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Annual survey of waterbird communities of The Living Murray icon sites

November 2008

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Cover photograph (David Kleinert): Royal spoonbill and Yellow billed spoonbill – Barmah–Millewa Forest.

Summary

1. Waterbird abundance and breeding were concentrated in the Lower Lakes, Coorong and Murray Mouth Icon site which supported a mean total of 134,635 waterbirds, comprising 46 species (96% of survey total), with Cape Barren Geese, Banded Stilt, Australian Shelduck, Great Cormorant and migratory shorebirds.

2. The total numbers of waterbirds surveyed in 2008, represented a 48% decrease on the numbers of waterbirds surveyed at the same time in 2007. This was reflected in decreased abundance across all the more numerous waterbird species and may have partly reflected availability of more habitat elsewhere (e.g. Paroo River system) but also was likely to reflect the increasing degradation of the Lower Lakes.

3. Numbers of waterbirds were considerably lower in 2008 compared to 2007 on four of the six icon sites (Barmah-Millewa, Hattah, River Murray, Lower Lakes and Coorong). Numbers of species were also lower in 2008 compared to 2007 on these four sites.

4. Within the Lower Lakes, Coorong and Murray Mouth Icon site, most waterbirds were distributed in the Coorong (59,645) and Murray Mouth (54,620). Lakes Albert (9,397) and Alexandrina (10,983) supported lower numbers of waterbirds. No waterbird breeding was recorded, a considerable decrease compared to 2007 (3,951 mean breeding index)

5. Water levels in the southern Coorong were low (<40 % full by area) in 2008 while the northern Coorong and lower lakes held considerably more water, they were lower than in 2007.

6. Across all Icon sites, breeding declined sharply in 2008 (76 mean breeding index) compared to the previous year (4,119), and this was confined to one icon site, Chowilla floodplain and Lindsay-Walpolla Islands. Only two species were recorded breeding, White Ibis (71) and Black Swan (5)

7. Severe drought conditions continue to impact on waterbird communities and limit the availability of other wetland, floodplain and riverine habitats throughout the Murray-Darling Basin, with concentrations only found on the Paroo overflow lakes.

8. Wetland habitat in the Barmah-Millewa Forest icon site was restricted to the main river channels and Moira Lake, and waterbird abundance was low.

9. Most shallow floodplain wetland habitat in Gunbower-Koondrook-Perricoota Forest system was dry and few waterbirds were present

10. Wetland habitat in the Chowilla floodplain & Lindsay-Wallpolla Islands icon site was mostly restricted to the main channels although a small number of deeper billabongs still held water. Numbers of waterbirds on lagoons were similar between 2007 and 2008 surveys.

11. River Murray channel sites held water at all sections surveyed between Lake Hume and the Murray mouth in 2008 but supported relatively low numbers and diversity of waterbirds, similar to that observed during the 2007 survey.

Introduction

We report results of aerial surveys of the six icon sites on the River Murray in November 2008. The report of the November 2007 aerial survey (Kingsford and Porter 2008) includes the background to this project and detailed methodology which we have only summarised in this report. There is good evidence of the importance and value of aerial surveys of waterbirds to track changes in waterbird communities at wetland sites (Kingsford 1995, Kingsford & Porter 1994, Kingsford et *al*. 1999, Halse *et al.* 2005; Kingsford and Porter 2009). The survey of icon sites in November 2008 was an aerial waterbird survey that repeated the methodology used to complete a survey of the sites in 2007. Similar aims applied to the 2008 survey as applied in 2007.

Aims

1. Undertake annual aerial waterbird surveys of The Living Murray (TLM) Icon Sites (Barmah-Millewa Forest; Gunbower-Koondrook-Perricoota Forest; Hattah Lakes, Chowilla Floodplain and Lindsay-Wallpolla Islands; Lower Lakes, Coorong and Murray Mouth; River Murray Channel) in November 2008 to coincide with the annual Eastern Australian Waterbird Survey
2. Undertake the surveys at a scale to inform on waterbirds on water bodies and wetlands within Icon Sites.
3. Report on waterbird survey at the icon site and with reference to the 2008 Eastern Australian Waterbird Survey

Methods

Description of methods is repeated in this report. Each Icon site was surveyed twice following standard methods established for aerial surveys of waterbirds in eastern Australia (Braithwaite *et al*. 1986, Kingsford 1999). The first survey was followed immediately by another to provide an estimate of counting error. For the River Murray Channel, a 5 km stretch was randomly selected between icon sites and surveyed twice to provide an unbiased estimate of waterbird use of the channel in different sections of the river. The sections were located as follows:

Icon section	River segment	Location
• Murray 1	Hume Dam-Barmah	35.813^0 S 145.481^0 E west of Tocumwal
• Murray 2	Barmah-Gunbower	35.68^0 S 144.191^0 E east of Barham
• Murray 3	Gunbower-Hattah	35.38^0 S 143.697^0 E east of Swan Hill

- Murray 4 Hattah-Wentworth 34.30^0 S 142.276^0 E east of Mildura
- Murray 5 Chowilla -Coorong 34·873^{0}S 139.515^0 E east of Mannum

Waterbirds were counted in November 2008 from a Cessna aircraft flown at a height of 30-46 m and a speed of 167-204 km/h (90-110 knots), within 150 m of the shoreline, where waterbirds usually congregate (Kingsford & Porter 1994; Kingsford 1999). An observer on each side of the aircraft counted all waterbirds sighted on their side of the aircraft. Waterbird species were identified and their numbers estimated and immediately recorded on digital audio recorders. Nesting birds and those with broods were also identified and counted. Some waterbird species could not reliably be identified to species level from the air and were grouped as follows: small grebes (Australian little grebe; Hoary headed grebe), large egrets (Intermediate Egret and Great Egret), terns (Crested tern; Lesser Crested tern; see Appendix 1) and small and large migratory wading birds (Charadriiformes; see Appendix 1). Wetland percent full (by area) was also estimated for each discrete wetland counted, enabling an index of wetland area to be constructed.

Two count types were used: total and proportional counts. For total counts the whole wetland is circumnavigated while for proportional counts a portion of the wetland (usually > 50 %) is counted. Counts for each species are totalled for each observer to give either a total count for a wetland or a proportional count for the wetland. Counts on proportions of wetlands are then extrapolated to give an index of total waterbird numbers for the whole wetland (Kingsford *et al*. 2004).

Final choice of counting approach was flexible to enable variable waterbird distribution, abundance and wetland composition to be adequately sampled. Additional wetlands outside icon site boundaries were included in an ad-hoc fashion where time allowed, usually with a single count. Within each Icon site, selected water bodies marked on 1:250 000 topographic maps and discrete bodies of open water >1 ha in size were counted separately to allow distribution of waterbird community within the site to be described. Waterbird species were separated into five functional groups (ducks and grebes; herbivores; piscivores; large wading birds and shorebirds) designed to reflect diet and foraging habitat (modified from Kingsford & Porter 1994; see Appendix 1).

Analyses

Waterbird abundance and species richness were compared with ANOVA using SYSTAT v12 software (Systat Inc. 2007). Data were log or fourth root transformed to stabilise variance and improve normality. Differences in waterbird communities among Icon sites, wetlands and replicate counts were compared using analysis of similarities (ANOSIM) (Clarke 1993) with PRIMER v6 software (Clarke & Gorley 2006). A one way global analysis was followed by pair wise comparisons to determine differences. The number of comparisons was generally small relative to the number of replicates, significantly reducing the risk of Type I error (Clarke 1993). A Bray-Curtis dissimilarity matrix of species abundance was calculated after log transformation to reduce heteroscedasticity and reduce the risk of Type I error. As well, we present a comparison of estimates of waterbirds surveyed on each icon site in 2007 compared to 2008.

Similarities and groupings among wetland species assemblages were analysed using hybrid non-metric multidimensional scaling (nMDS) (PRIMER v6 software; Clarke & Gorley 2006). Ordinations were done on a Bray-Curtis dissimilarity matrix (described above). Count replicates with zero individuals (e.g. Gunbower-Koondrook-Perricoota Forest) were omitted to improve comparison among non-zero counts. Configurations were calculated in two dimensions after 50 random starts and Shepard diagrams examined for degenerate solutions (Legendre & Legendre 1998).

Species which discriminated most among survey regions were identified by similarity percentage (SIMPER) analysis (Clarke & Warwick 1994). Average Bray-Curtis dissimilarity ($\overline{\delta}$) between all pairs of inter group samples was calculated from a matrix (47 x 53) of mean wetland species abundance and then decomposed into the separate contributions from each species and expressed as a percentage of average dissimilarity ($\overline{\delta}$).

Results and discussion

The Living Murray (TLM) Icon Wetland Sites supported mean total of more than 139,925 waterbirds, comprising 46 species in 2008. This was 56% of the total number estimated at the same time during Icon aerial surveys in 2007. This represented 58% of the total number of birds estimated by the Eastern Australian Waterbird Survey (EAWS) in 2008 (243,297) (Porter & Kingsford 2008).

Differences in abundance and species richness among icon sites in 2008 were highly significant ($F_{5,6}$=29.25, P<0.001 and $F_{5,6}$=10.45, P<0.011 respectively), similar to relative differences found from the 2007 survey. The Lower Lakes, Coorong and Murray Mouth icon site held 24 times more waterbirds than the other five icon sites combined (Table1; Fig. 1). Icon sites with high abundance also tended to have high species richness (Table 1). The diversity of waterbirds reflected a similar pattern (Table 1; Fig. 1).

Relative abundance of waterbird functional groups varied among icon wetlands (Fig. 2) and this was similar between years. In 2007 and 2008, Hattah Lakes supported proportionally more ducks than any other site, while Barmah-Millewa Forest, Gunbower-Koondrook-Perricoota Forest, Murray Channel and Lake Mulwala were dominated by piscivores. Shorebirds were most prominent on the Lower Lakes, Coorong and Murray Mouth icon site but this relative difference was lower than in 2007, reflecting the decrease in numbers of shorebirds in 2008 (Table 2a & 2b).

Total numbers of waterbirds were considerably lower in 2008 compared to 2007 for four of the six icon sites (2008 data expressed as a percentage of 2007): the Lower Lakes and Coorong (54%), Hattah Lakes (9%), Barmah-Millewa (1.5%) and River Murray (26%) (Table 1). Two of the sites had similar numbers in the two years: Chowilla floodplain and Lindsay-Wallpolla Islands (92%) and Gunbower-Koondrook-Perricoota Forest (138%) (Table 1; Fig. 3). Numbers of species were also lower in 2008 compared to 2007 for the four sites where numbers had decreased but were higher in the other two sites (Table 1, Fig. 3).

Mean total counts (all icon sites combined) of five species exceeded 20,000; Banded Stilt (34,080), Grey Teal (22,391) and Australian Shelduck (25,540) (Table 2b). Other abundant species (>5,000 mean total) were Small waders (10,113), Australian Pelican (5,455), Silver Gull (9,729) and terns (16,437) (Table 2b). All species were found in lower numbers in 2008 compared to 2007 (Table 2a & 2b).

Species less abundant in 2008 compared to 2007 included banded stilts (47%); grey teal (55%); Australian shelduck (68%); great cormorant (29%); terns (78%); small waders (73%); Australian pelicans (49%); silver gulls (26%); black swans (59%); whiskered terns (25%); pied cormorants (12%); straw-necked ibis (5%); Eurasian coot (31%); Pacific black duck (37%); black-winged stilts (19%); large waders (<1%); red-necked avocets (83%); chestnut teal (2%); Australian white ibis (16%) and Cape Barren Geese (13%).

The 2008 EAWS identified nine species as abundant (>5,000): Pink-eared duck (56,958), Grey Teal (52,382), Eurasian Coot (33,229), Plumed Whistling duck (21,261), Australian Pelican (13,501), Black Swan (10,494), Wood duck (6,730), Pacific black duck (6,639) and Hardhead (6,209) (Porter & Kingsford 2008).

EAWS 2008 results indicated severe and widespread drought conditions continued to affect wetlands, floodplains and rivers throughout much of eastern Australia. Trend analyses indicate that the declines in waterbird abundance, wetland area, breeding abundance and breeding species richness are significant (Kingsford & Porter 2009). The EAWS survey region experienced significant flooding in the Paroo-Warrego, Narran Lakes and Gippsland areas, early in 2008, however drought continued to affect wetlands, floodplains and rivers in other parts of eastern Australia. Trend analyses from EAWS data indicated overall declines in waterbird abundance, wetland area, breeding abundance and breeding species richness (Kingsford & Porter 2009), but increases in 2008 compared to the previous five years (Porter and Kingsford 2008).

The Macquarie Marshes, Lowbidgee and southern Menindee Lakes were dry or almost dry. Most rivers in the Murray-Darling Basin were also low with little water on the floodplains. Wetlands in the Gippsland area in the survey band were dry, but flooded shortly afterwards (November 2008). The Paroo overflow lakes and Cuttaburra channels held water after flooding in December 2007 and more than 50,000 waterbirds were recorded. Total waterbird abundance was below average (Fig. 3) and waterbirds were concentrated on a few wetlands. Five wetland systems held more than 66% of total abundance; Lake Galilee (25%, Band 9), Cuttaburra Creek (17%), Paroo overflow (16%), Barwon River (6%) and Cooper Creek waterholes

For the Icon sites in 2008, total mean breeding (nests and broods) abundance of 76 comprised of 2 species; White Ibis (71) and Black Swan (5). This was a considerable decline from 2007 (4,119) and 5 species. Total breeding index (all species combined) for the EAWS was below average but higher than in the two previous years, and concentrated (94%) in two locations – Rhyll Swamp in Band 1, and Lake Galilee in Band 9. Breeding species richness was low, and comprised mainly of three non-game species, White Ibis, Whiskered Tern and Black Swan (92%). Few active breeding sites were recorded elsewhere. Low numbers of waterbirds and breeding were observed on key wetland systems including Cooper Creek, Menindee Lakes, Lowbidgee and Macquarie Marshes extending a sequence of below average years. A combination of drought and long term cumulative effects of river regulation, continues to impact on wetland availability, waterbird abundance and breeding.

Severe drought conditions continued to impact on waterbird communities and limit the availability of other wetland, floodplain and riverine habitats throughout the Murray-Darling basin. Most floodplain or shallow Icon sites were dry or almost dry and supported few waterbirds. The main river channel held water but relatively few birds and with low species richness.

Table 1. Mean abundance and number of waterbird species on The Living Murray Icon Sites and Lake Mulwala in November 2007 and 2008

Icon Wetland	Abundance						Number of species			
	2007			2008			2007		2008	
	mean	%[1]	range	mean	%[1]	range	mean	range	mean	range
Lower Lakes, Coorong and Murray Mouth	249,146	92	198,686-299,606	134,645	96.24	98,131-171,158	42	41-43	37	36-38
Hattah Lakes	16,097	5.93	15,680-16,513	1,476	1.06	846-2,106	23	22-24	13.5	12-15
Chowilla-Lindsay Wallpolla	3,859	1.42	1,706-6,013	3,549	2.54	1,103-5,994	20.5	22-19	24	18-30
Lake Mulwala	1,520	-	-	239	-		8.5	-	14	-
Barmah-Millewa	1,368	0.50	1,146-1,589	21	0.01	18-23	14	14-14	4	3-5
River Murray	739	0.27	722-756	193	0.14	4-381	16.5	16-17	6.5	3-10
Gunbower-Perricoota	31	0.01	9-53	43	0.03	9-53	4	2-6	7	-
Total	271,240			139,904			46		45	

[1] Percent of survey total

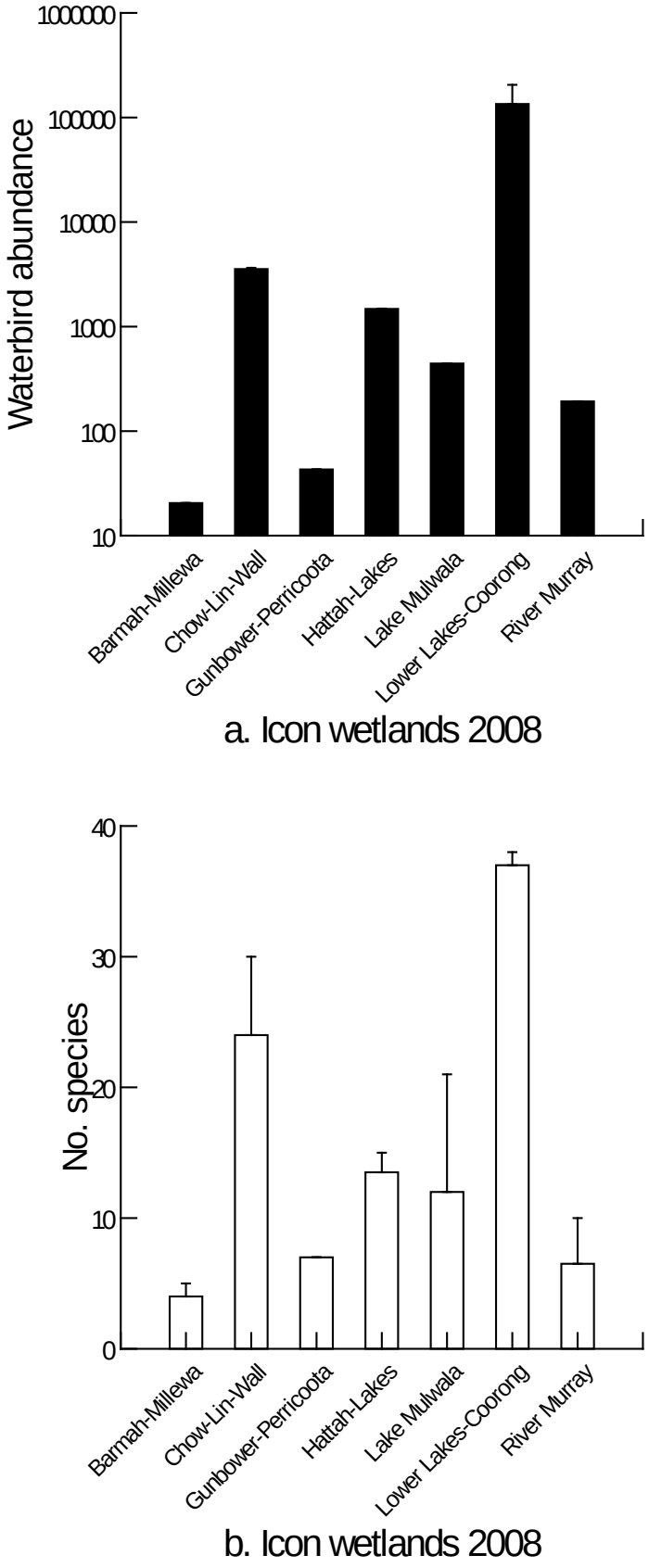

Figure 1. Mean (±se) waterbird abundance (a) and number of species (b) on Murray Icon wetlands and Lake Mulwala in November 2008. Note the log scale on the y-axis of the abundance plot.

Table 2a. Mean waterbird species abundance in TLM icon wetlands, November 2007

Species	Barmah-Millewa	Chowilla Lindsay Wallpolla	Gunbower-Koondrook-Perricoota	Hattah Lakes	Lower Lakes, Coorong, Murray Mouth	River Murray	total
Australasian shoveler	0	0	0	202	605	0	807
Australian Pelican	744	656	1	46	9408	118	10973
Australian shelduck	77	1042	0	50	36138	12	37318
Banded Stilt	0	0	0	0	73164	0	73164
Black Swan	0	490	0	1	6396	154	7041
Black winged stilt	13	0	0	96	2263	0	2372
Black-tailed native hen	0	2	0	16	0	0	18
Cape Barren Geese	0	0	0	0	1111	0	1111
Caspian Tern	0	2	0	0	862	0	864
Chestnut teal	0	0	0	0	1271	0	1271
Darter	1	16	1	1	7	5	30
Dusky moorhen	0	0	0	0	21	0	21
Egrets	27	12	1	3	107	1	150
Eurasian coot	0	474	0	606	1901	0	2980
Freckled duck	0	0	0	0	49	0	49
Glossy Ibis	0	0	0	179	42	14	234
Great Cormorant	5	17	0	24	25443	27	25516
Great crested grebe	0	0	0	0	299	0	299
Grebes	0	0	0	0	12	0	12
Grey Teal	0	351	0	13669	26476	51	40547
Gull billed tern	0	0	0	0	353	0	353
Hardhead	0	3	0	202	204	0	408
Large egret	0	8	0	0	94	0	101
Large wader	0	0	0	0	1574	0	1574
Little black cormorant	45	358	21	7	81	21	531
Little pied cormorant	7	36	1	0	22	10	75
Masked Lapwing	1	3	0	26	180	0	211
Musk Duck	0	0	0	0	45	0	45
Pacific Black duck	29	85	3	78	2664	47	2906
Pacific heron	0	1	0	24	0	2	26
Pied Cormorant	6	10	3	0	3845	4	3867
Pied oystercatcher	0	0	0	0	19	0	19
Pink-eared duck	0	0	0	337	13	0	350
Purple Swamphen	0	0	0	0	93	0	93
Red necked avocet	0	0	0	90	1463	0	1553
Royal spoonbill	94	4	0	0	78	5	181
Silver Gull	0	0	0	0	9729	0	9729
Small waders	0	0	0	265	13499	0	13764
Sooty Oystercatcher	0	0	0	0	8	0	8
Straw necked Ibis	0	0	0	0	3092	103	3195
Tern	0	0	0	0	21032	0	21032
Whiskered tern	147	0	0	2	3822	0	3971
White faced heron	21	5	0	7	36	25	92
White Ibis	60	15	0	1	1087	19	1181
Wood duck	12	257	1	21	25	121	437
Yellow billed spoonbill	80	17	0	149	514	2	762

Table 2b. Mean waterbird species abundance in TLM icon wetlands, November 2008

Species	Barmah-Millewa	Chowilla Lindsay Wallpolla	Gunbower-Koondrook-Perricoota	Hattah Lakes	Lower Lakes, Coorong	River Murray	total
Australasian shoveler	0	0	0	0	58	0	58
Australian Pelican	14	626	20	38	4673	95	5455
Australian shelduck	0	107	0	33	25401	0	25540
Banded Stilt	0	18	0	0	34063	0	34080
Black Swan	0	450	2	18	3687	27	4182
Black winged stilt	0	10	0	78	354	0	442
Black-tailed native hen	0	7	0	0	0	0	7
Cape Barren Geese	0	0	0	0	141	0	141
Caspian Tern	0	2	0	0	233	0	234
Chestnut teal	0	0	0	0	31	0	31
Darter	0	9	0	0	0	1	10
Double-banded plover	0	0	0	0	25	0	25
Egrets	1	12	2	0	29	1	43
Eurasian coot	0	490	0	0	424	17	930
Glossy Ibis	0	3	0	0	0	0	3
Great Cormorant	3	38	0	0	7484	4	7528
Great crested grebe	0	0	0	0	1	0	1
Grebes	0	0	0	0	315	0	315
Grey Teal	0	401	0	759	21231	0	22391
Gull billed tern	0	1	0	0	1	0	2
Hardhead	0	499	0	34	934	0	1466
Large egret	0	4	0	0	18	0	21
Large wader	0	0	0	0	5	0	5
Little black cormorant	0	176	4	0	271	24	472
Little pied cormorant	1	16	4	0	2481	0	2499
Masked Lapwing	0	0	0	16	22	0	37
Musk Duck	0	1	0	0	20	0	20
Pacific Black duck	3	163	4	137	758	3	1065
Pacific heron	0	0	0	2	0	0	2
Pied Cormorant	0	85	0	0	362	19	466
Pied oystercatcher	0	0	0	0	6	0	6
Pink-eared duck	0	10	0	30	15	0	55
Purple Swamphen	0	1	0	0	0	0	1
Red necked avocet	0	0	0	182	1105	0	1286
Royal spoonbill	0	22	0	0	45	0	67
Silver Gull	0	3	0	0	2516	0	2518
Small waders	0	0	0	50	10063	0	10113
Sooty Oystercatcher	0	0	0	0	3	0	3
Straw necked Ibis	0	0	0	0	158	0	158
Tern	0	2	0	0	16435	1	16437
Whiskered tern	0	10	0	0	985	0	995
White faced heron	0	2	0	16	30	0	48
White Ibis	0	49	0	0	139	0	188
Wood duck	0	311	7	40	0	3	358
Yellow billed spoonbill	0	28	0	47	135	0	209

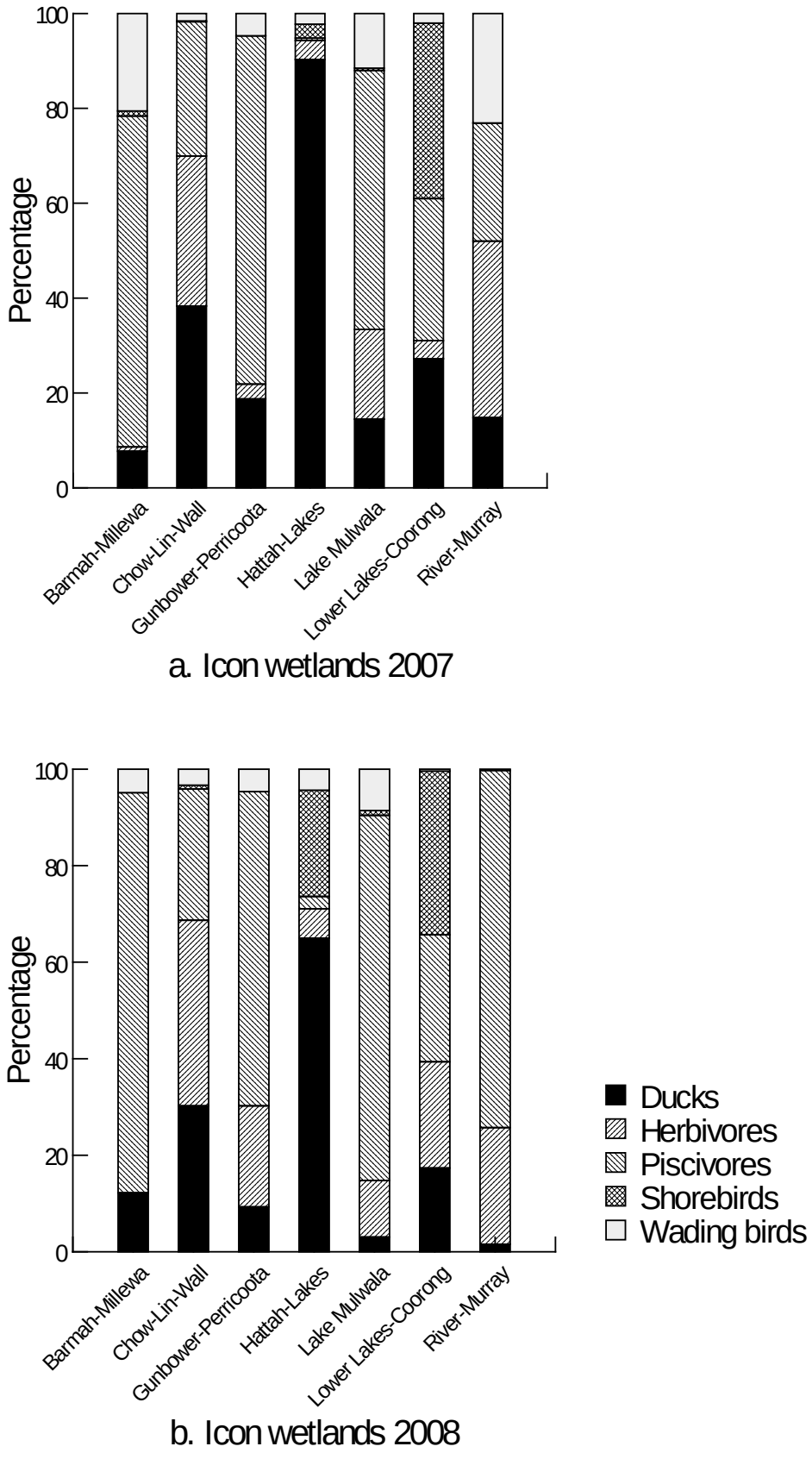

Figure 2. Relative abundance of five waterbird functional groups among icon wetlands and Lake Mulwala in 2007 (a) and 2008 (b)

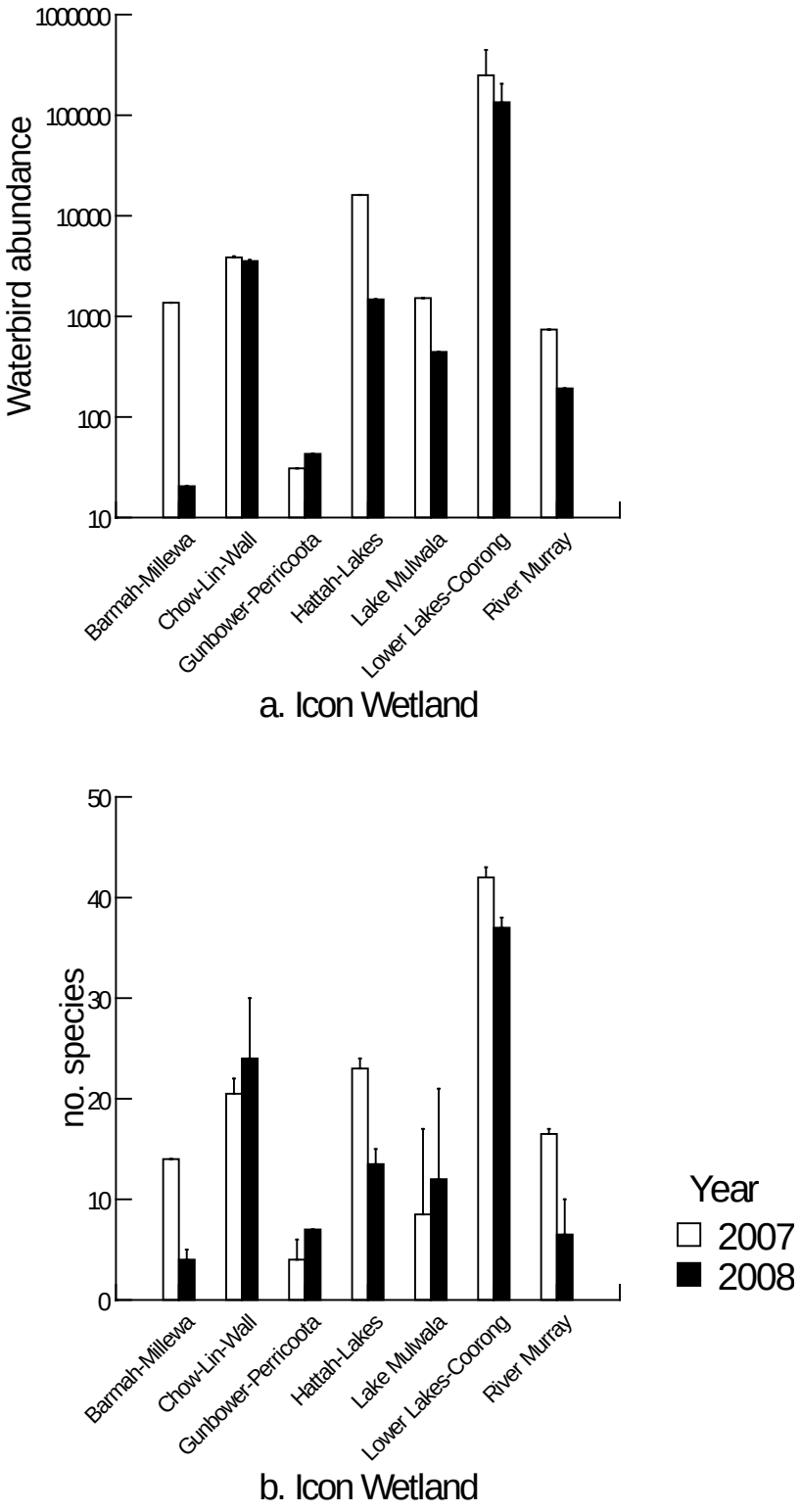

Figure 3. Comparison among icon wetlands of (a) waterbird mean abundance (±se) and (b) species richness (±se) estimates in 2007 and 2008 aerial surveys. Note the log scale on the y-axis of the abundance plot.

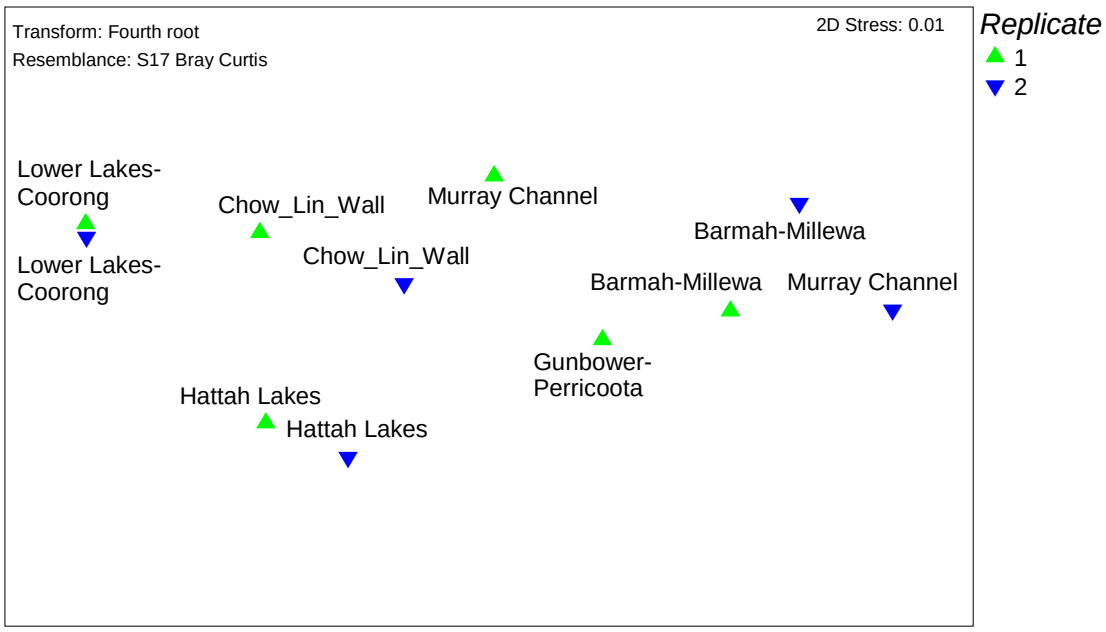

Figure 4. Ordination plot (nMDS) of Icon wetland species abundance in replicate counts, 2008. One replicate count with zero birds (Gunbower-Perricoota) was omitted from the ordination to improve the comparison among non-zero counts.

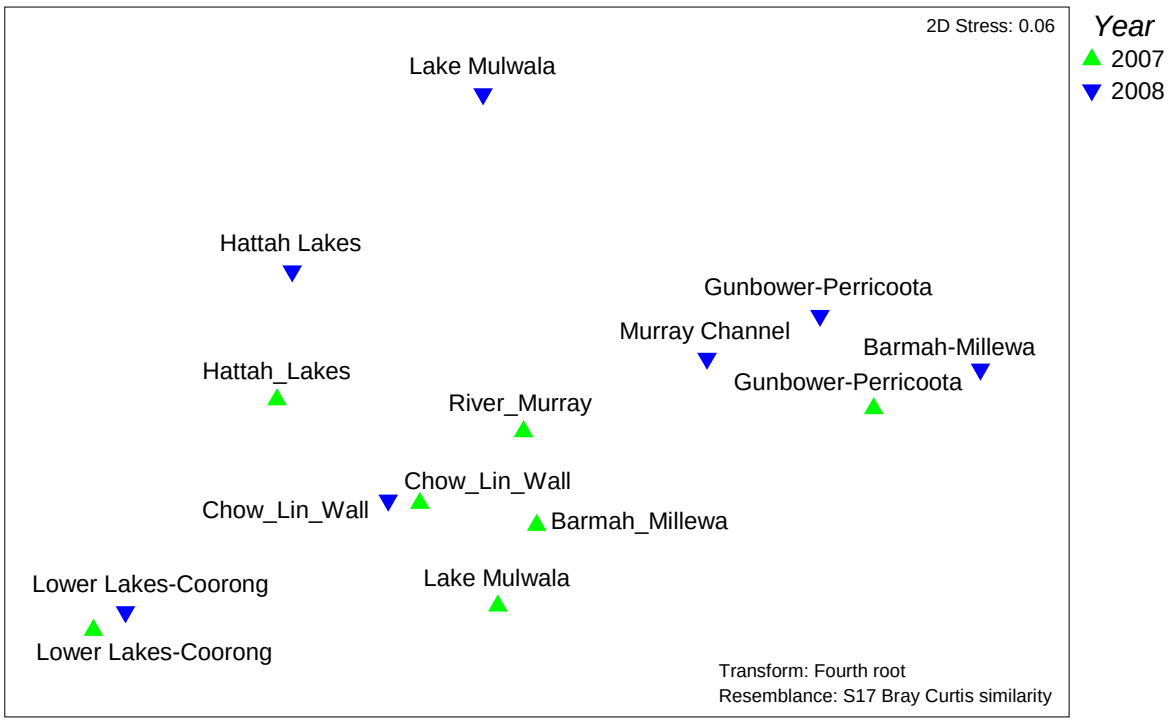

Figure 5. Ordination plot (nMDS) of Icon wetland mean species abundance in 2007 and 2008.

Waterbirds species assemblages in 2008 differed significantly among Icon sites (global *R*=0.25; *P*<0.001; Fig.3). There was no significant overall difference in the species abundances recorded in replicate counts of icon wetlands (global *R*=-0.131; *P*=0.820; Fig.4). This indicates that overall, survey methodology was consistent and waterbird mobility did not unduly bias results. Differences in replicate counts of icon sites was most pronounced where mean abundance was low (e.g. Murray Channel; Table 1, Fig.4). There were also clear similarities in assemblages over time (2007-2008) in some icon sites (Lower Lakes and Coorong Fig. 5). The forest habitats (Barmah-Millewa; Gunbower-Koondrook-Perricoota) and Lake Mulwala with low numbers of waterbirds had less consistent patterns over the two years.

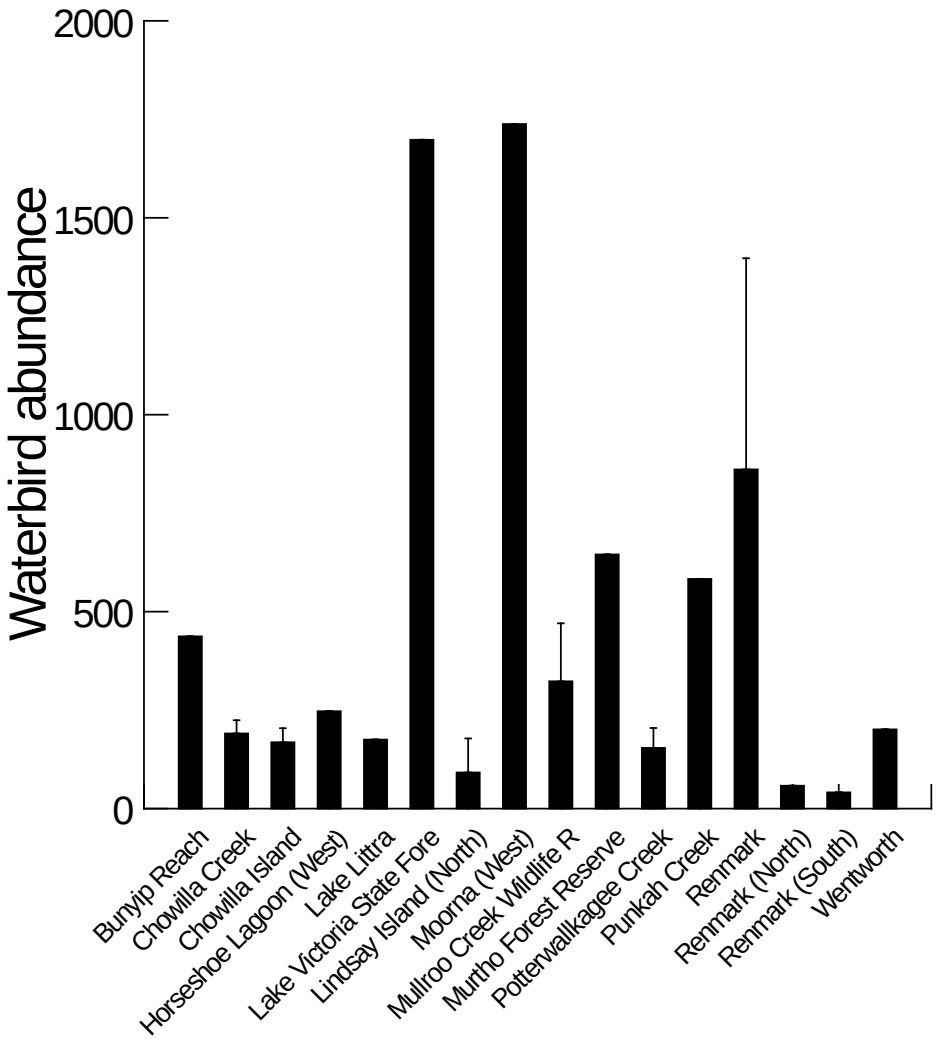

Figure 6. Mean waterbird abundance (±se) on wetland sections within Chowilla Floodplain and Lindsay-Walpolla Islands Icon site

Lower Lakes, Coorong and the Murray Mouth Icon site

Waterbirds were strongly concentrated in the Lower Lakes, Coorong and Murray Mouth Icon site which supported more than 134,645 (96%) of waterbirds surveyed, (Table 1). Total numbers in 2008 were only 54% of counts from 2007 survey. The site had the highest species richness (37) of any icon site, supporting large numbers of Banded Stilt, Australian Shelduck, Great Cormorant, Grey Teal, Terns and migratory shorebirds (Table 2b).

Most species were in lower numbers in 2008 compared to 2007 and the number of species identified were also lower in 2008 (Table 1; Fig. 1). No waterbird breeding was recorded at this site. Four discrete wetland sections which were counted– Murray Mouth, Lake Alexandrina, Lake Albert, and Coorong. The Coorong (59,646 mean total) and Murray Mouth (54,620) sections supported the most waterbirds.

Water extent in Lakes Alexandrina and Albert was estimated at 90% full (nb: surface area, not linearly related to volume). The northern coorong was near full while levels in the southern Coorong were low (<40 % full) and the area supported fewer waterbirds than the northern Coorong; Fig. 4).

Hattah Lakes Icon Site

Hattah Lakes held little water and consequently few birds (Table 1; Fig. 1). There were considerably fewer birds in 2008 compared to 2007 (Table 2a & 2b). The most numerous species were Grey Teal, Avocet and Pacific black duck (Table 2b).

Chowilla Floodplain & Lindsay-Wallpolla Islands Icon Site

Wetland habitat in the Chowilla & Lindsay Wallpolla icon site was mostly restricted to the main channels although a small number of deeper billabongs still held water (Fig.6). There were similar numbers of waterbirds and more species in 2008 compared to 2007 (Table 1). Most abundant species included Australian pelicans, Black Swans, Eurasian coot, Grey Teal and Hardhead (Table 2b).

Barmah-Millewa Forest Site

Wetland habitat in the Barmah-Millewa Forest icon site was restricted to the main river channels and Moira Lake, and waterbird abundance was low (Table 1; Fig.1). Numbers of waterbirds in 2008 were only 1.5% of numbers in 2007 and there was a considerable reduction of the number of species (Table 1). Anecdotal evidence suggests changes in vegetation cover (increased tall emergents) and loss of open water areas may impact on waterbird communities; this could be examined quantitatively in future reports if adequate vegetation mapping data becomes available.

River Murray Channel Icon Site

River Murray channel sites held water at all sections surveyed between Lake Hume and the Murray mouth but supported relatively low numbers and diversity of waterbirds (Fig.3).

Gunbower-Koondrook-Perricoota Forests Icon Site

Water was only confined to the main channel of the River Murray where there were few waterbirds (Table 1; Fig.3). Numbers 2008 were similar to estimates from 2007.

Additional Site – Lake Mulwala

Lake Mulwala supported 239 waterbirds (only a single count was done on this wetland) and 14 species. A small breeding colony of around 50 Pelicans and 20 White Ibis was recorded. Waterbird abundance was an order of magnitude lower compared to 2007.

Conclusions

The 2008 Icon survey results highlight the significance of the Lower Lakes, Coorong and Murray Mouth wetlands for waterbirds. These wetlands held more than 96% of total waterbird numbers across all six icon sites. Our findings agree with longer term EAWS results which identify the Coorong as consistently supporting large concentrations of waterbirds, making it one of the most important wetlands in Eastern Australia (Kingsford & Porter 2009). The Coorong wetlands are critically important for migratory shorebirds, which are known to be in serious decline across eastern Australia (Nebel *et al*. 2008). Between the 1980s until 2006, the mean number of shorebirds surveyed in the EAWS has declined by 77% (Nebel *et al*. 2008).

The total numbers of waterbirds surveyed in 2008 represented a 48% decrease on the numbers surveyed in 2007. Abundances were considerably lower in 2008 compared to 2007 on four of the six icon sites (Barmah-Millewa, Hattah, River Murray, Lower Lakes and Coorong). Numbers of species were also lower in 2008 compared to 2007 on these four sites. These may have partly reflected availability of more habitat elsewhere (e.g. Paroo River system) but also were likely to reflect the increasing degradation of the Lower Lakes and other icon sites. Drought, declines in wetland area and the impacts of river regulation may explain some of these declines (Nebel *et al*. 2008). Large scale flooding in eastern and central Australia was limited to the Paroo-Warrego in early 2008 (Kingsford *et al*. 2009)

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References

Braithwaite, L.W., Maher, M., Briggs, S.V. and Parker, B.S. (1986) An aerial survey of three game species of waterfowl (Family Anatidae) in eastern Australia. *Australian Wildlife Research* **13**, 213-23.

Clarke, K. R. (1993). Non-parametric multivariate analysis of changes in community structure. *Australian Journal of Ecology* **18**, 117-143.

Clarke, K.R. and Gorley, R.N. (2006) PRIMER V6: User Manual/Tutorial. Plymouth, UK, Primer-E Ltd.

Clarke, K. R. and Warwick, R. M. (1994). 'Change in Marine Communities: an approach to statistical analysis and interpretation.' (Natural Environment Research Council: UK.)

Halse, S.A., Pearson, G.B., Hassell, C., Collins, P., Scanlon, M.D., and Minton, C.D.T. (2005). Mandora Marsh, north-western Australia, an arid-zone wetland maintaining continental populations of waterbirds. *Emu* **105**, 115-125.

Kingsford, R. T. (1995). Occurrence of high concentrations of waterbirds in arid Australia . *Journal of Arid Environments* **29**, 421-425.

Kingsford, R.T. (1999) Aerial survey of waterbirds on wetlands as a measure of river and floodplain health. *Freshwater Biology* **41**, 425-438.

Kingsford, R.T., Jenkins K.M., and Porter, J.L. (2004) Imposed hydrological stability on lakes in arid australia and effects on waterbirds . *Ecology* **85**, 2478-2492.

Kingsford, R.T. and Porter, J.L. (1994) Waterbirds on an Adjacent Freshwater Lake and Salt Lake in Arid Australia. *Biological Conservation* **69**, 219-228.

Kingsford, R.T. and Porter, J.L. (2008) Survey of waterbird communities of the Living Murray icon sites-November 2007. Report to the Murray-Darling Basin Commission, University of NSW, Sydney.

Kingsford R.T**.** and Porter J.L. (2009). Monitoring waterbird populations with aerial surveys – what have we learnt? *Wildlife Research* 36, 29-40.

Kingsford, R.T., Wong, P.S., Braithwaite, L.W., and Maher, M.T. (1999) Waterbird abundance in eastern Australia, 1983-92. *Wildlife Research* **26**, 351-366.

Legendre, P. and Legendre, L. Numerical Ecology (1998) Amsterdam, Elsevier Science B.V. Developments in Environmental Modelling.

Porter, J.L. & Kingsford, R.T. (2008) Summary of Aerial Survey of Wetland Birds in Eastern Australia - October 2008. University of NSW Report pp.29

Systat Inc. (2007). SYSTAT 12. San Jose, California USA.

Appendix 1. Waterbird species and functional groups identified during aerial surveys.

Table A1.

Waterbirds	Specific name	Waterbirds	Specific name
Great Crested Grebe (d)	*Podiceps cristatus*	Brolga (lw)	*Grus rubicundus*
[a]Small grebes (d)		Comb-crested Jacana	*Irediparra gallinacea*
Hoary-headed Grebe	*Poliocephalus poliocephalus*	Pied Oystercatcher (sh)	*Haematopus longirostris*
Australasian Grebe	*Tachybaptus novaehollandiae*	Masked Lapwing (sh)	*Vanellus miles*
Australian Pelican (p)	*Pelecanus conspicillatus*	Banded Lapwing (sh)	*Vanellus tricolor*
Darter (p)	*Anhinga melanogaster*	Black-winged Stilt (sh)	*Himantopus himantopus*
Great Cormorant (p)	*Phalacrocorax carbo*	Banded Stilt (sh)	*Cladorhynchus leucocephalus*
Pied Cormorant (p)	*Phalacrocorax varius*	Red-necked Avocet (sh)	*Recurvirostris novaehollandiae*
Little Black Cormorant (p)	*Phalacrocorax sulcirostris*	[a]Large waders (sh)	
Little Pied Cormorant (p)	*Phalacrocorax melanoleucos*	Eastern Curlew	*Numenius madagascariensis*
Pacific Heron (lw)	*Ardea pacifica*	Whimbrel	*Numenius phaeopus*
White-faced Heron (lw)	*Ardea novaehollandiae*	Little Curlew	*Numenius minutus*
Great Egret (lw)	*Ardea alba*	Bar-tailed Godwit	*Limosa lapponica*
[a]Small egrets (lw)		Black-tailed Godwit	*Limosa nebularia*
Intermediate Egret	*Ardea intermedia*	[a]Small waders (sh)	
Little Egret	*Ardea garzetta*	Grey Plover	*Pluvialis squatorola*
Cattle Egret	*Ardea ibis*	Lesser Golden Plover	*Pluvialis dominica*
Nankeen Night Heron (lw)	*Nycticorax caledonicus*	Mongolian Plover	*Charadrius mongolus*
Black-necked Stork (lw)	*Xenorhynchus asiaticus*	Double-banded Plover	*Charadrius bicinctus*
Glossy Ibis (lw)	*Plegadis falcinellus*	Black-fronted Plover	*Charadrius melanops*
Australian White Ibis (lw)	*Threskiornis aethiopica*	Red-capped Plover	*Charadrius ruficapillus*
Straw-necked Ibis (lw)	*Threskiornis spinicollis*	Ruddy Turnstone	*Arenaria interpres*
Royal Spoonbill (lw)	*Platalea regia*	Grey-tailed Tattler	*Tringa brevipes*
Yellow-billed Spoonbill (lw)	*Platalea flavipes*	Common Sandpiper	*Tringa hypoleucos*
Magpie Goose (h)	*Anseranas semipalmata*	Marsh Sandpiper	*Tringa stagnatilis*
Plumed Whistling-duck (d)	*Dendrocygna eytoni*	Terek Sandpiper	*Tringa terek*
Wandering Whistling-duck (d)	*Dendrocygna arcuata*	Greenshank	*Tringa nebularia*
Black Swan (h)	*Cygnus atratus*	Red Knot	*Calidris canutis*
Freckled Duck (d)	*Stictonetta naevosa*	Great Knot	*Calidris tenuirostris*
Cape Barren Goose (h)	*Cereopsis novaehollandiae*	Sharp-tailed Sandpiper	*Calidris acuminata*
Australian Shelduck (d)	*Tadorna tadornoides*	Red-necked Stint	*Calidris ruficollis*
Radjah Shelduck (d)	*Tadorna radjah*	Curlew Sandpiper	*Calidris ferruginea*
Pacific Black Duck (d)	*Anas superciliosa*	Broad-billed Sandpiper	*Limicola falcinellus*
Mallard (d)	*Anas platyrhynchos*	Red-kneed Dotterel	*Erthrogonys cintus*
Grey Teal (d)	*Anas gracilis*	Latham's snipe	*Gallinago hardwickii*
Chestnut Teal (d)	*Anas castanea*	Silver Gull (p)	*Larus novaehollandiae*
Australasian Shoveler (d)	*Anas rhynchotis*	Pacific Gull (p)	*Larus pacificus*
Pink-eared Duck (d)	*Malacorhynchus membranaceus*	Whiskered Tern (p)	*Sterna hybrida*
Hardhead (d)	*Aythya australis*	Gull-billed Tern (p)	*Sterna nilotica*
Australian Wood Duck (d)	*Chenonetta jubata*	Caspian Tern (p)	*Hydroprogne caspia*
Cotton Pygmy-goose (d)	*Nettapus coromandelianus*	[a]Terns (undifferentiated) (p)	
Green Pygmy-goose (d)	*Nettapus pulchellus*	Silver Gull	*Larus novaehollandiae*
Blue-billed Duck (d)	*Oxyura australis*	Pacific Gull	*Larus pacificus*
Musk Duck (d)	*Biziura lobata*	Whiskered Tern	*Sterna hybrida*
Black-tailed Native-hen (h)	*Gallinula ventralis*	Gull-billed Tern	*Sterna nilotica*
Dusky Moorhen (d)	*Gallinula tenebrosa*	Caspian Tern	*Hydroprogne caspia*
Purple Swamphen (h)	*Porphyrio porphyrio*	Crested Tern	*Sterna bergii*
Eurasian Coot (h)	*Fulica atra*	Lesser crested Tern	*Sterna bengalensis*
		White-winged black Tern	*Chlidonias leucopterus*

[a] Species that could not be separated during aerial surveys. Funtional groups are: ducks and grebes (d); herbivores (h); shorebirds (sh); piscivores (p) and large wading birds (lw).

Appendix 2. Eastern Australian Waterbird Survey - 2008 summary results (Porter & Kingsford 2008)

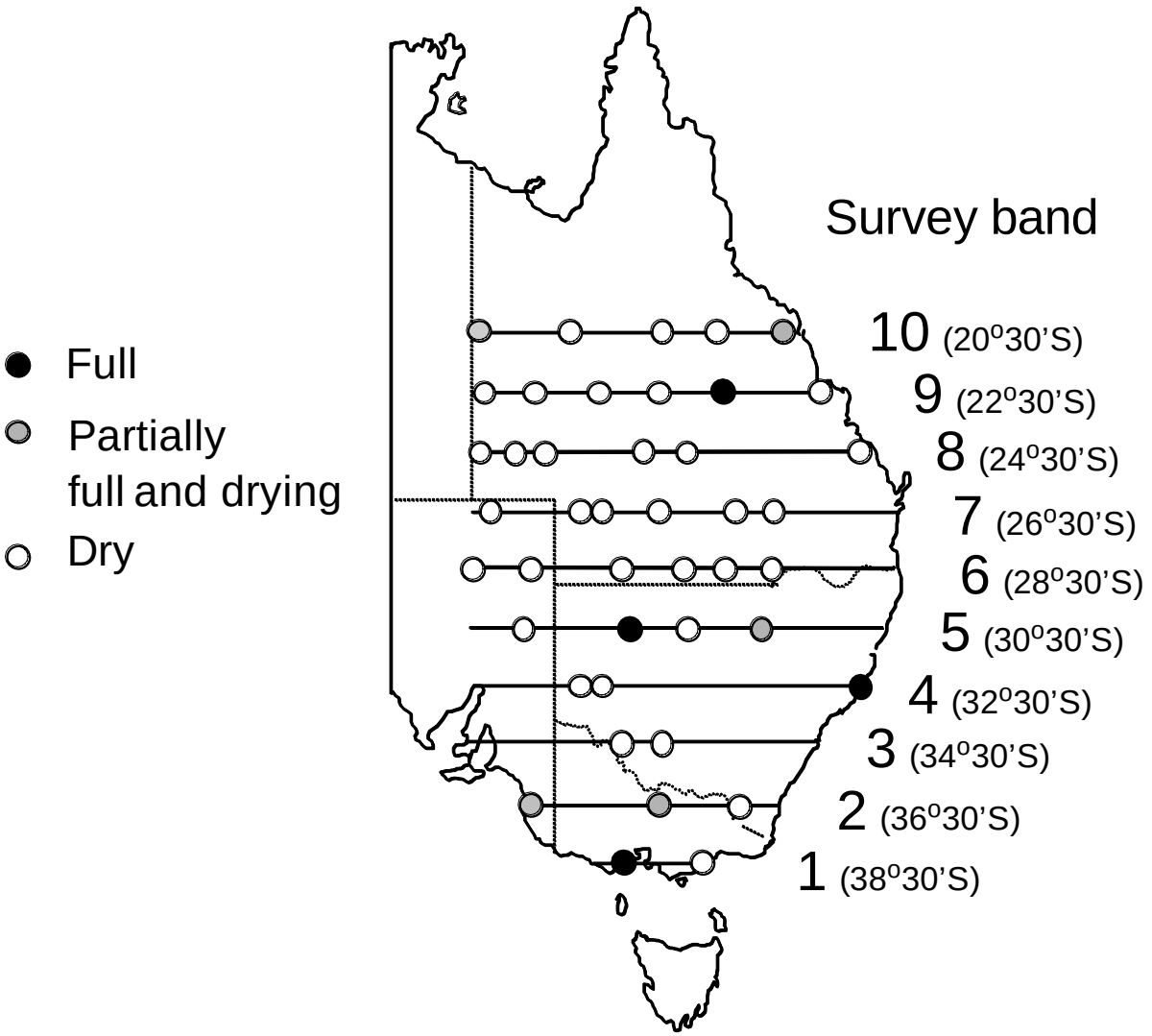

Fig. A2.1 Key to important wetlands in the EAWS from W-E, by band (1-10)

10 Lake Moondarra, Cloncurry River, Flinders River, Campaspe R, Burdekin R
9 Georgina R, Eyre Ck, Hamilton R, Diamantina R, Lake Galilee, Styx R
8 Mumbleberry-Torquinnie Lakes, Eyre Ck, Diamantina R, Thomson R, Barcoo R, various small coastal wetlands
7 Goyder Lagoon, Lake Yamma Yamma, Cooper Ck, Bulloo R, Paroo R, Warrego R
6 Lake Eyre, Lake Hope, Bulloo R, Paroo R, Warrego R, Balonne R,
5 Lake Frome, Paroo O'flow, Darling R, Macquarie Marshes
4 Menindee Lakes, Talyawalka Lakes, Myall Lakes
3 Murray River Lakes, Lowbidgee Swamp
2 Coorong, Cooper and Mokoan Lakes, Cooma-Monaro
1 Curdies Inlet, Jack Smith Lake