 9: Example of crown cover (left) NOT recommended for this monitoring program and "projected foliage cover" (right) recommended for use in this monitoring program (Hale et al. 2009).

In the event that a species cannot be identified in the field, the smallest practical sample of the specimen is collected. Specimen is labelled with site, date and quadrat. In the event that the plant cannot be identified with the aid of the appropriate keys of guides, a full description is made and stored for future reference.

The percentage cover (to the nearest 5%) is recorded for bare ground and litter (bark, leaves and twigs on ground).

4.2.4 Data analysis

Species cover data from each quadrat should be analysed with an appropriate multivariate statistical technique (e.g. Principal Component Analysis, Non-agglomerative Hierarchical Clustering) to distinguish vegetation communities at each location for subsequent analysis.

Vegetation communities from the same location can be compared over time with an appropriate statistical technique (e.g. Analysis of Variance; ANOVA) to determine changes over time with respect to cover and species composition.

Note: If the data from Murray et al. (1995b) could be sourced this may form a baseline against which change could be measured at a number of sites in the Peel-Harvey Estuary and Lakes Goegrup and Black.

5. References

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