Cryptic and colonial-nesting waterbirds in the Coorong, Lower Lakes and Murray Mouth: distribution, abundance and habitat associations 2013

Jody A O'Connor
Department of Environment, Water and Natural Resources

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Department of Environment, Water and Natural Resources

GPO Box 1047, Adelaide SA 5001

Telephone National (08) 8463 6946

International +61 8 8463 6946

Fax National (08) 8463 6999

International +61 8 8463 6999

Website www.environment.sa.gov.au

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Summary

This report presents the results of targeted waterbird surveys in the Coorong, Lower Lakes and Murray Mouth (CLLMM) region. The aim of these surveys was to improve our understanding regarding the spatial and temporal distribution of:

- Waterbirds that are dependent on emergent fringing vegetation (referred to as 'cryptic' species as most are difficult to detect)
- Colonial-nesting waterbirds.

The results of these surveys complement existing, general waterbird surveys that have been undertaken in the CLLMM since the mid-1980s, but that have not been specifically designed to comprehensively determine the distribution and abundance of these more specialist groups of birds.

This report presents the results of targeted surveys undertaken in spring and summer 2013–14, the second time that these surveys have been undertaken (the first having been undertaken in 2012–13). The key findings of this current survey are:

1. For cryptic waterbirds, slightly fewer individuals were recorded across all species in 2013–14 than in 2012–13. However, only one species recorded in 2012–13 was not recorded in 2013–14 (Australian Little Bittern)
2. The relationship between the distribution of cryptic waterbird species and habitat attributes of each survey site reinforced those patterns detected in 2012–13, further strengthening our understanding of the habitat requirements of these otherwise poorly known species
3. For colonial nesting waterbirds, the number of nests recorded for the dominant breeding species in the Coorong (Australian Pelican and Crested Tern) were lower in 2013–14 than 2012–13 (although survey effort was also lower in 2013–14). However the number of nests recorded for the dominant breeding species in the Lower Lakes (Australian White Ibis and Straw-necked Ibis) were higher in 2013–14 than in 2012–13
4. While there was some overlap in the spatial distribution of colonial waterbird breeding sites between 2012–13 and 2013–14, waterbird breeding was also recorded at two new sites in 2013–14.

Introduction

The Coorong and Lakes Alexandrina and Albert Wetland is internationally recognised as a Wetland of International Significance under the Ramsar Convention. A major reason for this recognition is the importance of the site for waterbirds (Eckert 2000; Phillips and Muller 2006; Rogers and Paton 2009). The diversity of wetland habitats within the Coorong and Lakes regularly support >200 000 individual waterbirds every summer, and act as an important drought refuge for many of South Australia's wetland bird populations (Paton 2010).

Our strong understanding of the ecology of some aspects of the Coorong and Lake's waterbird communities comes largely from a series of long-term waterbird monitoring programs. Most significantly, these monitoring programs have informed our understanding of how waterbird populations respond to environmental change in the CLLMM, particularly in relation to changes in water regime. However, the general nature of these monitoring programs has meant that they do not provide a strong understanding of a number of highly specialist species that are strongly associated with emergent fringing aquatic vegetation (e.g. reedbeds). Furthermore, while these monitoring programs provide excellent information regarding the abundance and distribution of most species, they don't provide complete coverage of particular breeding habitats. Both comprehensive waterbird breeding surveys, and surveys of specialist reed-dependent birds, require targeted survey effort that complement the more general surveys that currently occur.

In 2012, the South Australian Department of Environment, Water and Natural Resources (DEWNR) addressed the need for targeted surveys, by undertaking an initial survey through the CLLMM Recovery Program. Targeted surveys for these aspects of CLLMM bird communities were the focus of a two-year program. The results of this initial survey were presented in O'Connor et al. (2013). The present report presents the results of a repeat of these surveys undertaken in 2013. The aims of the survey were:

1. Improve the existing dataset for reed-dependent waterbirds and breeding waterbirds within the CLLMM wetland system
2. Compare the results of surveys performed in the 2012 and 2013 seasons, and relate the observed differences to changes in the wetlands' hydrology and other environmental conditions.

The results presented here and in O'Connor et al. 2013 will contribute to an updated Ecological Character Description report for the site (DEWNR, in prep).

Methodology

Cryptic waterbirds

Study sites

This study was conducted at 15 wetland sites around the edges of Lakes Alexandrina, Albert and their tributaries (Figure 1). Two rectangular 2 ha plots were sampled at each of the 15 study sites, (2 ha plots were chosen based on the standard BirdLife Australia sampling method). All plots included wetland edges, which are defined as the maximum extent of water bodies in September (e.g. lake shoreline, river edge or other wetland border). A summary of habitat characteristics and GPS co-ordinates for each of the 2 ha survey plots (15 sites, 30 survey plots) is provided in O'Connor et al. (2013).

Figure 1. Lakes Albert and Alexandrina and associated tributaries. The 15 sites surveyed for cryptic birds in 2012 and 2013 are shown as red symbols on the map. Reedy Island (yellow symbol) was only surveyed in September 2012; after which it was replaced by the Goolwa site for the remainder of the study.

Survey methods

Surveys were conducted over a 3–4 day period on a monthly basis between September and December 2013 (survey dates for 2012 are listed in O'Connor et al. 2013). Survey dates for 2013 were as follows: Survey 1, September 2-4; Survey 2: September 29 & 30, October 8 & 9; Survey 3: November 18-20; Survey 4: December 4-6 2013. Each of a pair of observers searched one of the two 2 ha plots at each site and recorded all birds (including non-target species) that were heard or seen within a 40 minute period. While there was some variation in the observers used to undertake the surveys, all observers were experienced

birdwatchers, and one observer (JO'C) was present at all surveys except for Survey 4 in 2013. Each plot was systematically searched by one observer (Plots A and B were searched at the same time by one of the two observers). The same plot was never surveyed more than twice by the same observer in each year (four surveys per year). GPS co-ordinates for all four corners of each 2 ha plot are provided in Appendix 2 of O'Connor et al. (2013).

In each of the surveys, the following information was recorded at each site:

- Weather conditions (wind, temperature etc.)
- Minimum and maximum water depth at each 2 ha plot
- Estimated % cover of water at each 2 ha plot.

For each search record, the following information was recorded and used in this study:

- Species identity
- Number of individuals
- Evidence of nesting/breeding behaviour.

Surveys commenced at approximately 6 am, and were completed by 8 pm. In the case of inclement weather (strong winds or high temperatures), surveys were stopped until conditions improved. Over the four survey visits, each site was surveyed twice in the morning and twice in the afternoon. Surveys were conducted throughout the day, however every site was surveyed at least once in early morning (before 9 am) or late afternoon (after 4 pm) when bird activity was expected to be at its peak.

To describe the effects of local habitat variables on cryptic bird abundance, information was collected about the plant species and communities that were present within each 2 ha plot (these floristic data were collected only once for each plot, during the November 2012 bird survey). Habitat and vegetation types were mapped using GIS. A full description of how this information was collected and analysed using GIS software is provided in O'Connor et al. 2013.

Occupancy, abundance, and habitat variables

Generalized Linear Models (GLM) were used to identify which habitat variables were associated with cryptic bird occupancy and abundance in 2012 and 2013. Occupancy data (binary presence/absence data) were analysed using a binomial distribution and a logit-link function. Abundance data were analysed using a Poisson distribution. The wetland habitat features used in these models are described in Table 1. Candidate habitat variables and habitat models were based on a review of key habitat features for the target species, drawn from expert models and published reports of habitat requirements (O'Connor et al. 2012; Marchant and Higgins 1990; Higgins 1993; Higgins and Davies 1996). Since the Australian Little Bittern, Baillon's Crake, Buff-banded Rail, Dusky Moorhen and Lewin's Rail each made up less than 1% of overall cryptic bird detections (n=1–16 observations per species per year), they were not included in the habitat analyses.

To reduce the number of models to be considered for each species (Burnham and Anderson 2002), two 'full' models were analysed with survey visit (8 surveys over the 2 years) as an ordinal variable. Model 1 contained all 14 habitat variables (Table 3) at the local (2 ha) scale, whereas Model 2 contained all 14 habitat variables at a broader landscape scale (within a 100m buffer zone from the centre point of the 2 ha plot). The model outputs were inspected for non-significant terms, which were removed from further analyses (Step 1). Next, 10 different models were run: one null model, one model that considered local reed cover only, one 'full' model at the local scale, one "full" model at the broader landscape scale, and 6 models that included the most likely combinations of significant variables from Step 1 (see discussion in Burnham and Anderson 2002 pages 333-334). Model selection was based on ΔAIC (Akaike Information Criteria) values that were calculated using corrected AIC values (AIC_C).

AIC_C was calculated using the equation below:

$$AIC_C = AIC + \frac{2K(K+1)}{N-K-1}$$

ΔAIC is a measure of each model relative to the 'best' model and is calculated as:

$$\Delta AIC = \Delta_i = AIC_i - \min AIC.$$

Only models within 2 units of the ΔAIC value were retained for further consideration (Burnham and Anderson 2002). Analyses of occupancy and abundance data were run separately.

Table 1. Details of habitat variables included in GLM analyses

Category	**Variable**
Vegetation Characteristics	Reeds
	Sedges <1 m
	Sedges >1 m
	Samphire
	Aquatic herbs>1 m
	Aquatic herbs<1 m
	Lignum
	Aquatic ferns
	Grasses
Physical features of the site	Mudflat (wet)
	Open water
	Minimum water level in the 2 ha plot in October
	Maximum water level in the 2 ha plot in October
	% of the 2 ha plot that was inundated with water in October

Colonial-nesting waterbirds

Survey methods were repeated from O'Connor et al. 2013, with the exception that breeding activity in both the lakes and Coorong were recorded on the same date in the 2013–14 survey period (the Coorong and Lakes were surveyed on separate flights/dates in 2012–13). The entire perimeter of the Lower Lakes and Coorong was again surveyed for signs of waterbird breeding activity. Survey dates are as following: October 29 2013, December 16 2013, and February 6 2014. Surveys were conducted >6 weeks apart to avoid duplicate counting of the same active nests during their incubation periods. The incubation period of all species is <5 weeks (Marchant and Higgins 1990)

Surveys were conducted from a Cessna aircraft, flown at a height of 500 feet at an airspeed of 90–110 knots. Two observers trained in waterbird identification took part in each survey; each person observing activity from their side of the aircraft. Upon location of breeding colonies, one observer recorded the following data: 1) species identity, 2) estimated number of breeding birds present, and 3) GPS location. The second observer took photographs of each colony, which were later used to verify species identity, number of active nests, number of non-nesting adults, and number of young (pelicans only) at each colony.

Results

Cryptic waterbirds

Detection and abundance

A total of 1376 records of cryptic birds were recorded across the four surveys undertaken in 2013. This compared with 1951 bird records across four surveys in 2012. Between 3–9 cryptic species were detected at each site in 2013 (Table 2). Table 2 shows the maximum number of each cryptic bird species observed at each site in any of the four survey months. A summary of the total number of observations of each species at each site in 2013 is provided in Appendix 1. The highest number of species (9) was detected at Clayton Bay (Figure 1; Table 2).

Table 2. Summary of the maximum number of each cryptic waterbird species (per month) detected at the 15 surveyed sites in 2013. The total number of species is also provided for each site.

	Boggy Creek	Finniss River	Goolwa	Jacobs	Kennedy Bay	Clayton Bay	Loveday Bay	Milang Snipe Sanctuary	Pomanda Point	Narrung Narrows	Poltalloch	Reedy Point	Tolderol	Tookayerta	Waltowa
Australasian Bittern		1		2			1		1				1		
Australian Little Bittern															
Australian Crake		2	2			1		1	3			3	2	2	5
Baillon's Crake						2									
Spotless Crake	1	4	5	3	1	1			4	2		2	4	8	3
Buff-banded Rail			1		1										
Lewin's Rail	1	1			2								1	3	1
Latham's Snipe						1	1	7				1			
Australian Reed Warbler	5	5	10	19	1	5	7	7	11	14	1	4	13	11	6
Golden-headed Cisticola		5	2		9	18	3	5	8	4	1	9	16	2	4
Little Grassbird	9	2	13	14	11	8	5	6	24	16	3	6	11	13	17
Purple Swamphen	16	1	10	9	3	32	4	9	16	7		1	6	1	6
Dusky Moorhen	1		1												
Total # species	**6**	**8**	**8**	**5**	**7**	**8**	**6**	**6**	**7**	**5**	**3**	**7**	**8**	**7**	**7**

All 13 cryptic species were detected in at least three of the eight surveys undertaken across the two years (2012–13). The Australian Painted-snipe was also a focal species of this study, but was not detected in any surveys. The Australian Little Bittern was detected in low numbers in 2012 (3 records), but was not observed in 2013. As this species is rarely recorded in the Lower Lakes (O'Connor et al. 2013) or Lower Murray River generally, its lack of detections in the Lower Lakes in 2013 is not necessarily a strong indicator of changes in habitat quality.

The three Passerine species (Australian Reed Warbler, Little Grassbird and Golden-headed Cisticola), and the Purple Swamphen were the most abundant species in both 2012 and 2013 (O'Connor et al. 2012, Appendix 1). These four species were detected a total of 200-460 times between September and December 2013. The two crake species and Latham's Snipe were the next most common group, with 20-76 detections in 2013. The following species were rarely recorded in 2013 with only 2–13 observations across the four month survey period: Australasian Bittern, Baillon's Crake, Buff-banded Rail, Dusky Moorhen and Lewin's Rail.

Of the 3327 cryptic bird records across 2012 and 2013, 27% were seen and 73% were heard. Nesting activity in 2013 was only recorded for the Purple Swamphen (2 nests with chicks), although the Australian Reed Warbler, Golden-headed Cisticola and Little Grassbird were sometimes seen carrying nesting material.

The Endangered Mount Lofty Ranges Southern Emu-wren, *Stipiturus malachurus intermedius,* was again recorded at the Finniss site in 2013 (although it was not a focal species for this study). A total of 14 individual records were collected over three surveys.

Table 3. Summary of monthly and total records of each focal cryptic waterbird species across the 15 sites surveyed in 2013

Species	Sept	Oct	Nov	Dec	Total records per species
Australasian Bittern	4	3	1	0	8
Australian Reed Warbler	85	95	78	51	309
Australian Crake	13	9	7	3	32
Baillon's Crake	2	0	0	0	2
Buff-banded Rail	0	2	0	0	2
Dusky Moorhen	1	0	2	0	3
Golden-headed Cisticola	40	50	70	40	200
Latham's Snipe	0	6	5	9	20
Lewin's Rail	5	3	4	1	13
Australian Little Bittern	0	0	0	0	0
Little Grassbird	129	127	118	86	460
Purple Swamphen	96	68	47	40	251
Spotless Crake	24	24	22	6	76
Total birds/month	**399**	**387**	**354**	**236**	

Relation of species occupancy/abundance to habitat variables

The 'best' models (ΔAIC = 0) for predicting occupancy and abundance in 2012 and 2013 used different habitat variables for each species. For example the best abundance model for the Australasian Bittern included only two parameters: reed cover and visit (Table 4, Figure 2a). Abundance models for other species, such as the Australian Reed Warbler, Golden-headed Cisticola and Purple Swamphen (Figures 2b–d), were more complex (models for all three species contained 11 parameters (Table 4)). Samphire (Figure 2e) and aquatic herb cover (>1 m) and year were positively associated with occupancy of Latham's Snipe, whereas reed cover had a negative effect (Figure 2f). No local habitat variables were significant predictors of Latham's Snipe abundance, possibly because this species was found at only few sites that had very different habitat characteristics (see O'Connor et al. 2013).

Ten GLMs included habitat variables within the 2 ha study plots, and the 6 remaining models included variables within the 100 m buffer zone. For example, the Spotless Crake responds to lignum cover at the broader landscape scale (buffer zone), whereas Little Grassbird abundance was positively associated with Lignum at a local (2 ha) scale (Table 4).

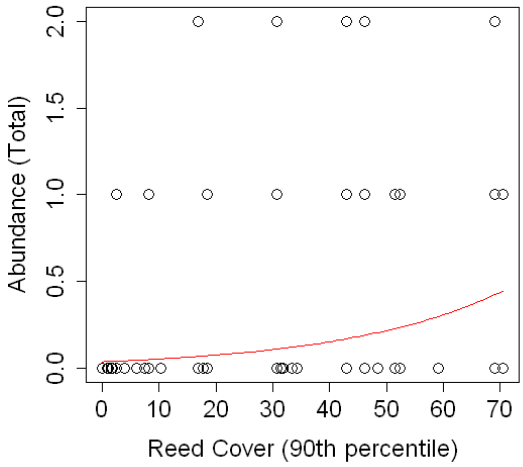
GLMs for each species now include data from both the 2012 and 2013 surveys, hence some of the 'best models' now differ slightly from those given in O'Connor et al. 2013. These differences should represent improvements on the original models due to increased sample sizes. An example of one change in model parameters is that the Australasian Bittern responded to reed cover in the buffer zone using 2012 data only, but was found to respond to reed cover at a local scale (2 ha) using data from 2012 and 2013. This may be influenced by the repeated observation (n=3) of one individual at Loveday Bay, which has a small area of reeds within the 2 ha plot, but very little outside of that area.

Due to the low number of detections over 2012–13, GLMs were not performed for the following species: Baillon's Crake, Lewin's Rail, Buff-banded Rail, Dusky Moorhen and Australian Little Bittern. Habitat associations of these species in regard to co-occurring species are discussed in O'Connor et al. 2013.

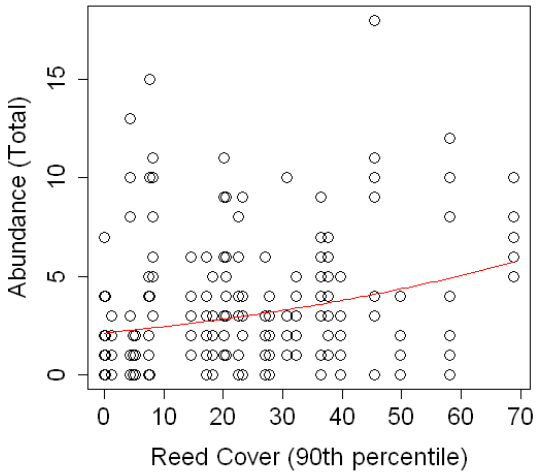
Table 4. Habitat relationship model results by species, in 2 ha plots (2 ha) or the 2 ha plot+ 100 m buffer zone (Buffer). *K*=number of parameters included in model. See Table 1 for descriptions of variables.

Abundance and occupancy data analyses are shown. Non-significant model parameters are indicated in parentheses (probability of inclusion >.05).Parameters in bold font had a positive effect on abundance or occupancy, whereas parameters in normal font had a negative effect. The number of alternative models (where ΔAIC_c =<2; change in Akaike's Information Criterion adjusted for small sample size) are indicated in the final column, with associated model details in Appendix 2.

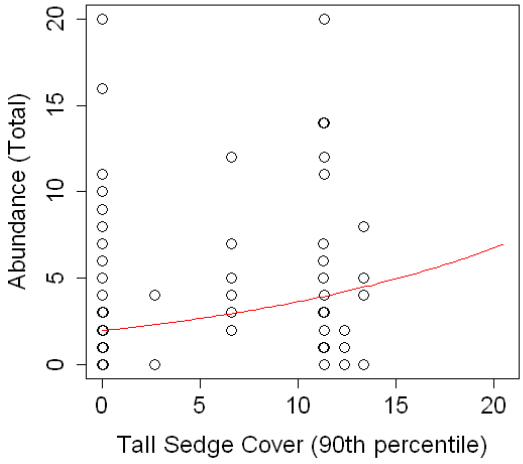
Species	Analysis	Area	Model parameters	*K*	No. alternative models
Australasian Bittern	Abundance	2 ha	**Reeds,** Visit	2	1
	Occupancy	2 ha	**Reeds**	1	0
Australian Reed Warbler	Abundance	Buffer	**Reeds,** Sedges>1 m**, Samphire,** Aquatic Herbs>1 m**, Aquatic Herb<1 m, Mudflat, Aquatic Ferns, Grasses, % inundated, Max Water Level, Visit**	11	0
	Occupancy	2 ha	**Reeds, Aquatic Ferns**	2	0
Australian Crake	Abundance	2 ha	**Reeds, Sedges<1 m, Lignum,** Year**, Visit**	5	0
	Occupancy	Buffer	**Reeds, Lignum, Month**	3	0
Golden-headed Cisticola	Abundance	Buffer	**Sedges<1 m, Sedges>1 m, Samphire, Aquatic Herbs>1 m,** Aquatic Herbs<1 m**, Lignum,** Aquatic Ferns**,** % inundated**, Max Water Level, Visit, Year**	11	0
	Occupancy	2 ha	Sedges<1 m, Samphire, Aquatic Herbs>1 m, **Mudflat,** Aquatic Ferns,	5	1
Little Grassbird	Abundance	2 ha	**Lignum, % inundated, Min Water Level, Visit,** Year	5	0
	Occupancy	2 ha	Samphire, Visit, Year	3	0
Purple Swamphen	Abundance	2 ha	**Reeds, Sedges<1 m, Sedges>1 m,** Aquatic Herbs>1 m**, Aquatic Herbs<1 m, Lignum, Aquatic Ferns, % inundated, Year, Visit**	10	1
	Occupancy	Buffer	Sedges<1 m**, Aquatic Ferns, Min Water Level,** Visit**, Year**	4	0
Spotless Crake	Abundance	Buffer	**Aquatic Herbs<1 m, Lignum, % inundated**	3	0
	Occupancy	Buffer	Aquatic Herbs<1 m**, Lignum, % inundated**	3	0
Latham's Snipe	Abundance	2 ha	**Full Model** Reeds, Sedges<1 m, Sedges>1 m, Samphire, **Aquatic Herbs>1 m**, Aquatic Herbs<1 m, Lignum, Open Water, Mudflat, Aquatic Ferns, Grasses, **% inundated**, Max Water Level, **Min Water Level**, **Visit**, Year	15	0
	Occupancy	2 ha	**Samphire, Aquatic Herbs>1 m, Year**	3	1



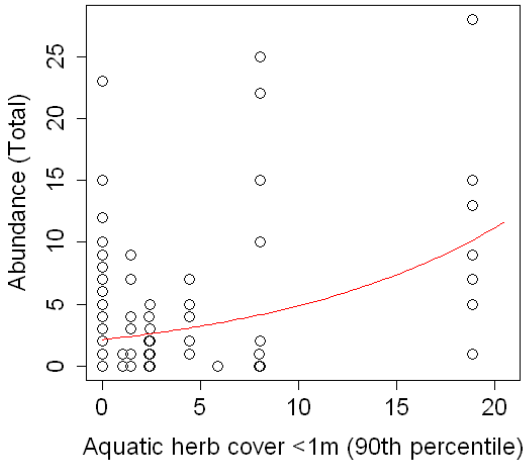
a. Australasian Bittern



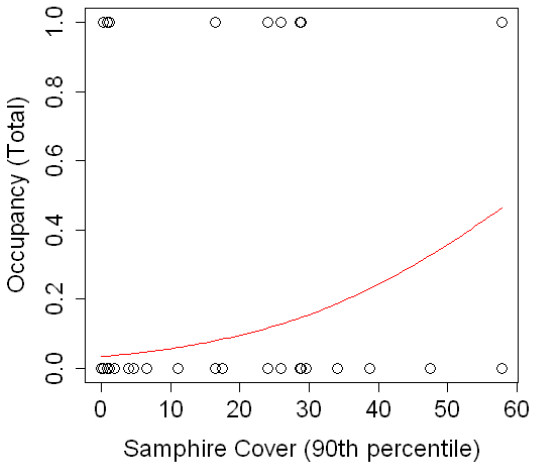
b. Australian Reed Warbler



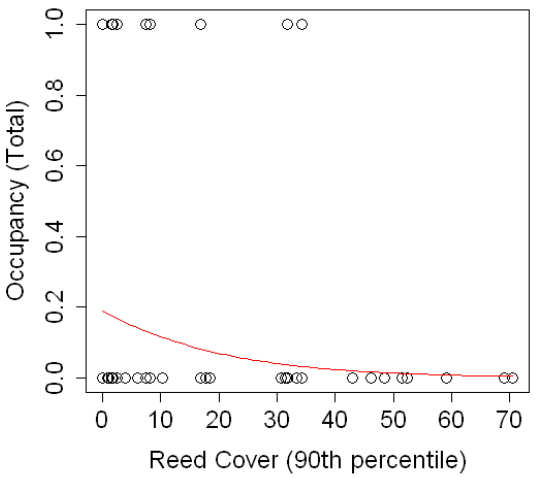
c. Golden-headed Cisticola



d. Purple Swamphen



e. Latham's Snipe



f. Latham's Snipe

Figure 2. The relationship between a) reed cover (2 ha plot) and Australasian Bittern abundance, b) reed cover (buffer zone) and Australian Reed Warbler abundance, c) tall sedge (>1 m) cover (buffer zone) and Golden-headed Cisticola abundance, d) aquatic herb cover (2 ha plot) and Purple Swamphen abundance, e) Samphire cover (2 ha plot), and Latham's Snipe Occupancy, f) reed cover (2 ha plot) and Latham's Snipe site occupancy. Occupancy refers to whether a species was detected at the site at each visit (0=no, 1=yes), whereas Abundance refers to the total number of each species detected per site per visit. All figures include data from 2012 & 2013.

Colonial-nesting waterbirds

2013–14 survey results

Waterbird breeding colonies were detected at five locations in the Lakes (Figure 3; Table 5) and on four different islands in the Southern Coorong (Figure 4; Table 5) between October 2013 and February 2014. The largest colonies at a single location included those of Crested Terns (1750 nests on Teal Island), Australian Pelicans (1142 nests on North Pelican Island), and Straw-necked Ibis (1555 nests at Boggy Lake). Straw-necked and Australian White Ibis commonly nested in large mixed colonies (Table 5, Figure 3).

Appendix 3 lists breeding records from the Coorong and Lakes by date and location in 2012 and 2013.

Trends across 2012–13 and 2013–14 survey periods

62% (8/13) of breeding locations supported active breeding colonies in both the 2012–13 and 2013–14 survey periods (Table 5). Breeding locations that were not active in the 2012–13 period include an island in the Mulgundawa Salt Lakes (227 Silver Gull nests) and Goat Island (near Clayton Bay in the lakes: 6 Royal Spoonbill nests).

Temporal patterns in species breeding activity were similar across the two survey periods. For example, ibis colonies were active in all spring and early summer surveys, but were inactive by February in 2013 and 2014. Pied Cormorant nesting occurred from December onwards, and Australian Pelican breeding activity was observed or confirmed in all surveys (excluding the February 2014 survey when thick cloud cover prevented observation of Southern Coorong Islands).

Royal Spoonbill nests were detected in low numbers in the lakes (≤26 nests in total) in each survey period. Fairy Tern colonies were not detected across the entire 2012–14 survey period using the aerial survey method, even when the aircraft flew over nesting sites that were known to be to active.

Both ibis species nested in larger numbers in 2013 compared to 2012 (Table 6). Nearly twice as many Straw-necked Ibis nests were observed in 2013 compared to 2012 (3664 nests and 1957 nests respectively).

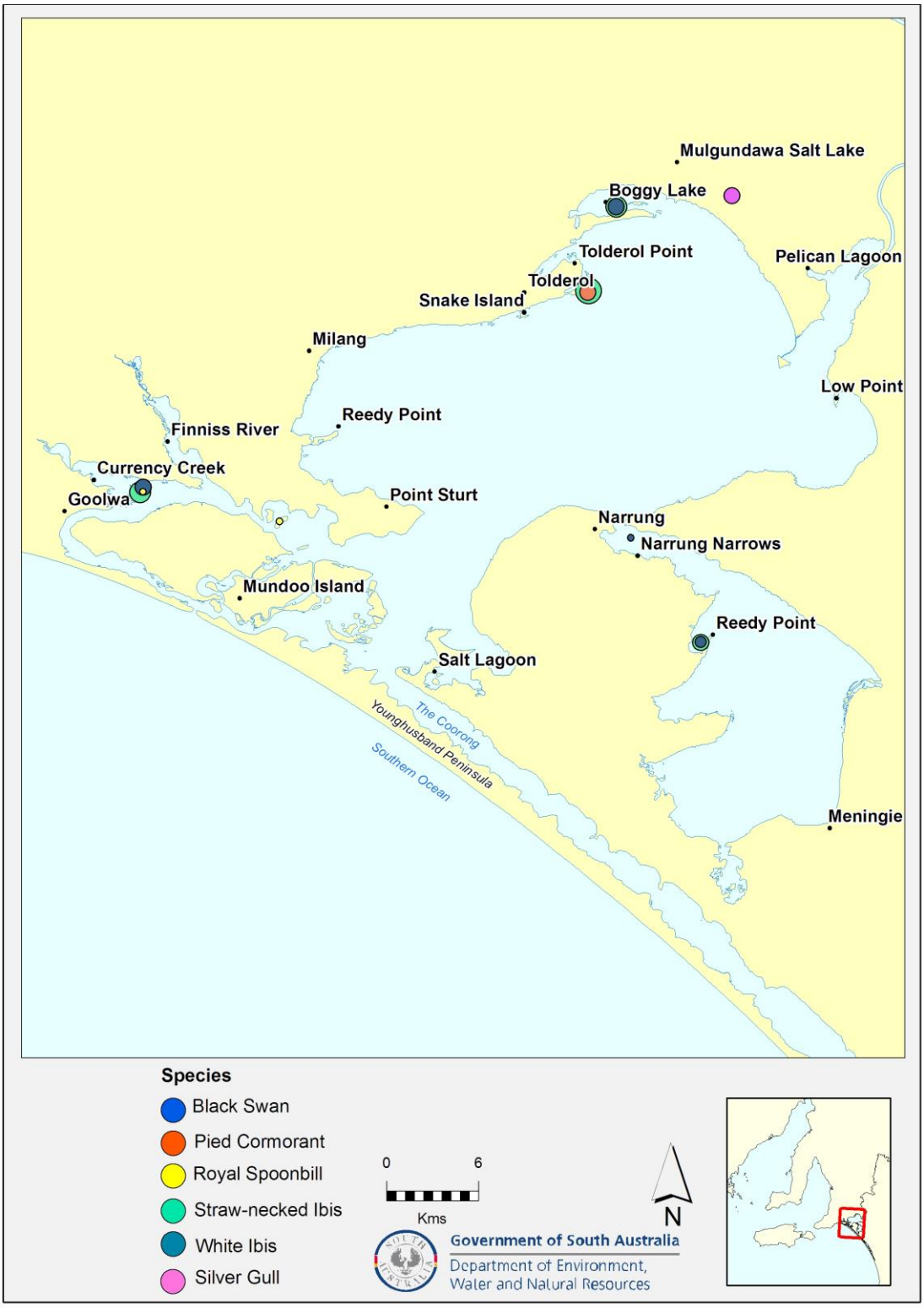


Figure 3. Distribution and abundance of waterbird breeding activity (active nests) in the Lower Lakes, October to December 2013 (no active nests were observed in the February 2014 survey)

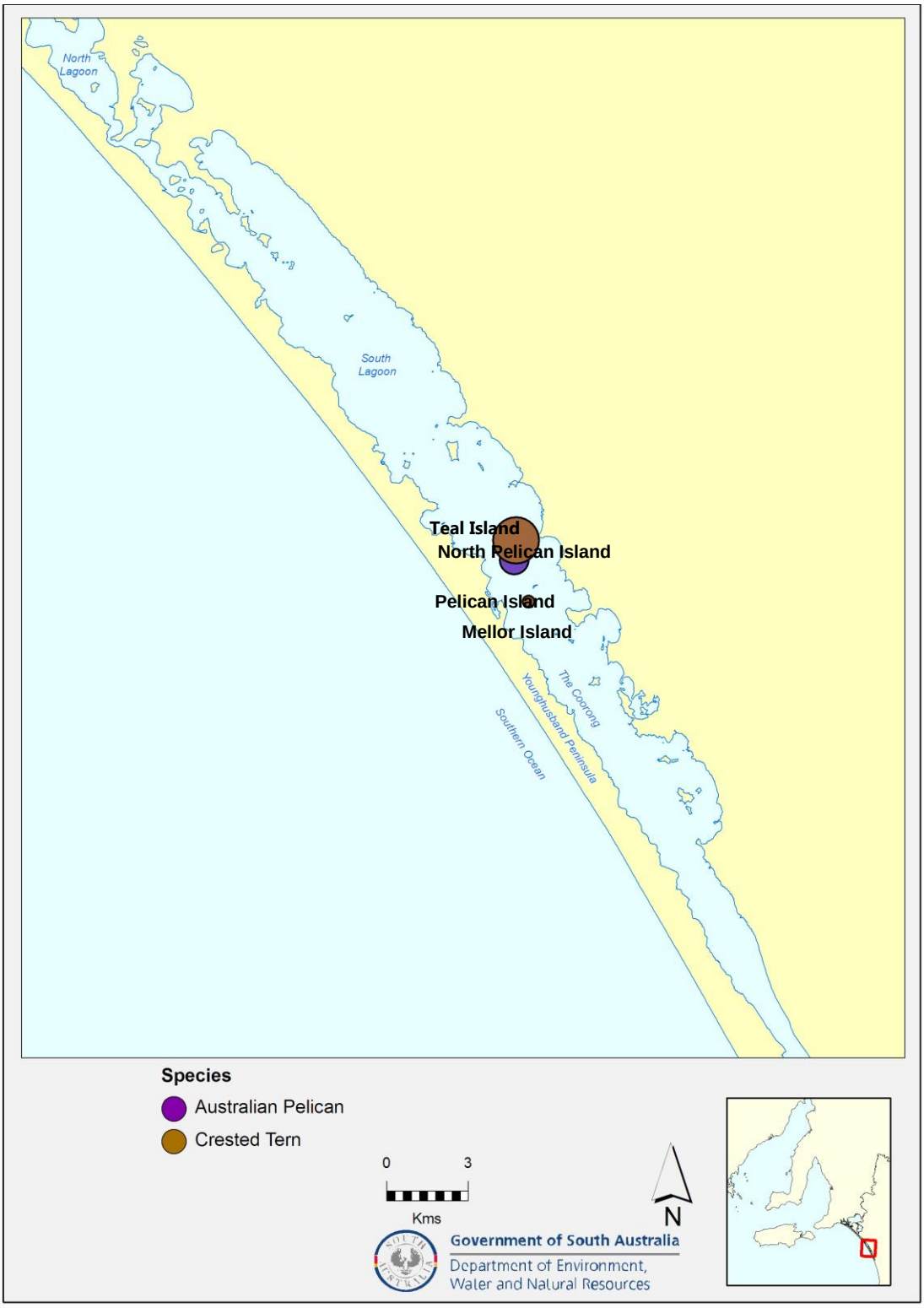


Figure 4. Distribution and abundance of waterbird breeding activity (active nests) in the Coorong, October to December 2013

Table 5. Location and number of active nests (nests with incubating/brooding parent), non-nesting birds and chicks/juveniles observed in the Lakes and Coorong from October 2012 to February 2013, and October 2013 to February 2014. Counts represent cumulative numbers observed over three surveys in each 5-month survey period.

			2012/13			2013/14		
Species	**Area**	**Wetland/island**	**Active nests**	**Non-nesting birds**	**Chicks/ juveniles**	**Active nests**	**Non-nesting birds**	**Chicks/ juveniles**
Australian Pelican	Coorong	Mellor Island	562	378	155	0*	0*	0*
Australian Pelican	Coorong	North Pelican Island	1361	3505	700	1142*	620*	705*
Australian Pelican	Coorong	Pelican Island	247	57	0	0*	0*	0*
Australian White Ibis	Lakes	Boggy Lake	179	28	0	422	20	0
Australian White Ibis	Lakes	Currency Creek	119	0	0	446	0	0
Australian White Ibis	Lakes	Lake Albert West	120	0	0	90	0	0
Australian White Ibis	Lakes	Low Point	90	0	0	0	0	0
Australian White Ibis	Lakes	Narrung Narrows	115	0	0	48	0	0
Australian White Ibis	Lakes	Point Sturt	13	12	0	0	0	0
Australian White Ibis	Lakes	Tolderol Point	0	0	0	40	0	0
Australian White Ibis	Lakes	Unnamed bay, west of Reedy Point, Lake Alexandrina	64	5	0	0	0	0
Black Swan	Lakes	Lake Albert (East)	0	0	10	0	0	0
Black Swan	Lakes	Low Point	1	0	0	0	0	0
Black Swan	Lakes	Narrung Narrows (West)	1	0	0	0	0	0
Caspian Tern	Coorong	Pelican Island	40	5	0	0*	0*	0*
Crested Tern	Coorong	Pelican Island	4050	800	0	285*	320*	0*
Crested Tern	Coorong	Teal Island	0	0	0	1750*	50*	0*
Pied Cormorant	Lakes	Tolderol Point	916	430	3	270	800	0
Royal Spoonbill	Lakes	Currency Creek	0	0	0	20	0	0
Royal Spoonbill	Lakes	Goat Island	0	0	0	6	0	0

Royal Spoonbill	Lakes	Lake Albert	10	0	0	0	0	0
Silver Gull	Lakes	Muldungawa Salt Lakes	0	0	0	227	0	0
Straw-necked Ibis	Lakes	Boggy Lake	606	9	0	960	100	0
Straw-necked Ibis	Lakes	Currency Creek	159	0	0	723	0	0
Straw-necked Ibis	Lakes	Lake Albert West	160	0	0	426	0	0
Straw-necked Ibis	Lakes	Tolderol Point	67	3	0	1555	0	0
Straw-necked Ibis	Lakes	Unnamed bay, west of Reedy Point, Lake Alexandrina	1032	10	0	0	0	0
		Total	**9912**	**5242**	**868**	**8410**	**1910**	**705**

* Coorong South Lagoon was surveyed in October and December 2013 only (poor visibility prevented observations in February 2014), but was surveyed in all three aerial surveys in the prior observation period (14 November and 27 December 2012, and 22 February 2013).

Table 6. Total number of active nests observed for each waterbird species over the 2012/13 and 2013/14 survey periods

		Total nests	
Common name	**Scientific name**	**2012–13**	**2013–14**
Australian Pelican	*Pelecanus conspicillatus*	2170	1142*
Australian White Ibis	*Threskiornis moluccus*	700	1046
Black Swan	*Cygnus atratus*	2	0
Caspian Tern	*Hydroprogne caspia*	40	0*
Crested Tern	*Thalasseus bergii*	4050	2035*
Pied Cormorant	*Phalacrocorax varius*	916	270
Royal Spoonbill	*Platalea regia*	10	26
Silver Gull	*Chroicocephalus novaehollandiae*	0	227
Straw-necked Ibis	*Threskiornis spinicollis*	1957	3664

*Coorong South Lagoon was surveyed in October and December 2013 only (poor visibility prevented observations in February 2014)

Past and present breeding activity

Twenty-one colonial-nesting species have been recorded nesting in the CLLMM since 1911 (O'Connor et al. 2013), nine of which were recorded in the 2012–14 aerial surveys.

The 12 colonial-nesting waterbird species that have been recorded in the past, but not in our current surveys are listed in Table 7. Eight of these species have not been observed to breed in the CLLMM since the 1960s and 1970s, but one species, the White-faced Heron has not been recorded in over 80 years. Both the Banded Stilt and Red-necked Avocet nested in unusually high levels under extreme hypersaline conditions in 2006, although the latter also breeds in small numbers in the Coorong in most years. Fairy Terns are small-bodied and nest in smaller colonies, so were not detected in the aerial surveys.

One additional species, the Little Tern, has been recorded breeding in very small numbers (i.e. one nest in Jan. 2014) in on-ground/boat surveys (D. Paton, unpublished data).

Table 7. Species that have been observed to breed in the CLLMM, but were not detected in 2012–14 aerial surveys. Full details of each breeding record are provided in O'Connor et al. 2013, unless an additional source is provided in the 'Year last recorded breeding in CLLMM' column.

Species	Year last recorded breeding in CLLMM	Reason breeding not observed in aerial surveys
Glossy Ibis	1971	No recent breeding activity recorded
Banded Stilt	2006	Unusual breeding event in 2006 (see Gosbell and Christie 2006)
Red-necked Avocet	2010	Species breeds sporadically and usually in small numbers (but larger numbers in 2006)
Great Cormorant	1979	No recent breeding activity recorded
Little Black Cormorant	1979	No recent breeding activity recorded
Little Pied Cormorant	1976	No recent breeding activity recorded
Musk Duck	1960s	No recent breeding activity recorded
Pacific Black Duck	1960s	No recent breeding activity recorded
Nankeen Night Heron	1966	No recent recorded breeding activity. This species tends to congregate under closed tree canopies (i.e. pines) around the lakes, obscuring visibility from above.
White-faced Heron	1931	No recent breeding activity recorded
Yellow-billed Spoonbill	1979	No recent breeding activity recorded
Fairy Tern	2014 (D. Paton, unpublished data)	Birds are small-bodied, and form relatively small groups of 10-60 birds (D. Paton, unpublished data)

Discussion

Cryptic waterbirds

Surveys of cryptic waterbirds conducted in the CLLMM region in 2013–14 found that the distribution, abundance and species were comparable between 2013–14 and 2012–13. One species – Australian Little Bittern – that was recorded in 2012–13, was not recorded in 2013–14. However, this species is rare in the Lower Lakes, and in the Lower Murray more generally (Pickering, 2010; Atlas of Living Australia), and thus its absence is highly unlikely to reflect important changes in local habitat conditions for this species. While the total number of records was lower in 2013–14 than 2012–13 for many species, overall the pattern of distribution and abundance for cryptic waterbirds in the CLLMM did not change significantly among the two survey years.

As in 2012–13, the most common species recorded in this survey were three passerine species (Australian Reed Warbler, Little Grassbird and Golden-headed Cisticola), and the Purple Swamphen. However, a number of regionally rare species were also recorded, including Latham's Snipe and Australasian Bittern. This suggests that the CLLMM continues to provide some habitat for these threatened species, as well as the more common species.

While these patterns suggest a degree of consistency in the waterbird community of the CLLMM region, these data do not reflect the range of environmental conditions under which these species have been (or are likely to be) subjected to. We do not have an adequate understanding, for example, of how the recent drought that occurred in the region affected the distribution and abundance of cryptic waterbirds, although we can infer from natural history that some species were likely to have been significantly affected (e.g. Australasian Bittern) (see Birds Australia, 2011; Marchant and Higgins, 1990) . Furthermore, we have limited to no understanding of the distribution and abundance of these species prior to the drought, and so cannot judge whether the patterns we have observed over the last two years reflect longer-term patterns during "good" years, or whether these species are still in post-drought recovery (or declining). While we can indirectly draw some conclusions based on the historic distribution of key habitat features, the only way to quantitatively address these issues in through investment in a long-term monitoring program with the specific intent of understanding the response of these species to environmental change.

In this study, General Linear Models identified differences in the structural complexity of habitats occupied by cryptic waterbird species. The features of commonly occupied habitat types are influenced by the different life-history requirements of each species (i.e. nesting, foraging and predation evasion requirements). For example the Australasian Bittern was associated with homogenous reed-dominated habitats, typically characterised by dense stands of *Phragmites australis* and or *Typha*. Reeds provide concealed nesting substrate (O'Donnell 2011) and foraging habitat that supports various prey types, including frogs, fish and invertebrates (Higgins and Davies 1996). The occupancy and abundance of Spotless and Australian Crake at surveyed sites were positively associated with lignum (and up to 2 other habitat features as outlined in Table 4). In our surveys, both species were observed to forage on mudflats close to large lignum bushes, and run to shelter underneath these bushes when human observers came within approximately 5–10 metres. Lignum was always observed to occur in close proximity to reed habitats, which are a known nesting substrate for crakes (Higgins and Davies 1996) as well as many other cryptic species, including bitterns and passerines (Little Grassbird, Golden-headed Cisticola and Australian Reed Warbler). Purple Swamphen nests were also observed in *Typha*-dominated reed habitats in this study. Other species, such as the Australian Reed Warbler, Golden-headed Cisticola and Purple Swamphen were associated with habitats containing a greater variety of vegetation types (i.e. reeds, sedges, herbs, lignum and ferns for swamphens) than other species. It is difficult to discriminate the relative importance and functions of all of these various vegetation types to a species, and it is likely that the differing heights and structural densities of various vegetation types contribute to a number of habitat requirements. Furthermore, since these species were detected at the majority of survey sites, it may have been more difficult for the models to discriminate between 'good' and 'poor' habitat features for this species.

One key question, highlighted by these results is: what role do the Lower Lakes' ecosystems play in supporting regional populations of these cryptic species? If we are to manage fringing aquatic environments such that they support habitat for these species, what are the implications for regional or global populations? What are the implications of local loss of habitat? As for other waterbird species for which the CLLMM forms only part of their range, an understanding of the regional context within which the CLLMM operates is required to both better predict the response of these species to local intervention, and better understand the local requirements of these species within the broader context which they operate. The relationship

between flow regimes and the provision of cryptic bird habitat should also be explored if we are to manage the wetlands for these species.

Colonial-nesting waterbirds

Survey flights over the spring–summer waterbird breeding seasons of 2012–14 have helped to provide a snapshot of colonial-nesting waterbird breeding activity in major CLLMM wetland areas. Twenty-two colonial-nesting species have been recorded nesting in the CLLMM since 1911(O'Connor et al. 2013), nine of which were recorded in the 2012–14 aerial surveys.

While the species recorded breeding in 2013–14 and 2012–13 were comparable, there was some variation in the number of nests recorded between these two seasons. For species that breed in the Coorong in abundance (Australian Pelican, Crested Tern), fewer nests were recorded in 2013–14 compared with 2012–13, while for species that breed in the Lower Lakes (Australian White Ibis, Straw-necked Ibis), more nests were recorded in the latter period. The fewer nests recorded in the Coorong can at least partly be attributed to the lower survey effort in 2013–14 (weather conditions precluded a February survey). However this explanation does not preclude other environmentally driven explanations, such as changes in the availability of food in the Coorong in 2013–14 vs 2012–13, or changes in the environmental conditions of sites outside of the CLLMM between these two periods. As with the cryptic bird discussion, the drivers of breeding effort in the CLLMM requires a longer-term dataset, coupled with explicit response models for these species (such as those developed by O'Connor et al. 2013). While we don't necessarily have a long-term, consistently collected dataset to support our understanding of breeding responses to environmental change, we do have a collated anecdotal record of breeding waterbirds in the Coorong, which was discussed in detail in O'Connor et al. 2013.

As discussed in O'Connor et al. (2013), some colonial-nesting species historically nested in large numbers but have not been observed to breed in the CLLMM since the 1960's and 1970s. These species include the Glossy Ibis, Little Black Cormorant, Great Cormorant, Little Pied Cormorant, and Yellow-billed Spoonbill. Seven species were regularly observed breeding with hundreds (if not thousands) of nests on islands in Salt Lagoon (Lake Alexandrina) (O'Connor et al. 2013). No breeding activity has been recorded on the Salt Lagoon Islands since the late 1970s (O'Connor et al. 2013). The reasons for this change are unclear, but could include: 1) change in prey availability (mainly fish), 2) change in the availability of nesting substrate, or 3) changes in off-site habitat availability. Two duck species: Musk and Pacific Black Duck also nested in their hundreds in wetlands around Lake Alexandrina until the 1960s (Paton et al. 2009). One hypothesis for the lack of breeding activity for these two species is the lack of submerged aquatic vegetation and associated macroinvertebrate prey following the arrival of European Carp in the early 1970s (Paton et al. 2009).

The aerial survey technique is particularly useful for detecting solitary/small groups of larger species, such as Royal Spoonbills, or large groups of smaller species such as Crested Terns. However, we were not able to detect nests of smaller species such as Fairy Terns, which nest in much smaller colonies than Crested Terns. Similarly, we did not detect nesting activity of solitary-nesting species such as Hooded and Red-capped Plovers or Pied or Sooty Oystercatchers. Studies of these species require more intensive on-ground or boat surveys of beach and Coorong island sites in order to identify breeding activity. Oystercatcher and plover nesting at ocean beach sites is currently monitored via the BirdLife Australia beach-nesting birds project (bi-annual), and Fairy Tern breeding success has been monitored annually by the University of Adelaide and DEWNR.

Conclusions

This study shows that the Coorong, Lower Lakes and Murray Mouth wetland habitats support significant numbers of cryptic waterbirds, and breeding activity of colonial-nesting waterbirds.

The presence and abundance of cryptic waterbirds show species-specific patterns relating to habitat assemblages at each survey site. Some species require homogenous reed- or samphire-dominated wetlands, whereas others prefer more heterogenous assemblages of aquatic plants and other habitat features such as mudflat. Lake water levels (and therefore water delivery to the site), should therefore be maintained at appropriate levels that will support a variety of wetland types, that will in turn provide habitat for cryptic bird populations. Revegetation programs aimed at increasing overall wetland biodiversity could also consider the habitat preference of cryptic bird species as discussed here.

Islands in the Coorong and Lake Alexandrina and Lake Albert supported large numbers of colonial-nesting waterbirds between 2012–14. The results of the aerial surveys represent waterbird breeding activity in a short period of relatively high water levels following almost a decade of drought. Waterbird breeding activity is closely linked to water availability, therefore the data presented here reflect breeding in relatively 'good' years. However the number of species or individuals breeding in the 2012–14 surveys may still represent populations that are recovering from the long period of low water flows. Continued monitoring of colonial-nesting waterbirds is required in order to assess longer-term trends in response to environmental change, with particular reference to water delivery, and in the context of regional and global impacts on these populations and species.

References

Atlas of Living Australia website at http://bie.ala.org.au/species/Ixobrychus+minutus. Accessed 21 January 2015Birdlife Australia, (2011) The Bittern Chronicle. Issue 3, September 2011

Burnham KP, Anderson DR (2002) 'Model Selection and Multimodel Inference, A Practical Information-theoretic Approach.' (Springer-Verlag: New York, USA)

Higgins, P.J. (ed.), (1993) 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 2. Raptors to Lapwings.' (Oxford University Press: Melbourne).

Higgins, P.J. and Davies, S.J.J.F. (eds.) (1996) 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 3. Snipe to Pigeons.' (Oxford University Press: Melbourne).

Marchant S, Higgins PJ (Eds) (1990) 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 1: Ratites to Ducks.' (Oxford University Press: Melbourne)

O'Connor, J, Rogers, D.J., and Pisanu, Phil (2012), 'Modelling waterbird responses to ecological conditions in the Coorong, Lower Lakes, and Murray Mouth Ramsar site (Preliminary Progress Report)', (South Australian Department of Environment and Natural Resources: Adelaide).

O'Connor J, Rogers D, Pisanu P (2013) Cryptic and colonial-nesting waterbirds in the Coorong, Lower Lakes and Murray Mouth: distribution, abundance and habitat associations. DEWNR report for the Coorong, Lower Lakes and Murray Mouth program.

Paton, D. C., D. J. Rogers, P. Cale, N. Willoughby, and J. A. Gates. 2009. Chapter 14. Birds *in* J. T. Jennings, ed. Natural History of the Riverland and Murraylands, Royal Society of South Australia Inc, Adelaide. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Pickering, R. 2010. Summary of the Australasian Bittern and Australian Little Bittern surveys 2009/2010. *Western Australian Bird Notes*. 134: 13–14

Appendices

Appendix 1. Summary of the number of each cryptic bird species detected at each of the 16 surveyed sites.

The total number of species and observations are also provided for each site.

	Boggy Creek	Finniss River	Goolwa	Jacobs	Kennedy Bay	Clayton Bay	Loveday Bay	Milang Snipe Sanctuary	Pomanda Point	Narrung Narrows	Poltalloch	Reedy Point	Tolderol	Tookayerta	Waltowa
Australasian Bittern	0	1	0	2	0	0	2	0	2	0	0	0	1	0	0
Australian Reed Warbler	10	14	28	47	2	13	21	19	38	34	2	9	33	30	9
Australian Crake	0	3	2	0	0	2	0	2	5	0	0	3	4	6	5
Baillon's Crake	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Buff-banded Rail	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Dusky Moorhen	1	0	2	0	0	0	0	0	0	0	0	0	0		
Golden-headed	0	16	4	0	24	36	6	14	11	8	1	21	47	6	6
Latham's Snipe	0	0	0	0	0	1	1	17	0	0	0	1	0	0	0
Lewin's Rail	1	1	0	0	2	0	0	0	0	0	0	0	1	7	1
Australian Little Bittern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Grassbird	30	4	44	44	23	22	12	10	74	47	7	23	34	31	55
Purple Swamphen	36	1	26	21	8	57	11	17	36	15	0	1	9	1	12
Spotless Crake	2	10	11	6	1	1	0	0	7	2	0	2	6	22	6
Total # species	6	8	8	5	7	8	6	6	7	5	3	7	8	7	7
Total Observations	80	50	118	120	61	134	53	79	173	106	10	60	135	103	94

Appendix 2. Alternative habitat relationship model results

• (ΔAIC_c = <2) by species, in 2 ha plots (2 ha) or the 2 ha plot+ 100 m buffer zone (Buffer). *K*=number of parameters included in mode.

• Abundance and occupancy data analyses are shown.

• Non-significant model parameters are indicated in parentheses (probability of inclusion >.05).

• Parameters in bold font have a positive effect on abundance or occupancy, whereas parameters in normal font have a negative effect.

Species	Analysis	Area	Model parameters	*K*
Australasian Bittern	Abundance	2 ha	**Reeds,** Year	2
Golden-headed Cisticola	Occupancy	2 ha	Sedges<1 m, Samphire, Aquatic Herbs>1 m, Aquatic Herbs<1 m, **Mudflat**	5
Purple Swamphen	Abundance	2 ha	**Reeds, Sedges>1 m, Samphire, Aquatic Herbs<1 m,** Aquatic Herbs>1 m**, Lignum, Open Water, Mudflat, Aquatic Ferns, Grasses, % inundated,** Month	12
Latham's Snipe	Occupancy	2 ha	**Samphire, Aquatic Herbs>1 m**	2

Appendix 3. Waterbird breeding records by date and location

Date	Species	Nests	Young	Non-nesting birds	Area	Site	Latitude	Longitude
11-Nov-12	Australian Pelican	390	1790	280	Coorong	North Pelican Island	6010256	370116
27-Dec-12	Australian Pelican	360	190		Coorong	Mellor Island	6007537	371655
27-Dec-12	Australian Pelican	950	1180	280	Coorong	North Pelican Island	6010256	370116
15-Jan-13	Australian Pelican	202	188	155	Coorong	Mellor Island	6007537	371655
15-Jan-13	Australian Pelican	21	535	140	Coorong	North Pelican Island	6010256	370116
15-Jan-13	Australian Pelican	247	57		Coorong	Pelican Island	6008715	370620
29-Oct-13	Australian Pelican	830	630	30	Coorong	North Pelican Island	6010256.0	370116.0
16-Dec-13	Australian Pelican	312	75	590	Coorong	North Pelican Island	6010256.0	370116.0
10-Oct-12	Black Swan	10			Lake Albert	Lake Albert (East)	6060394.895	340441.6
10-Oct-12	Black Swan	1			Lake Albert	Narrung Narrows (West)	6067972.046	336423.2
10-Oct-12	Black Swan	1			Lake Albert	Rumply Point	6077528.323	350910
11-Nov-12	Caspian Tern	10	5		Coorong	North Pelican Island	6010256	370116
27-Dec-12	Caspian Tern	30			Coorong	Pelican Island	6008715	370620
11-Nov-12	Crested Tern	700	220		Coorong	North Pelican Island	6010256	370116
27-Dec-12	Crested Tern	3350	580		Coorong	Pelican Island	6008715	370620
29-Oct-13	Crested Tern	285		320	Coorong	Pelican Island	6008718.0	370632.4
16-Dec-13	Crested Tern	1750		50	Coorong	Teal Island	6010986	370184

Date	Species	Nests	Young	Non-nesting birds	Area	Site	Latitude	Longitude
4-Dec-12	Pied Cormorant	340	250		Lake Alexandrina	Tolderol	6084024.236	333580.2
15-Jan-13	Pied Cormorant	576	180	3	Lake alexandrina	Tolderol	6084149.848	333652.4
16-Dec-13	Pied Cormorant	270		800	Lake Alexandrina	Tolderol	6084084.2	333595.2
15-Jan-13	Royal Spoonbill	10			Lake Albert	Lake Albert	6060780.266	340957.7
16-Dec-13	Royal Spoonbill	20			Tributaries	Currency/Finniss	6071000.0	304461.9
16-Dec-13	Royal Spoonbill	6			Lakes	Goat Island (near Clayton Bay)	6069067	313397
29-Oct-13	Silver Gull	210			Inland Wetland	Muldungawa Salt Lakes	6090395	343038
16-Dec-13	Silver Gull		17		Inland Wetland	Muldungawa Salt Lakes	6090395	343038
10-Oct-12	Straw-necked Ibis	445			Lake Alexandrina	Boggy Lake	6088987.979	334753.2
10-Oct-12	Straw-necked Ibis	160			Lake Albert	Narrung Narrows (East)	6060394.895	340441.6
4-Dec-12	Straw-necked Ibis	161	9		Lake Alexandrina	Boggy Lake	6089683.377	335463.4
4-Dec-12	Straw-necked Ibis	159			Tributaries	Currency Creek	6070352.165	304626.9
4-Dec-12	Straw-necked Ibis	67	3		Lake Alexandrina	Tolderol	6084024.236	333580.2
4-Dec-12	Straw-necked Ibis	1032	10		Lake Albert	Unnamed bay, west of Reedy Point	6061114.906	340994.4

Date	Species	Nests	Young	Non-nesting birds	Area	Site	Latitude	Longitude
29-Oct-13	Straw-necked Ibis	760		100	Lake Alexandrina	Boggy Lake	6089683.4	335463.0
29-Oct-13	Straw-necked Ibis	683			Tributaries	Currency/Finniss	6070959.7	304263.5
29-Oct-13	Straw-necked Ibis	1270			Lake Alexandrina	Tolderol	6084149.8	333652.4
29-Oct-13	Straw-necked Ibis	426			Lake Albert	West Lake Albert	6061114.9	340994.4
16-Dec-13	Straw-necked Ibis		200	50	Lake Alexandrina	Boggy Lake	6089683.4	335463.0
16-Dec-13	Straw-necked Ibis	40			Tributaries	Currency/Finniss	6070959.7	304263.5
16-Dec-13	Straw-necked Ibis	285		100	Lake Alexandrina	Tolderol	6084149.8	333652.4
10-Oct-12	Australian White Ibis	80			Lake Alexandrina	Boggy Lake	6088987.979	334753.2
10-Oct-12	Australian White Ibis	90			Lake Alexandrina	Low Point	6077528.323	350910
10-Oct-12	Australian White Ibis	120			Lake Albert	Narrung Narrows (East)	6060394.895	340441.6
10-Oct-12	Australian White Ibis	30			Lake Albert	Narrung Narrows (West)	6067514.2	336678.4
4-Dec-12	Australian White Ibis	79	28		Lake Alexandrina	Boggy Lake	6089683.377	335463.4
4-Dec-12	Australian White Ibis	20			Lake Alexandrina	Boggy Lake	6089683.377	335463.4

Date	Species	Nests	Young	Non-nesting birds	Area	Site	Latitude	Longitude
4-Dec-12	Australian White Ibis	47			Tributaries	Currency Creek	6071293.711	304594.6
4-Dec-12	Australian White Ibis	72			Tributaries	Currency Creek	6070352.165	304626.9
4-Dec-12	Australian White Ibis	10			Lake Albert	Narrung Narrows	6067085.699	335242.4
4-Dec-12	Australian White Ibis	75			Lake Albert	Narrung Narrows	6068067.025	335506.4
4-Dec-12	Australian White Ibis	13	12		Lake Alexandrina	Point Sturt	6071752.843	317349.5
4-Dec-12	Australian White Ibis	64	5		Lake Albert	Unnamed bay, west of Reedy Point	6061114.906	340994.4
29-Oct-13	Australian White Ibis	422		20	Lake Alexandrina	Boggy Lake	6089683.4	335463.0
29-Oct-13	Australian White Ibis	446			Tributaries	Currency/Finniss	6071293.7	304461.9
29-Oct-13	Australian White Ibis	48			Lake Albert	Narrung Narrows	6067972.0	336423.2
29-Oct-13	Australian White Ibis	40			Lake Alexandrina	Tolderol	6084024.2	333580.2
29-Oct-13	Australian White Ibis	90			Lake Albert	West Lake Albert	6061144.9	340994.4
16-Dec-13	Australian White Ibis		100	100	Lake Alexandrina	Boggy Lake	6089683.4	335463.0

Appendix 4. Summary of additional cryptic bird observations at Lower Lakes' wetland sites between September 2012 and December 2013.

All birds were 'seen' other than one Australasian Bittern, which was 'heard' (indicated in table)

Date	Species	Location	Details	Observer
13/09/2012	Australasian Bittern	Jenny's Lagoon (Loveday Bay)	1 adult	Regina Durbridge
25/10/2012	Australasian Bittern	Waltowa Wetland (Lake Albert)	1 adult	Regina Durbridge
17/12/2012	Australasian Bittern	Jenny's Lagoon (Loveday Bay)	1 adult	Melissa Tucker
17/12/2012	Australasian Bittern	Loveday Bay	1 adult	Melissa Tucker
18/12/2013	Australasian Bittern	Boggy Creek	1 adult calling	Kate Mason
20/01/2013	Australia Crake	Goolwa Bird Hide	2 adults	Eremaea Birdlines record
3/11/2012	Australian Crake	Goolwa (Tokuremoar Reserve)	1 adult	Birdpedia (AUS) record
5/01/2013	Australian Crake	Goolwa Bird Hide	4 adults	Eremaea Birdlines record
5/01/2013	Australian Crake	Goolwa (Tokuremoar Reserve)	3 adults	Birdpedia (AUS) record
13/02/2013	Australian Crake	Goolwa Sewage Ponds	26 adults	Birdpedia (AUS) record
5/01/2013	Baillon's Crake	Goolwa Bird Hide	1 adult	Eremaea Birdlines record
19/09/2013	Baillon's Crake	Milang Snipe Sanctuary	1 adult	Wildlife Surveillance Camera (Kate Mason)
20/12/2013	Baillon's Crake	Milang Snipe Sanctuary	1 adult	Wildlife Surveillance Camera (Kate Mason)
2/09/2012	Buff-banded Rail	Narrung (near Ferry)	2 adults	Graham Warneke
8/09/2012	Buff-banded Rail	Narrung (near Ferry)	1 adult	Teresa Jack
4/01/2013	Buff-banded Rail	Milang-Clayton Road	4 adults	Birdpedia (AUS) record
13/11/2012	Dusky Moorhen	Goolwa North (Alison Avenue)	2 adults, 2 young	Regina Durbridge
10/12/2012	Latham's Snipe	Point Sturt Lagoon	1 adult	Birdpedia (AUS) Record
5/01/2013	Latham's Snipe	Goolwa Bird Hide	3 adults	Eremaea Birdlines record
13/01/2013	Latham's Snipe	Goolwa Bird Hide	3 adults	Eremaea Birdlines record
20/01/2013	Latham's Snipe	Goolwa Bird Hide	1 adult	Eremaea Birdlines record
7/02/2013	Latham's Snipe	Point Sturt	2 adults	Birdpedia (AUS) record
20/01/2013	Spotless Crake	Goolwa Bird Hide	1 adult	Eremaea Birdlines record