Condition Monitoring of the Lower Lakes, Coorong and Murray Mouth Icon

Site: Waterbirds 2013

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June 2013

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

Australian Government

MURRAY–DARLING BASIN AUTHORITY

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Image on front page: Sharp-tailed Sandpipers and Red-necked Stints foraging in the Coorong.
Image courtesy of David Paton

Executive Summary

Over 283,000 waterbirds were counted using the Coorong and Lower Lakes in summer 2013. Two thirds of the birds (around 186,000) were using the Coorong with the Lower Lakes supporting nearly 98,000. Ten species of waterbird had abundances in excess of 10,000 birds: Grey Teal (*Anas gracilis*), Australian Shelduck (*Tadorna tadornoides*), Pied Cormorant (*Phalacrocorax varius*), Great Cormorant (*Phalacrocorax carbo*), Red-necked Stint (*Calidris ruficollis*), Sharp-tailed Sandpiper (*Calidris acuminata),* European Coot (*Fulica atra),* Silver Gull *Chroicocephalus novaehollandiae*),, Whiskered Tern (*Chlidonias hybridus*), and Australian Pelican (*Pelecanus conspicillatus).* Except for the two cormorants, these species were more prominent in the Coorong than they were in the Lower Lakes. Two other species exceeded 5000 individuals: Chestnut Teal (*Anas castanea*) which were mainly using the Coorong and Pacific Black Ducks (*Anas superciliosa*) which were mainly using the freshwater wetlands of the Lower Lakes.

Of the 73 species of waterbirds detected during the 2013 count, 19 were found primarily using the Lower Lakes, 29 primarily used the Coorong and 25 used both wetland systems to a reasonable extent. The two wetlands provide complementary resources that support different waterbird communities. The waterbirds using the Coorong, however, were unique, as they included a range of migratory and endemic shorebirds and coastal species not prominent elsewhere within the Murray Darling Basin.

The abundances of most species have increased over the last 3-5 years and a wide variety of species were present in higher abundances in 2013 suggesting that their populations could still be recovering. Further annual counts will be required to determine if their populations are still recovering. Several species however continued to decline including both species of spoonbill. Pied Oystercatchers (*Haematopus longirostris*) were in their lowest abundances recorded, and Fairy Terns (*Sternula nereis*) and Common Greenshanks (*Tringa nebularia*) had not returned to the abundances recorded prior to the start of the millennium drought. These poor responses are of concern and highlight a need for a series of autecological studies on a range of waterbird species using the region to understand causes for decline and so manage the waterbird communities of the region more effectively.

One of the major changes over the last five years has been the loss of extensive areas of mud flat covered with shallow water in the Lower Lakes. Although these were formed by the exceptionally low water levels in the Lower Lakes in 2009 and 2010, they illustrated the importance of these habitat features to shorebirds. Since the return of flows to the Murray, water levels in the Lower Lakes have returned to the more typical managed water levels and those habitats have all but been excluded from the Lower Lakes. Many other waterbirds are also tied to shallow water habitats and there may be merit in exploring the options to lower the managed levels to increase areas of suitable habitat for waterbirds in the Lower Lakes.

Although numbers of waterbirds using a wetland are largely used to indicate the importance of a wetland for particular species, numbers alone may be misleading. First the numbers of birds using a wetland in any one year may be influenced by the availability and condition of other wetlands within a region or even beyond. Thus low abundances in anyone year may indicate other wetlands are supporting a species, while high abundances may indicate that other wetlands are not available. Large numbers of waterbirds, then, is an indication of importance in that year, while low abundances may not be overly informative. Second, and importantly the quality of a wetland may also depend on the ease with which various species of waterbirds can harvest resources, and so some assessment of the behaviour of birds using a wetland is also required to assess the quality of an area. For the Coorong and Lower Lakes, the effort required by different species to harvest food

differed greatly. Most fish-eating species were only spending a small proportion of their time foraging consistent with good abundances of suitable prey. These contrasted with the effort required by some of the abundant shorebirds. For example, more than 80% of the individual Red-necked Stints, Sharp-tailed Sandpipers, Banded Stilts (*Cladorhynchus leucocephalus*) and Red-capped Plovers (*Charadrius ruficapillus*) counted in 2013 were foraging and sometimes more than 90%. Selected waterfowl (such as the Grey Teal) may also be spending large amounts of their time foraging in parts of the Coorong. High levels of foraging suggest the available habitats were not of high quality for these species. For the Coorong this is not surprising given that the key aquatic macrophyte *Ruppia tuberosa* had still not recovered to any extent, despite suitable salinities being in place for the last two years. The failure of this plant to recovery is consistent with the loss of its seed bank during the last 10 years. Recovery of this species will depend on translocating seeds back into the Coorong from other wetlands and on re-instating adequate flows over the Barrages during spring. While *Ruppia tuberosa* remains absent from its former range, the full recovery of the waterbird communities of the Coorong is unlikely. Ongoing monitoring of both the plants and the birds is required.

Introduction

The Lower Lakes, Coorong and Murray Mouth (LLCMM) region is a Wetland of International Importance under the Ramsar Convention and is one of the The Living Murray's (TLM) icon sites within the Murray-Darling Basin. Large numbers of small migratory and non-migratory waders (sandpipers, plovers, stilts), piscivorous birds (pelicans, cormorants, grebes, terns) and waterfowl (swans, ducks) use components of this wetland system, particularly during summer (e.g. Paton 2010). This abundance and diversity of waterbirds was one of the prime reasons for the LLCMM region being listing as a Wetland of International Importance. Most waterbirds use the shallow but often highly productive margins of wetlands, and the permanent wetlands of the Coorong and Lower Lakes have historically provided extensive areas of shallow productive wetland habitat, even in droughts.

Waterbird use of the Lower Lakes has been assessed annually since 2009, while the Coorong and Murray Mouth region has been assessed annually since 2000 with the counts taking place during summer when the extent of birds using these wetlands is highest (Paton 2010). These systematic counts are then used to document changes in the distributions and abundances of waterbirds within the different components of the LLCMM and in recent years this annual census has been used to assess various waterbird-related targets (e.g. Paton & Bailey 2012a,b) listed in the LLCMM Icon Site Condition Monitoring Plan (Maunsell 2009). Amongst these targets is target B-1 - *to maintain or improve bird populations in the Lower Lakes, Coorong and Murray Mouth.* This report presents the results of the 2013 summer waterbird census for the LLCMM region as a whole. In the past separate reports on waterbird use have been provided for the two major systems, one on waterbird use of the freshwater wetlands of the Lower Lakes (e.g. Paton & Bailey 2012a) and a separate report for the estuarine to hypersaline wetlands of the Coorong (Paton & Bailey 2012b). These two wetland systems are complementary in terms of the wetland systems that they provide but also as they are likely to exchange waterbirds on a regular basis. For these reasons the counts from both monitoring areas have been combined in this report.

The annual counts of waterbirds within the LLCMM need to be placed in context, the context of a wetland system that is recovering from severe perturbations that resulted in the quality of wetland habitats deteriorating for waterbirds. With these wetlands now recovering post drought, a key focus for the current waterbird monitoring was to establish if the waterbird communities had also recovered. To appreciate any recovery requires an understanding of the extent to which these wetland systems were perturbed and the causes of those perturbations.

Over the last decade, there were dramatic changes to the hydrology of the LLCMM region. These changes have been attributed to an extensive drought within the Murray-Darling Basin during most of this period, coupled with on-going over-extraction of water for human use. Within the Lower Lakes, water levels during 2009 and most of 2010 were consistently below sea-level (-0.7m to -0.9m AHD in Lake Alexandrina; and -0.5m AHD in Lake Albert). This resulted in the waterline disconnecting from the fringing vegetation, along with an increased risk of acid-sulfate soils being exposed to the air, leading to potential acidification. For the Coorong and Murray Mouth there were no substantial River Murray flows over the barrages for almost eight years between 2002-2010. During this period the Mouth and associated channels had to be dredged to keep the Murray Mouth open. The lack of environmental flows also affected the ecology of the Coorong, disrupting seasonal patterns to water levels and resulting in the accumulation of excessive amounts of salt in the South Lagoon (Paton 2010). These hydrological changes led to changes in the distributions and abundances of key aquatic food resources (plants, invertebrates and fish) used by waterbirds. As the salinities increased the distributions of the salt tolerant fish, the small-mouthed hardyhead (*Atherinosoma microstoma*) and the salt-tolerant chironomid (*Tanytarsus barbitarsis*) retracted to

the North Lagoon. From 2007 onwards both were absent from the South Lagoon when salinities exceeded 150gL^{-1}. However brine shrimps (*Parartemia zietziana*) that had not been previously recorded in the Coorong thrived in the South Lagoon and southern reaches of the North Lagoon during this period. The other major change to food resources was the loss of the key aquatic macrophyte *Ruppia tuberosa*. These ecological changes in turn affected the distributions and abundances of waterbirds with many piscivorous and herbivorous bird species forced to vacate the South Lagoon (Paton 2010).

During the latter half of 2010, extensive rains within the Murray-Darling Basin brought floods to the River Murray and flows returned to the Lower Lakes. Water levels returned to the more typical managed water levels of around +0.65m AHD in 2011 and 2012. With these changes in water levels there were dramatic changes in the waterbird communities using the Lower Lakes. For example in 2009 and 2010 there were tens of thousands of stints and sandpipers foraging around the shorelines of the Lower Lakes taking advantage of rarely exposed mudflats. However in spring 2010 water levels in the lakes were re-instated to more typical levels, covering the extensive areas of mudflat that were covered with shallow water in 2009 and 2010 with deep water. This excluded wading birds like stints and sandpipers and consequently they had all but disappeared from the Lower Lakes when the counts were undertaken in January 2011 (e.g. Paton & Bailey 2010, 2011a). In January 2011, slightly fewer than 40,000 waterbirds were using the Lower Lakes, compared to 80,000-110,000 in the previous two years; with many species having declined in abundance (Paton & Bailey 2011a). A few species, however, were increasing in abundance and distribution in January 2011 and these and other species had increased further in abundance and distribution by January 2012. However the current management to maintain water levels in the Lower Lakes at above +0.65 m AHD led to few, if any, sandpipers, stints and plovers using the shorelines of the Lower Lakes in January 2012 (Paton & Bailey 2012a).

Once the Lower Lakes had re-filled in spring 2010, the barrage gates were opened, reinstating flows to the Murray Mouth in late September 2010. With this release the northern channels of the Murray Estuary were quickly freshened, before flows continued down the Coorong diluring the high salinities in the South Lagoon as well. The general consensus was that this freshening of the Coorong would be beneficial, allowing a wide range of different taxa including plants, invertebrates, fish and birds to rebuild their population sizes. In January 2011, chironomids had recolonised the South Lagoon and were abundant, yet only small numbers of hardyheads were in the South Lagoon, and there was no detectable recovery of *Ruppia tuberosa*. However *Ruppia* and chironomids were still abundant in the middle and southern sections of the North Lagoon, where they had established during the previous five years (Paton & Bailey 2011b). Brine shrimps, however, continued to be abundant throughout the South Lagoon. The other key food resource, various polychaete worms (particularly *Capitella* spp.) were still mainly restricted to the northern sections of the North Lagoon and the Murray Estuary (Paton & Bailey 2011b). Despite some modest recovery, waterbird numbers for the Coorong and Lower Lakes were the lowest on record in January 2011, the low numbers were largely attributed to extremely high water levels, excluding most birds from accessing food resources around the shores of the wetlands (Paton & Bailey 2011b). With the continuation of flows and the maintenance of lower salinities throughout 2011, there were further changes in the distributions and abundances of food resources. By July 2011 there were no brine shrimps detected in the Coorong, and by January 2012 small mouth hardyhead were extremely abundant in the southern Coorong (Paton & Bailey 2012b). However there had been no recovery of *Ruppia tuberosa*. In fact *Ruppia tuberosa* had declined further by January 2012 as the extensive beds that were present in the North Lagoon in January 2011 were absent, having vanished by June 2011 (Paton & Bailey 2012c). Given that the seed bank for this species was almost non-existent in the Coorong, the recovery of *Ruppia tuberosa* to its former range and abundance seems highly unlikely without intervention (Paton & Bailey 2012c, Paton & Bailey

2013). The recovery of components of the waterbird communities that once used the Coorong are likely to be compromised by the lack of recovery of this aquatic plant.

Methods

Counting birds in the Coorong

In order to census the waterbirds of the Coorong, the system was divided into 1-km sections, running approximately perpendicular to the direction of the wetlands. This sampling strategy was initially established in 1984-5 when the birds using the South Lagoon were first counted (Paton 2010) and the same sampling strategy was applied to the whole Coorong when complete counts commenced in 2000 to allow historical comparisons (e.g. Paton *et al.* 2009; Paton 2010). The Murray Estuary was, therefore, divided into 17 x1-km sections running from Pelican Point to Goolwa Barrage while the North Lagoon of the Coorong was divided into 45 x 1-km sections running from Parnka Point to Pelican Point. The South Lagoon consisted of 55 x 1-km sections running from Parnka Point to 42-Mile Crossing; however, the number of sections actually counted in summer in the South Lagoon has varied (between 43 and 48) with inter-annual variations in water levels (with the southernmost end being completely exposed in years with low water levels).

Within each 1-km section, counts of waterbirds were conducted both on foot, and by boat. In 2013 the eastern shorelines of each section were walked by at least two observers while open water areas in the middle of the Coorong and other areas inaccessible by foot (such as islands) were counted from a boat, again by at least two observers. The western shorelines were either counted on foot or from a small boat, again with at least two observers. All waterbirds detected within each component (e.g. eastern shoreline, western shoreline, centre, islands) of each 1-km section were recorded. This division of the data into 1-km sections allows for assessments of changes in distribution through time, at a fine-scale. For the purpose of this report details to this level are not required.

In addition, since 2006, birds were grouped according to their general behaviour (e.g. foraging, roosting, flying, and nesting). These behavioural data provided some information on the functional reasons for the distribution of waterbirds. For example, some species are abundant in relatively small areas of the South Lagoon, which reflects the distribution of suitable nest sites (rocky islands), rather than food resources.

Within a census period, between 10 and 20 consecutive 1-km sections were counted per day, depending on the number of birds, their geographical location within each section, as well as other factors such as weather conditions. Some variance thus occurs in the total duration (7-16 days) of the census from one year to the next. In 2013, the census of waterbirds in the Coorong was conducted between the 9th and 17th January 2013 (9 days) with the counts commencing at the southern end of the Coorong and moving northwards during the sampling period, as was the case in previous years.

Counting birds in the Lower Lakes

Similar methods were used to count waterbirds around the shores of the Lower Lakes between 16th January and 5th February 2013, with a total of 9 survey days. The shorelines of each lake were divided into 1 km x 1 km grid cells (based on Transverse Mercator Projection, Map Grid of Australia (MGA94), Zone 54) and the numbers of birds present in each grid cell were recorded along with their activity (foraging, flying, resting, breeding), allowing both the abundance and the distribution of birds over the Lower Lakes to be determined. Grid cells, however, differed in the amount of shoreline present and also in the extent of shallow water but no adjustments of the numbers of birds was undertaken to account for any differences in grid cells. The time spent

surveying each 1km x 1km grid also varied depending on the length of shoreline and aquatic habitat and the ease with which the cell could be covered. The time spent in each cell was set as the time required to cover all aquatic habitat and count all of the birds within the cell. Usually two or three observers worked collaboratively to cover each grid cell. In all, 507 grid cells (126 around Lake Albert, 302 around Lake Alexandrina and a further 79 which covered the Goolwa Channel and related tributaries) were counted during the census period, with all cells containing shoreline being surveyed.

Within each section, shoreline counts of waterbirds were conducted either by foot or from a small boat or both depending on the extent of backwaters and ease of access with a boat to the shoreline. During the counts, the location of observers was continuously verified using hand-held GPS units to ensure the integrity of data for each section of shoreline.

All waterbird observations were made using either binoculars (8-10x magnification), or spotting scopes (20x-60x magnification). Birds were identified to species, counted, and their activity classified to one of four categories (foraging, resting, flying-over or breeding).

Assessing changes in the food resources for birds in the Coorong

Since 2001 the relative abundances of key food resources (small fish, aquatic benthic invertebrates, seeds, turions and plants) for waterbirds have been assessed in the Coorong at the same time as the bird counts. The same methods are used each year. In January 2013, four sets of 25 core samples (core size: 7.5cm ø, 4cm deep) of surface mud were collected at each of 17 monitoring sites spread along the Coorong (see the appendix for details of the locations). Each of the four sets was collected at a different position relative to the waterline. In January 2011 three sampling positions were used because of very high water levels (the waterline, in water 30cm deep and in water 60 cm deep). In January 2012 and 2013 with lower water levels (ca 40-50cm lower) many of the 17 sampling sites had exposed mud flats and at those sites an additional 25 core samples were taken from dry mud mid-way between the waterline and the high-water mark (shoreline), as well as the samples at the waterline and in water that was 30cm and 60cm deep. All mud samples were then sifted *in situ* through an Endecott sieve (500 μm mesh size), and the abundance of plant (*Ruppia* spp.) propagules (seeds, turions) and shoots, chironomid larvae and pupae, and other aquatic invertebrates (e.g. polychaetes) were recorded. Water quality measures were also taken at this time, with turbidity recorded *in situ* using a Secchi disc, and water samples collected and conductivity subsequently measured with a TPS conductivity metre in the laboratory, with samples being diluted when required to remain within the optimum range of the conductivity sensor being used. Conductivity was converted to salinities (gL^{-1}) using the equation developed by Webster (unpubl.) specifically for the Coorong. Previously the equation developed by Williams (1988) was used to convert conductivities to concentration but this equation slightly under-estimates salinities particularly at high conductivities. Estimates of fish abundance were collected by dragging a 7m seine net, a distance of 50m, in water approximately 0.7m deep. The seine net was dragged three times at each of the 17 sites to provide replicate samples.

Results and Preliminary Discussion

Abundances of birds in the Coorong and Lower Lakes in 2013

Over 186,000 waterbirds from 66 species were counted in the Coorong in January 2013 (Table 1). The Australian Shelduck (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Eurasian Coot (*Fulica atra*), Red-necked Stint (*Calidris ruficollis*) and Sharp-tailed Sandpiper (*Calidris acuminata*) were

present in abundances that exceeded 10,000 individuals. These species accounted for over 65% of the birds that were counted. Four other species were present in abundances exceeding 5,000 individuals (Chestnut Teal (*Anas castanea*), Australian Pelican (*Pelecanus conspicillatus*), Whiskered Tern (*Chlidonias hybridus*) and Silver Gull (*Chroicocephalus novaehollandiae*), Table 1). The North Lagoon had nearly 93,000 waterbirds present in January 2013, compared with a little over 50,000 using the Estuary and a little over 45,000 using the South Lagoon.

Table 1. Numbers of waterbirds counted in the Coorong in January 2013. The table shows the abundances of each species in each section of the Coorong: South Lagoon; North Lagoon and Murray Estuary

Species	Status* (SA, EPBC, IUCN)	South Lagoon	North Lagoon	Murray Estuary	Total
Black Swan		45	1715	956	2716
Australian Shelduck		1387	19740	405	21532
Australian Wood Duck				7	7
Pink-eared Duck			130	10	140
Australasian Shoveler	RA	11	40		51
Grey Teal		5389	31151	16001	52541
Chestnut Teal		935	7159	533	8627
Pacific Black Duck		7	60	206	273
Hardhead			1349	2436	3785
Musk Duck	RA	7	114	52	173
Cape Barren Goose	RA		39	251	290
Hoary-headed Grebe		256	494	207	957
Great Crested Grebe	RA	46	127	118	291
Darter	RA		1		1
Little Pied Cormorant			124	66	190
Great Cormorant		2	69	1545	1616
Little Black Cormorant		590	1066	927	2583
Pied Cormorant		496	1690	7	2193
Black-faced Cormorant		250		4	254
Australian Pelican		4710	1857	1202	7769
Little Tern	END, MIG	4			4
Fairy Tern	END,VUL,VUL	255	28		283
Gull-billed Tern			2	5	7
Caspian Tern		74	500	512	1086
Whiskered Tern		2296	2674	1053	6023
Common Tern		2	22	1	25
Crested Tern		1324	100	317	1741
Great Egret	MIG	12	158	73	243
White-faced Tern		41	79	59	179
Little Egret	RA		16	8	24
Nankeen Night Heron			7	1	8

Table 1. Continued

Species	Status* (SA, EPBC, IUCN)	South	North	Estuary	Total
Australian White Ibis			124	271	395
Straw-necked Ibis			30	1	31
Royal Spoonbill			14	65	79
Pacific Gull				8	8
Silver Gull		1116	3836	1345	6297
Purple Swamphen				2	2
Buff-banded Rail			1		1
Australian Spotted Crake		5		1	6
Black-tailed Native Hen		28	43	62	133
Eurasian Coot		68	2448	7719	10235
Pied Oystercatcher	RA	3	26	57	86
Sooty Oystercatcher	RA			2	2
Black-winged Stilt		58	33	227	318
Red-necked Avocet		1255	1759	1468	4482
Banded Stilt	VUL	1024	673	61	1758
Pacific Golden Plover	RA, MIG		7	38	45
Red-capped Plover		838	226	344	1408
Black-fronted Dotterel				2	2
Hooded Plover		20	2	2	24
Red-kneed Dotterel		7	5	38	50
Banded Lapwing			44		44
Masked Lapwing		178	257	120	555
Bar-tailed Godwit	MIG			56	56
Eastern Curlew	RA, MIG			11	11
Common Greenshank	MIG	36	72	174	282
Marsh Sandpiper	MIG		1	1	2
Wood Sandpiper	MIG			1	1
Sanderling	MIG		118	2	120
Red-necked Stint	MIG	16394	7180	5928	29502
Sharp-tailed Sandpiper	MIG	3032	5120	5239	13391
Curlew Sandpiper	MIG	89	359	350	798
White-breasted Sea Eagle	END, MIG			2	2
Clamorous Reed-Warbler				4	4
Little Grassbird		6		1	7
Golden-headed Cisticola				4	4
Grand Total		**42296**	**92889**	**50568**	**186563**

**State NPW Act listed species where END=endangered; VUL = Vulnerable; RA = Rare
EPBC listed species where END= endangered; VUL = Vulnerable; MIG = Migratory
IUCN listed species where END = endangered; VUL =Vulnerable

Nearly 98,000 waterbirds (60 species) were counted using the Lower Lakes in 2013 (Table 2). Seven species accounted for over 70% of the birds that were counted. For three species more than10,000 individuals were counted in the Lower Lakes in January 2013: Australian Shelduck, Great Cormorant (*Phalacrocorax carbo*) and Pied Cormorant (*P. varius*). More than 5,000 Grey Teal, Australian Pelican, Whiskered Tern and Eurasian Coot were also present. Over 59,000 birds were counted using Lake Alexandrina compared to nearly 28,000 for Lake Albert and over 10,000 for the Goolwa Channel (Table 2).

Table 2. Numbers of waterbirds using the Lower Lakes in 2013. The abundances are shown for each of three components of the Lower Lakes: Lake Albert, Lake Alexandrina and the Goolwa Channel.

Species	Status* (SA, EPBC, IUCN)	Lake Albert	Lake Alexandrina	Goolwa Channel	Total
Black Swan		418	1147	234	1799
Australian Shelduck		6555	4440	852	11847
Australian Wood Duck		20	45	81	146
Pink-eared Duck		417	62	2	481
Australasian Shoveler	RA	49	4	3	56
Grey Teal		3508	3627	553	7688
Chestnut Teal		102	20	8	130
Mallard hybrid or derivative				36	36
Pacific Black Duck		1302	2789	890	4981
Hardhead		73	518	283	874
Musk Duck	RA	2	6	1	9
Freckled Duck	RA		5		5
Cape Barren Goose	RA	236	1419		1655
Domestic Goose			15		15
Australasian Grebe			10	10	20
Hoary-headed Grebe		40	77	7	124
Great Crested Grebe	RA	83	60	58	201
Darter	RA	23	64	35	122
Little Pied Cormorant		41	120	34	195
Great Cormorant		1069	22382	2290	25741
Little Black Cormorant		367	303	237	907
Pied Cormorant		1639	9461	205	11305
Australian Pelican		1306	3870	390	5566
Fairy Tern	END, VUL, VUL			1	1
Caspian Tern		383	965	36	1384
Whiskered Tern		2044	3219	434	5697
Common Tern			1		1
Crested Tern		164	400	35	599
Eastern Great Egret	MIG	186	148	60	394
Cattle Egret	RA, MIG			2	2
White-faced Heron		86	57	15	158

Table 2. Continued

Species	Status* (SA, EPBC, IUCN)	Lake Albert	Lake Alexandrina	Goolwa Channel	Total
Little Egret	RA	5	1	1	7
Nankeen Night Heron		1	12	5	18
Australian White Ibis		261	282	68	611
Straw-necked Ibis		1354	252	14	1620
Royal Spoonbill		86	45	35	166
Yellow-billed Spoonbill		1	8	3	12
Pacific Gull				1	1
Silver Gull		2827	434	480	3741
Purple Swamphen		166	352	276	794
Baillon's Crake				2	2
Australian Spotted Crake		2	9	3	14
Black-tailed Native-hen		600	609	183	1392
Dusky Moorhen				44	44
Eurasian Coot		1992	1445	2625	6062
Black-winged Stilt		31	76	48	155
Red-necked Avocet		8			8
Banded Stilt	VUL	12	10		22
Red-capped Plover		1			1
Red-kneed Dotterel		35	5	16	56
Masked Lapwing		154	344	54	552
Latham's Snipe	RA, MIG	1			1
Common Greenshank	MIG	7	4		11
Wood Sandpiper	MIG	1	1		2
Red-necked Stint	MIG	76	4		80
Sharp-tailed Sandpiper	MIG	123	174		297
White-bellied Sea-Eagle	END, MIG		1		1
Clamorous Reed-Warbler		12	48	29	89
Little Grassbird		1	13	1	15
Golden-headed Cisticola		6	43	2	51
Total		**27876**	**59406**	**10682**	**97964**

**State NPW Act listed species where END=endangered; VUL = Vulnerable; RA = Rare
EPBC listed species where END= endangered; VUL = Vulnerable; MIG = Migratory
IUCN listed species where END = endangered; VUL =Vulnerable

Overall the Coorong and Lower Lakes were supporting in excess of 283,000 waterbirds during the summer census in 2013 with the Coorong supporting about twice as many birds as the Lower Lakes (Table 3). The bird communities were markedly different between the two wetland systems. Of the 73 species recorded, 19 species were found primarily in the freshwater wetlands of the Lower Lakes, 29 species found primarily in the saline wetlands of the Coorong, with 25 species using both wetlands to a reasonable extent (Table 3).

Of the prominent species of waterfowl using the Coorong and Lower Lakes region, Grey Teal, Chestnut Teal, Hardhead (*Aythya australis*) and Musk Duck (*Biziura lobota*) mainly used the Coorong while Pacific Black Ducks mainly used the freshwater habitats of the Lower Lakes (Table 3). Black Swan (*Cygnus atratus*), Australian Shelduck, Pink-eared Duck (*Malacorhynchus membranaceus*) and Australasian Shovelers (*Anas rhynchotis*) used both wetland systems.

Of the fish-eating species Hoary-headed Grebes (*Poliocephalus poliocephalus*) largely used the Coorong, the Australasian Grebe (*Tachybaptus novaehollandiae*) largely the Lower Lakes and the larger Great Crested Grebe (*Podiceps cristatus*) used both (Table 3). Darters (*Anhinga melanogaster*), Great Cormorants and Pied Cormorants were using the Lower Lakes predominantly but because of large numbers, both cormorant species were prominent in the Coorong. Little Black Cormorants (*Phalacrocorax sulcirostris*) and Little Pied Cormorants (*Phalacrocorax melanoleucos*) used both the freshwater habitats of the Lower Lakes and the salty waters of the Coorong to similar extents, while small numbers of the essentially marine Black-faced Cormorant (*Phalacrocorax fuscescens*) were restricted to the Coorong (Table 3). Caspian Terns (*Sterna caspia*) and Whiskered Terns used both the Coorong and the Lower Lakes extensively, while the other prominent terns (Crested Tern *Thalasseus bergii*, Fairy Tern *Sternula nereis*) used the Coorong to a much greater extent.

In general, herons, egrets, ibis and spoonbills used both wetlands to similar extents as did the Silver Gull. The Purple Swamphen (*Porphyrio porphyrio*), Black-tailed Native-hen (*Gallinula ventralis*) and Dusky Moorhen (*Gallinula tenebrosa*) were largely using the Lower Lakes, while the Eurasian Coot was abundant in both wetland systems.

Lastly, but significantly, almost all of the shorebirds (sandpipers, plovers) were strongly associated with the Coorong (Table 3). Masked Lapwings (*Vanellus miles*), Red-kneed Dotterels (*Erythogonys cinctus)*, and Black-winged Stilts (*Himantopus himantopus*) however, used both the Lower Lakes and Coorong, and although only present in small numbers during the census in 2013, Latham's Snipe (*Gallinago hardwicki*) and Wood Sandpiper (*Tringa glareola*) might be expected to be predominantly associated with freshwater habitats.

Assessing the importance of these wetlands for waterbirds should not be based just on abundances. How the birds are using these wetlands is also very important. In Table 3 the percentage of birds that were foraging when counted is given. This percentage provides a measure of the effort or time a species needs to allocate to foraging. Those species with low percentages of birds that were foraging were either foraging on rich food sources that were easily gathered and or were foraging away from the Coorong and Lower Lakes. Those species that have high percentages of birds foraging indicate species that have to spend significant amounts of time to harvest sufficient food, and if that is the case then the food resources and quality of the habitats are poor. Within the Coorong and Lower Lakes there are a suite of birds that are spending very little of their time foraging while there are others that are spending significant amounts of their time foraging (> 90%; Table 3). The species that are spending significant amounts of their time foraging are shorebirds, notably Red-necked Stints, Sharp-tailed Sandpipers, Red-capped Plovers and Banded Stilts, where typically more than 90% of the birds counted were foraging. This suggests that the quantity and quality of the food resources was poor for these species. In January 2013 four dead and very lean Red-necked Stints and a Banded Stilt (*Cladorhynchus leucocephalus*) were found along the shores of the Coorong, supporting the notion that the resources for these species were poor.

The behaviour of most of the fish-eating species (e.g. cormorants, terns, egrets, herons and pelicans) contrasted strongly with the behaviours of shorebirds. For fish-eating species often less than 20% of the birds counted were foraging (Table 3). The only fish-eating species with relatively high numbers of foraging birds were grebes, but for these species it is more difficult to ascertain when

birds are foraging because they dive to escape disturbance as well as dive to forage. A number of waterfowl also had very low numbers of foraging birds recorded during counts, including many species of ducks and allies. Some of the low counts for these species need to be treated with care because wetland areas can be used as safe refuges and or places to undergo moult rather than being significant foraging habitat. For example, many of the Australian Shelducks counted on or near the wetlands in January 2013 were flying off the wetland to forage on terrestrial vegetation (irrigated lucerne) for periods of time during the day and potentially also at night, suggesting that they were obtaining most of their food from these sources. However, some of the shelducks were also moulting and so unable to easily leave the water for 2-3 weeks. These birds would have depended on aquatic food resources within Coorong or the Lower Lakes during these times. Other species that foraged away from the wetlands were Cape Barren Geese (*Cereopsis novaehollandiae*), Straw-necked Ibis (*Threskiornis spinicollis*), Australian White Ibis *Threskiornis molucca*), and a number of the Pacific Black Ducks that were counted. Another potential explanation for the low levels of foraging behaviour recorded for some waterfowl might be that they were simply resting before flying on to other wetlands.

Changes in the abundances of birds using the Coorong and Lower Lakes

The abundances of waterbirds using the Coorong and Lower Lakes have changed dramatically over the last 5 years (Table 4). Such changes were not unexpected as the conditions of both wetland systems have changed dramatically over this period. In 2009 and 2010 water levels in the Lower Lakes approached -1 m AHD, and the usual shoreline and fringing reed beds were out of the water. In some places the water had receded more than a kilometre away from the shoreline. These conditions provided extensive mudflats covered in shallow water, ideal for shorebirds to use. However the disconnect between the water and the fringing reeds would not favour species like the Purple Swamphen. Consistent with this large numbers of shorebirds (stints, sandpipers and plovers) used the Lower Lakes in these two years (Fig. 1). With the return of River Murray flows in 2010, the lakes refilled and water levels were at or above 0.6 m AHD in 2011 and have been maintained at this level since then. With these water levels there were no mudflats covered in shallow water and virtually no shorebirds have used the Lower Lakes in 2011, 2012 or 2013 (e.g. Fig 1). In contrast, Purple Swamphens were largely absent from the Lower Lakes (despite the species being present and widely distributed around the Lower Lakes) in 2009 and 2010, but since 2011 they have been slowly returning to the region (Fig. 1). A number of other species have shown steady increases over the last few years, including Pied Cormorants, Great Cormorants, Pacific Black Ducks as well as some egrets and possibly ibis (Fig. 1). In contrast the numbers of Royal Spoonbills and Yellow-billed Spoonbills have been declining.

The Coorong has also undergone significant changes over the last five years. In 2009 and 2010 the salinities across the southern Coorong were extremely high and around 150 gL^{-1}(Fig. 2). With the return of freshwater flows to the Murray Mouth in late 2010 the salinities dropped and in the South Lagoon averaged around 110 gL^{-1} in both January 2011 and January 2012. In January 2013 the salinities had dropped further across the Coorong and were similar to the salinities that existed in January 2001and January 2002 before the millennium drought (Fig. 2). The average salinity for the South Lagoon in January 2013 was 86 gL^{-1}, the first time that the average January salinity had been below 100gL^{-1} in the South Lagoon for more than a decade. These changes in salinity influence the distributions and abundances of aquatic organisms that provide food resources for birds (Figs 3-5). In 2009 and 2010 there were no fish in the South Lagoon and very few chironomids because of the high salinities, but with the lower salinities in 2011 both began to recolonise the southern Coorong. Figure 3 shows the distributions and abundances of chironomid larvae along the Coorong over the last 3 years. In general, chironomids were widespread long the Coorong in January 2013 but not as abundant at many sites as in the previous year. Polychaetes showed a similar distribution to previous years and were restricted to the northern Coorong where they were abundant, perhaps

Table 3. Overall abundances of different waterbird species counted in the Coorong and Lower Lakes in 2013, and the relative use of the Lower Lakes and Coorong by different species. Birds were assigned to either the Lower Lakes or Coorong system if >80% of the birds were counted in the Lower Lakes or Coorong respectively. If a species was more evenly spread across both wetlands that species was assigned to both. The percentage of birds that were foraging when counted is also given for birds using the different wetlands.

Species	Lower Lakes	Coorong	Total	System (%)	Lakes % forage	Coorong % forage
Black Swan	1799	2716	4515	Both (40)	19.8	30.0
Australian Shelduck	11847	21532	33379	Both (35)	8.8	4.7
Australian Wood Duck	146	7	153	Lakes (95)	19.2	0.0
Pink-eared Duck	481	140	621	Both (77)	80.9	7.9
Australasian Shoveler	56	51	107	Both (52)	89.3	13.7
Grey Teal	7688	52541	60229	Coor (87)	17.5	23.9
Chestnut Teal	130	8627	8757	Coor (99)	22.3	3.2
Mallard hybrids derivatives	36		36	Lakes (100)	0.0	
Pacific Black Duck	4981	273	5254	Lakes (95)	20.6	13.9
Hardhead	874	3785	4659	Coor (81)	8.7	6.8
Musk Duck	9	173	182	Coor (95)	55.6	57.8
Freckled Duck	5		5	Lakes (100)	0.0	
Cape Barren Goose	1655	290	1945	Lakes (85)	58.4	0.7
Domestic goose	15		15	Lakes (100)	0.0	
Australasian Grebe	20		20	Lakes (100)	70.0	
Hoary-headed Grebe	124	957	1081	Coor (89)	67.7	66.1
Great Crested Grebe	201	291	492	Both (41)	66.2	48.1
Darter	122	1	123	Lakes (99)	13.1	0.0
Little Pied Cormorant	195	190	385	Both (51)	6.2	7.4
Great Cormorant	25741	1616	27357	Lakes (94)	2.8	13.9
Little Black Cormorant	907	2583	3490	Both (26)	11.9	1.7
Pied Cormorant	11305	2193	13498	Lakes (84)	12.0	3.6
Black-faced Cormorant		254	254	Coor (100)		0.8
Australian Pelican	5566	7769	13335	Both (42)	13.2	6.1
Litte Tern		4	4	Coor (100)		0.0
Fairy Tern	1	283	284	Coor (100)	0.0	6.7
Gull-billed Tern		7	7	Coor (100)		28.6
Caspian Tern	1384	1086	2470	Both (56)	12.1	12.1
Whiskered Tern	5697	6023	11720	Both (49)	60.2	32.9
Common Tern	1	25	26	Coor (96)	0.0	4.0
Crested Tern	599	1741	2340	Both (74)	9.3	1.0
Great Egret	394	243	637	Both (62)	37.1	29.6
Cattle Egret	2		2	Lakes (100)	0.0	
White-faced Heron	158	179	337	Both (47)	31.6	42.5
Little Egret	7	24	31	Both (23)	28.6	20.8
Nankeen Night Heron	18	8	26	Both (69)	5.6	0.0

continued

Table 3 cont

Species	Lower Lakes	Coorong	Total	System (%)	Lakes % forage	Coorong % forage
Australian White Ibis	611	395	1006	Both (61)	54.5	57.5
Straw-necked Ibis	1620	31	1651	Lakes (98)	12.7	19.4
Royal Spoonbill	166	79	245	Both (68)	28.9	2.5
Yellow-billed Spoonbill	12		12	Lakes (100)	58.3	
Pacific Gull	1	8	9	Coor (89)	0.0	0.0
Silver Gull	3741	6297	10038	Both (37)	4.0	28.6
Purple Swamphen	794	2	796	Lakes (100)	59.1	0.0
Buff-banded Rail		1	1	Coor (100)		0.0
Baillon's Crake	2		2	Lakes (100)	100.0	
Australian Spotted Crake	14	6	20	Both (70)	100.0	100.0
Black-tailed Native-hen	1392	133	1525	Lakes (91)	25.2	54.9
Dusky Moorhen	44		44	Lakes (100)	61.4	
Eurasian Coot	6062	10235	16297	Both (37)	52.9	33.7
Pied Oystercatcher		86	86	Coor (100)		11.6
Sooty Oystercatcher		2	2	Coor (100)		100.0
Black-winged Stilt	155	318	473	Both (33)	57.4	67.0
Red-necked Avocet	8	4482	4490	Coor (100)	0.0	50.8
Banded Stilt	22	1758	1780	Coor (99)	95.5	89.4
Pacific Golden Plover		45	45	Coor (100)		40.0
Red-capped Plover	1	1408	1409	Coor (100)	0.0	83.8
Black-fronted Dotterel		2	2	Coor (100)		0.0
Hooded Plover		24	24	Coor (100)		41.7
Red-kneed Dotterel	56	50	106	Both (52)	78.6	44.0
Banded Lapwing		44	44	Coor (100)		0.0
Masked Lapwing	552	555	1107	Both (50)	7.8	16.2
Latham's Snipe	1		1	Lakes (100)	0.0	
Bar-tailed Godwit		56	56	Coor (100)		21.4
Eastern Curlew		11	11	Coor (100)		81.8
Common Greenshank	11	282	293	Coor (96)	18.2	50.4
Marsh Sandpiper		2	2	Coor (100)		100.0
Wood Sandpiper	2	1	3	Both (67)	0.0	0.0
Sanderling		120	120	Coor (100)		99.2
Red-necked Stint	80	29502	29582	Coor (100)	100.0	92.4
Sharp-tailed Sandpiper	297	13391	13688	Coor (98)	77.8	90.3
Curlew Sandpiper		798	798	Coor (100)		96.1
White-bellied Sea-Eagle	1	2	3	Both (33)	0.0	0.0
Clamorous Reed-Warbler	89	4	93	Lakes (96)	0.0	0.0
Little Grassbird	15	7	22	Both (68)	0.0	0.0
Golden-headed Cisticola	51	4	55	Lakes (93)	3.9	0.0
TOTAL	**97964**	**186853**	**283717**			

Table 4. Changes in the abundances of waterbirds counted in the Coorong and Lower Lakes in summer (Jan-Feb) from 2009 to 2013.

Species	**2009**	**2010**	**2011**	**2012**	**2013**
Black Swan	1782	3400	4376	2767	4515
Australian Shelduck	28484	40865	31847	29389	33379
Australian Wood Duck	2	0	9	54	153
Pink-eared Duck	2	0	0	266	621
Australasian Shoveller	6	17	8	19	107
Grey Teal	19644	21046	1026	46919	60229
Chestnut Teal	7073	5051	5209	8697	8757
Mallard (hybrid& derivatives)	13	16	1	10	36
Pacific Black Duck	1416	2033	1729	5978	5254
Hardhead	12	44	1	342	4659
Blue-billed Duck	0	1	1	4	
Musk Duck	113	304	25	159	182
Freckled Duck				9	5
Cape Barren Goose	1738	1433	1383	2320	1945
Domestic Goose	4	13	36	27	15
Australasian Grebe				71	20
Hoary-headed Grebe	14961	9120	0	7403	1081
Great Crested Grebe	799	520	219	694	492
Darter	2	5	2	124	123
Little Pied Cormorant	477	103	81	730	385
Great Cormorant	3186	6173	7723	15332	27357
Little Black Cormorant	1378	2020	1659	26563	3490
Pied Cormorant	1611	1087	1944	4840	13498
Black-faced Cormorant	76	220	209	291	254
Australian Pelican	5425	7509	7260	8903	13335
Little Tern					4
Fairy Tern	347	326	168	362	284
Gull-billed Tern	4	8	4	5	7
Caspian Tern	550	455	561	1531	2470
Whiskered Tern	14718	9103	235	12159	11720
Common Tern	2	1	0	0	26
Crested Tern	7719	11958	4090	7141	2340
Australasian Bittern				1	
Great Egret	117	64	108	575	637
Intermediate Egret	0	0	2	0	0
Cattle Egret				8	2
White-faced Heron	189	270	355	310	337
White-necked Heron	0	1	0	0	
Little Egret	22	4	4	28	31
Nankeen Night Heron	0	0	6	9	26

Continued

Table 4. Continued

Species	2009	2010	2011	2012	2013
Glossy Ibis				61	0
Australian White Ibis	620	376	1346	1366	1006
Straw-necked Ibis	835	405	536	2591	1651
Royal Spoonbill	396	346	234	139	245
Yellow-billed Spoonbill	55	58	18	24	12
Pacific Gull	2	9	1	11	9
Silver Gull	14017	13621	17658	11236	10038
Purple Swamphen	9	0	47	446	796
Lewin's Rail	1	0	1	0	0
Buff-banded Rail					1
Baillon's Crake					2
Australian Spotted Crake	2	3	0	29	20
Spotless Crake				3	0
Black-tailed Native-hen	7	31	0	135	1525
Dusky Moorhen	13	0	30	44	44
Eurasian Coot	284	3321	41	5075	16297
Pied Oystercatcher	206	186	131	130	86
Sooty Oystercatcher	0	1	5	4	2
Black-winged Stilt	732	621	51	367	473
Red-necked Avocet	474	1193	162	3189	4490
Banded Stilt	213109	49448	18054	11700	1780
Pacific Golden Plover	26	50	0	0	45
Grey Plover	1	2	0	0	0
Red-capped Plover	2729	1596	73	1331	1409
Lesser Sand Plover	2	0	0	0	0
Greater Sand Plover	3	0	0	0	0
Black-fronted Dotterel	1	0	2	0	2
Hooded Plover	5	5	4	8	24
Red-kneed Dotterel	5	31	1	88	106
Banded Lapwing	178	1092	2	0	44
Masked Lapwing	1481	1325	710	815	1107
Latham's Snipe	0	4	0	7	1
Black-tailed Godwit	89	174	0	0	0
Bar-tailed Godwit	2	0	32	50	56
Whimbrel	0	1	1	0	0
Eastern Curlew	30	15	3	9	11
Terek Sandpiper	1	0	0	0	0
Common Sandpiper	1	0	0	0	0
Common Greenshank	578	714	237	182	293
Marsh Sandpiper	10	11	0	14	2
Wood Sandpiper	0	7	0	0	3

Continued

Table 4. Continued

Species	2009	2010	2011	2012	2013
Ruddy Turnstone	0	4	0	0	0
Great Knot	1	0	0	0	0
Red Knot	0	1	0	0	0
Sanderling	0	515	0	0	120
Red-necked Stint	44050	48582	6605	21120	29582
Sharp-tailed Sandpiper	25693	30023	37	5702	13688
Curlew Sandpiper	938	1988	217	350	798
unident small waders	0	2500	0	0	0
Total	418458	281429	116526	250271	283717

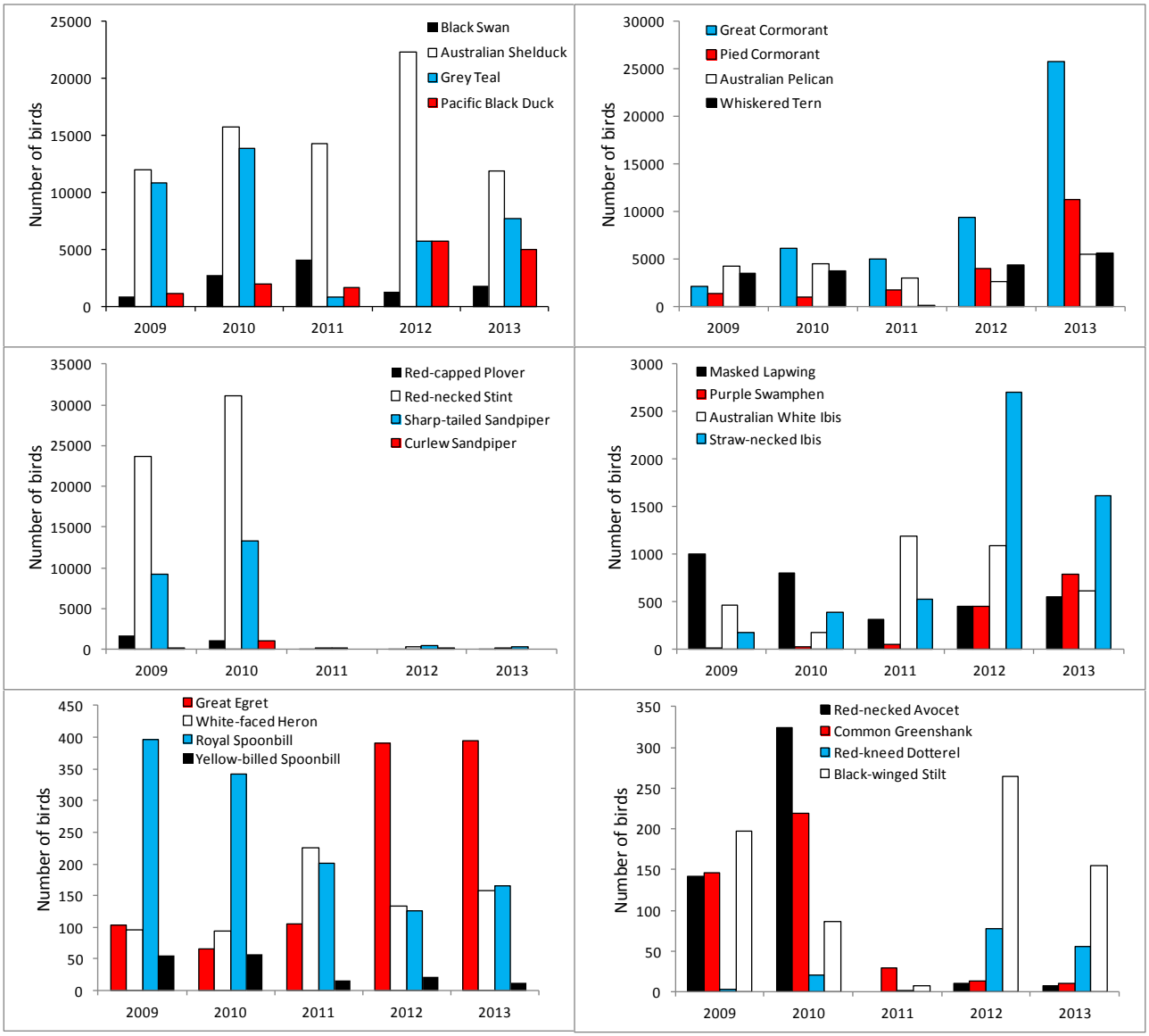

Figure 1. Changes in the numbers of 24 species of waterbirds using the Lower Lakes in summer from 2009-2013. Note that the scales on the y-axis vary from one image to the next.

more so in 2013 than the previous two years. Small-mouthed Hardyheads were much more abundant in January 2012 than January 2013 (Fig. 4) but as in previous years hardyheads were more abundant in the southern Coorong while other species of small fish were more abundant in the northern Coorong. As expected with reductions in salinity, other species of fish were more prominent further south in the Coorong in January 2013 while the small-mouthed hardyhead had retracted from some of the more northerly sites used in previous years (Fig. 4).

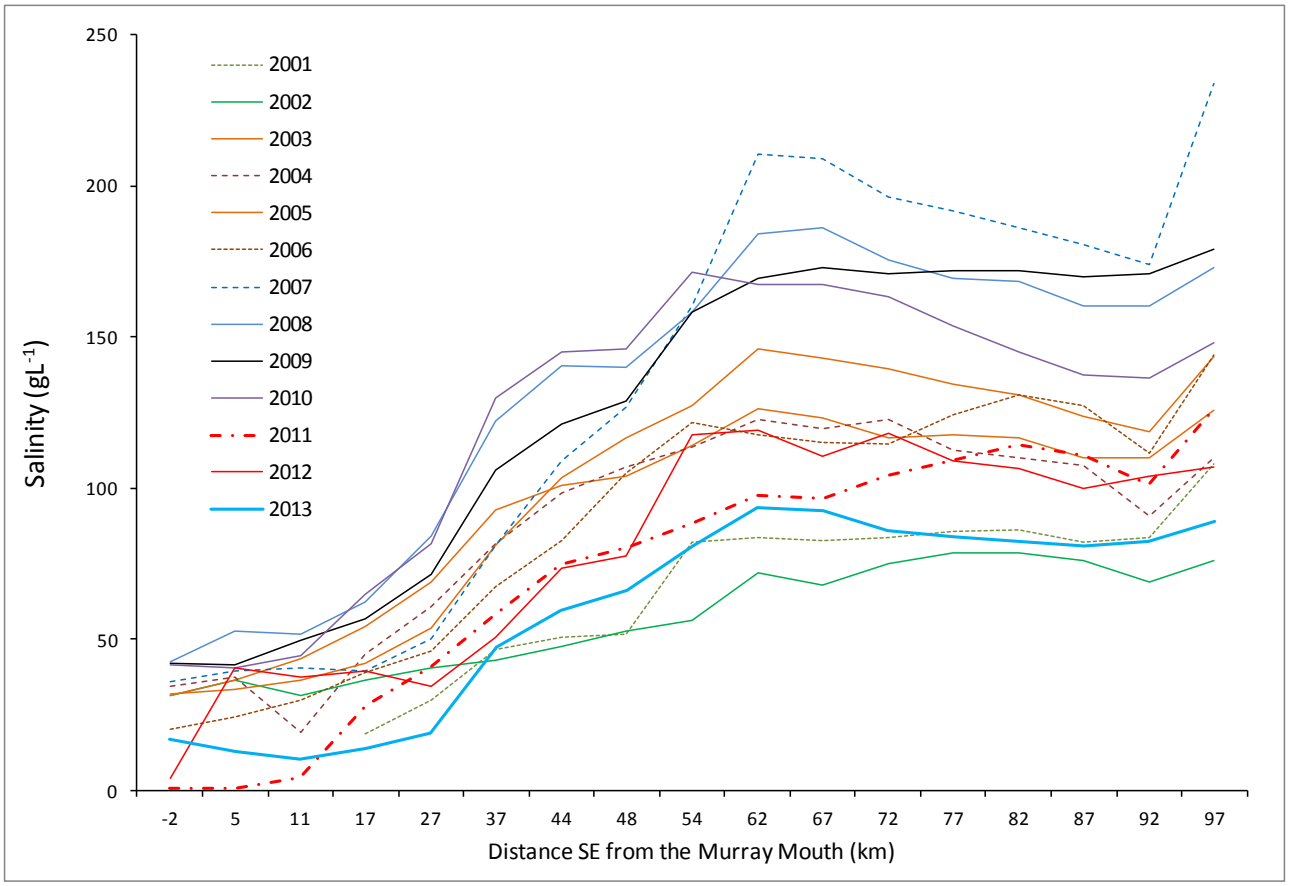

Figure 2. Salinities along the Coorong in January from 2001 to 2013. Position along the Coorong is defined as the distance from the Murray Mouth, where negative values are NW of the mouth and positive values are SE. The junction of the two lagoons (Parnka Point) is at kilometre 59. The salinities shown for 2001 and 2002 were typical of the salinities recorded during summer over the previous 30-40 years (Paton 2010).

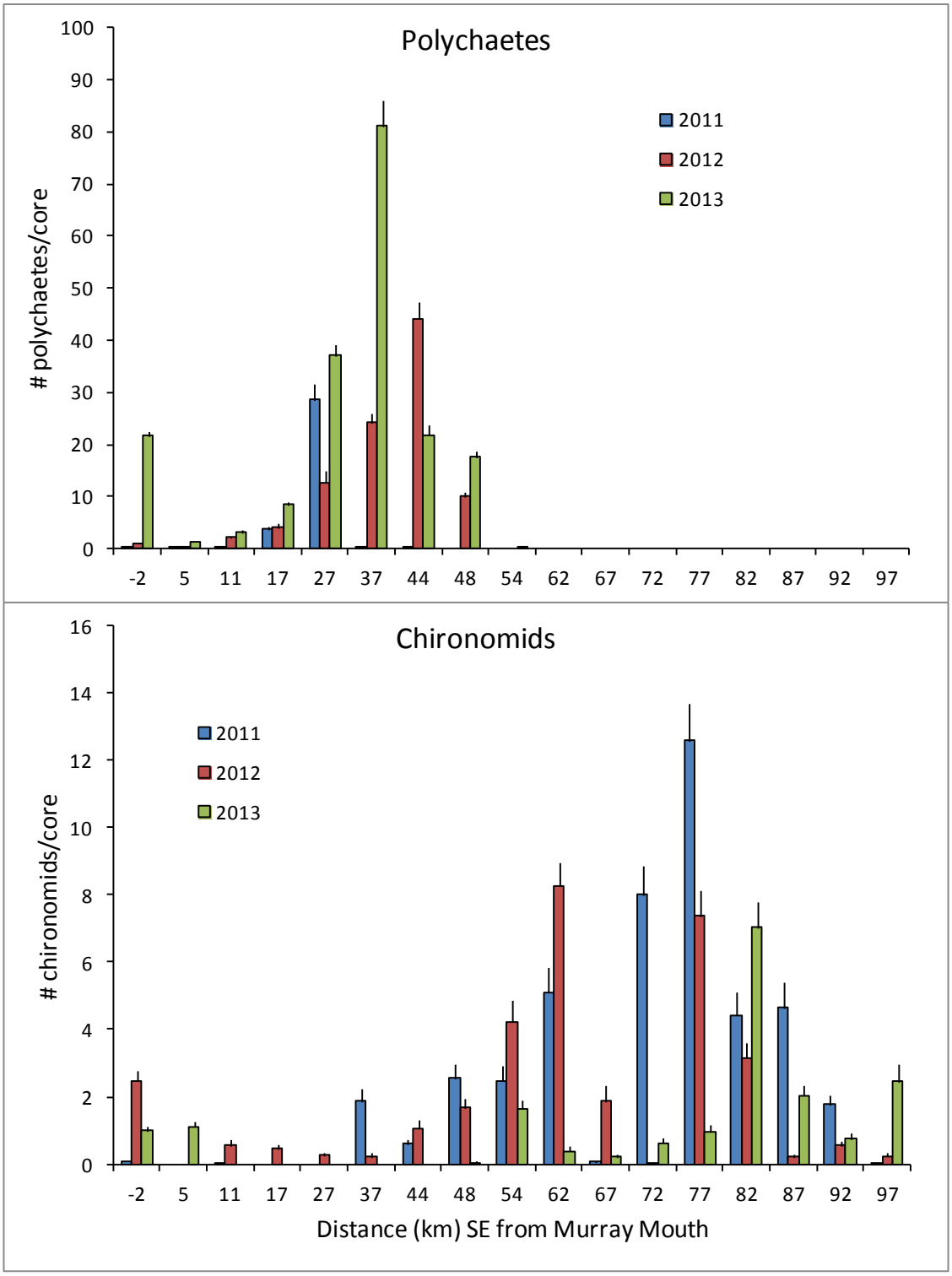

Figure 3. Mean number (+ s.e.) of polychaete worms and chironomid larvae found in 50 cores (25 samples taken in water 30cm deep and 25 samples at 60cm water depth) at 17 sites spread along the Coorong in January from 2011 to 2013. Data can be converted to items/m^2 by multiplying by 226. Note that the scales on the y-axis differ for the two types of invertebrates. Sites at -2, 5 and 11 km are in the region known as the Murray estuary; those at 17-54 km are in the North Lagoon, while those from 62-97 km are in the South Lagoon. Negative distances are NW of the Murray Mouth. Note that the chironomids occupying the southern Coorong were *Tanytarsus barbitarsis* while those near the Murray Mouth were another species (probably a species of *Chironomus*), while the polychaetes include at least 3 species of which the most abundant was a species of *Capitella*.

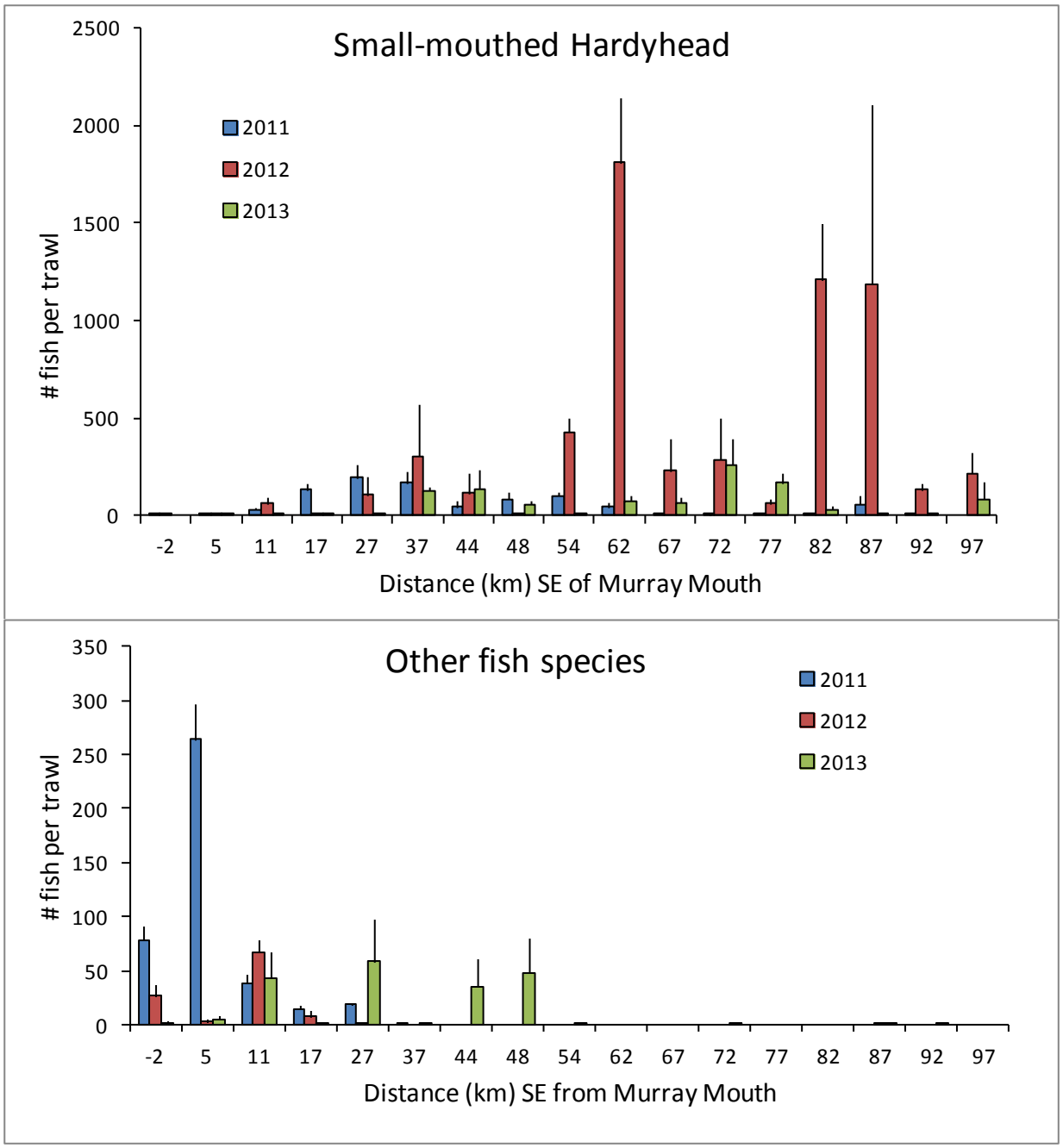

Figure 4. The distribution and abundance of small fish along the Coorong in January from 2011 to 2013. Data are means (+s.e.) of three replicate 50m long trawls with a 7m seine net. Note that the scales on the y-axis differ for the two types of fish. Sites at -2, 5 and 11 km are in the region known as the Murray estuary; those at 17-54 km are in the North Lagoon; while those from 62-97 km are in the South Lagoon. Negative distances are NW of the Murray Mouth.

The other key food resource used in the Coorong by a range of waterbirds is *Ruppia tuberosa*. Despite favourable salinities, the populations of *Ruppia tuberosa* that were abundant and widespread across the southern Coorong prior to the millennium drought have hardly recovered, with just small populations present at some sites in January 2013 (Fig. 5; Paton & Bailey 2013a). Although *Ruppia tuberosa* was prominent in the North Lagoon in January 2011, *Ruppia tuberosa* had all but disappeared from this region by July 2011 (Paton & Bailey 2012c). This lack of recovery of *Ruppia tuberosa* was predicted based on the depauperate nature of the seed banks across the southern Coorong (e.g. Paton *et al.* 2011, Paton & Bailey 2012c, 2013b). The failure of the plants to establish and to begin to replenish their seed banks over the last two years has been attributed to low water levels in spring due to inadequate freshwater flows over the barrages (Paton & Bailey 2013a, b).

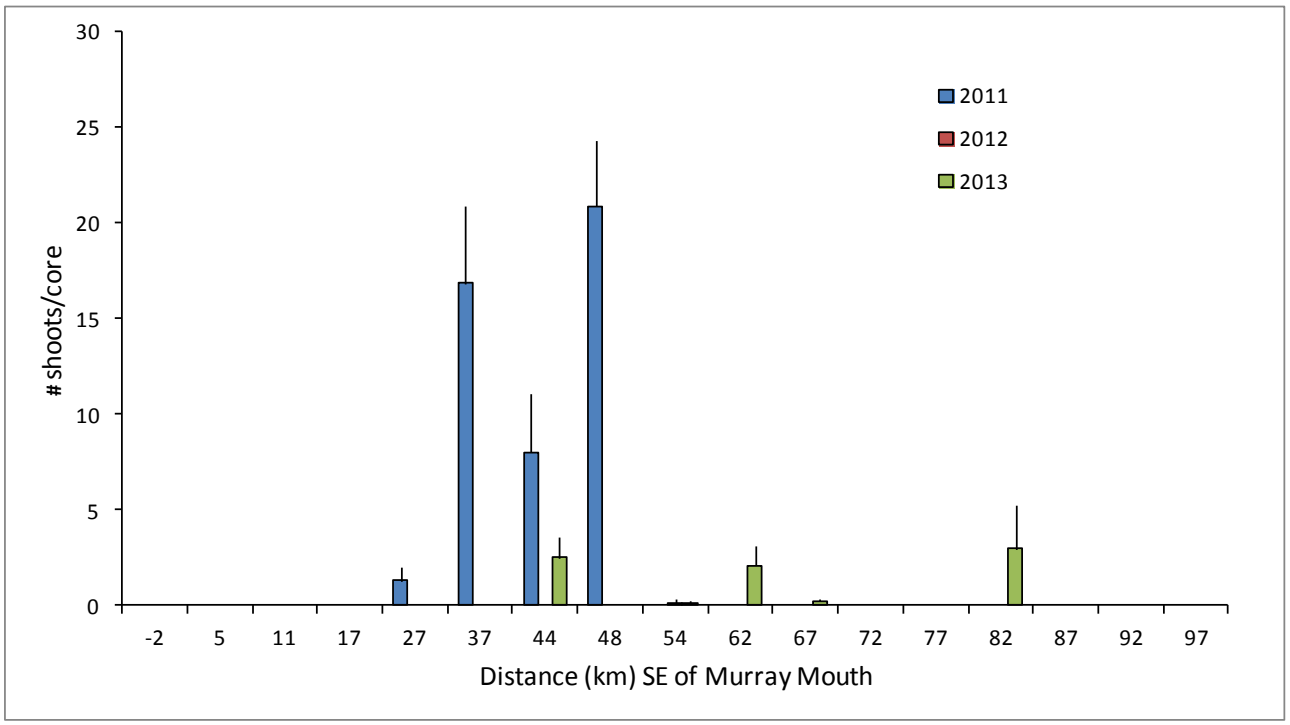

Figure 5. Mean number of *Ruppia tuberosa* shoots (+ s.e) present in 50 core samples (25 taken at each of two water depths (0.3m and 0.6m)) at 17 sites spread along the Coorong in January 2011 and January 2012. Data can be converted to shoots/m^2 by multiplying by 226. Sites at -2, 5 and 11 km are in the region known as the Murray estuary; sites at 17-54 km are in the North Lagoon; while those from 62-97 km are in the South Lagoon. Negative distances are NW of the Murray Mouth.

Changes in the abundances of 22 species of waterbirds in the Coorong over the last five years (2009-2013) are shown in Figure 6. Of these some have shown dramatic increases in abundances in the last 2 years, for example Grey Teal, Black Swan, Caspian Tern, Eastern Great Egret (*Egretta alba),* and Australian Pelican have increased steadily over the period. A range of shorebirds including Red-necked Avocet (*Recurvirostra novaehollandiae*), Red-capped Plover, Red-necked Stint and Sharp-tailed Sandpipers have also increased over the last three years from the low abundances recorded in January 2011 when high water levels excluded many shorebirds from the Coorong. However, four species, including Common Greenshank (*Tringa nebularia*), Fairy Tern, Pied Oystercatcher (*Haematopus longirostris*) and Black-winged Stilt have not shown any substantial increase in abundance and distribution over the last 3 years. In January 2013 only 86 Pied Oystercatchers were detected in the Coorong, the first time in 14 years that fewer than 100

individuals were detected and none of these birds were breeding; unlike in previous years when pairs of birds bred on the islands in the South Lagoon. The numbers of Fairy Terns also dropped from the previous year despite successful breeding in 2012 and the numbers recorded in recent years remain well below the numbers recorded in 2000-2001 when more than 600 individuals were counted. Even these numbers are low compared to counts in the 1980s where over 1300 individuals used the South Lagoon alone (Paton 2010). For Common Greenshanks more than 400 individuals were counted in each year from 2000-2010, but for the last three years this species has remained in numbers below 200. This species feeds predominantly on small fish caught in shallow water around the edges of the Coorong. The decline in abundance for Common Greenshanks was substantial in 2011 and appears linked to the extremely high water levels that established in both the Coorong and the Lower Lakes in that year.

One of the striking patterns in the abundances of waterbirds within the region has been the low numbers of many species of birds using the Coorong and Lower Lakes in 2011 (Table 4, Fig. 1 and 6). Although many of these birds may have moved to other inland flooded wetlands in response to widespread rains during 2010, the lack of suitable shallow wetland areas around the margins of both the Coorong and the Lower Lakes in 2011 may have also contributed. These high water levels would have excluded many shorebirds and waders that rely on mudflats covered by shallow water for foraging. Two years on from 2011, the expectation would be that the majority of species would have increased in abundance and distribution in both the Lower Lakes and Coorong. Most species have shown a steady increase since 2011 but not all species. In general the fish-eating species (pelicans, most cormorants, several terns, egrets) have increased over the last five years (Table 4). However, two of the fish-eating bird species selected for condition monitoring have not shown any substantial recovery: the Fairy Tern and Common Greenshank. Hoary-headed and Great Crested Grebes have also not shown any recent increases in abundance, perhaps because other wetlands have provided alternative habitat for them. The abundances of the prominent migratory waders (Curlew Sandpiper, Sharp-tailed Sandpiper and Red-necked Stint) have also increased since 2011, but have not reached pre-2011 abundances (Table 4). A similar pattern has been detected for resident shorebirds such as the Red-capped Plover, Black-winged Stilt and Masked Lapwing. In recent years their abundances have been increasing but they are still to reach pre 2011 abundances (Table 4). In contrast the numbers of Red-necked Avocets have increased steadily over the last 5 years, while Banded Stilts were in low abundances in January 2013.

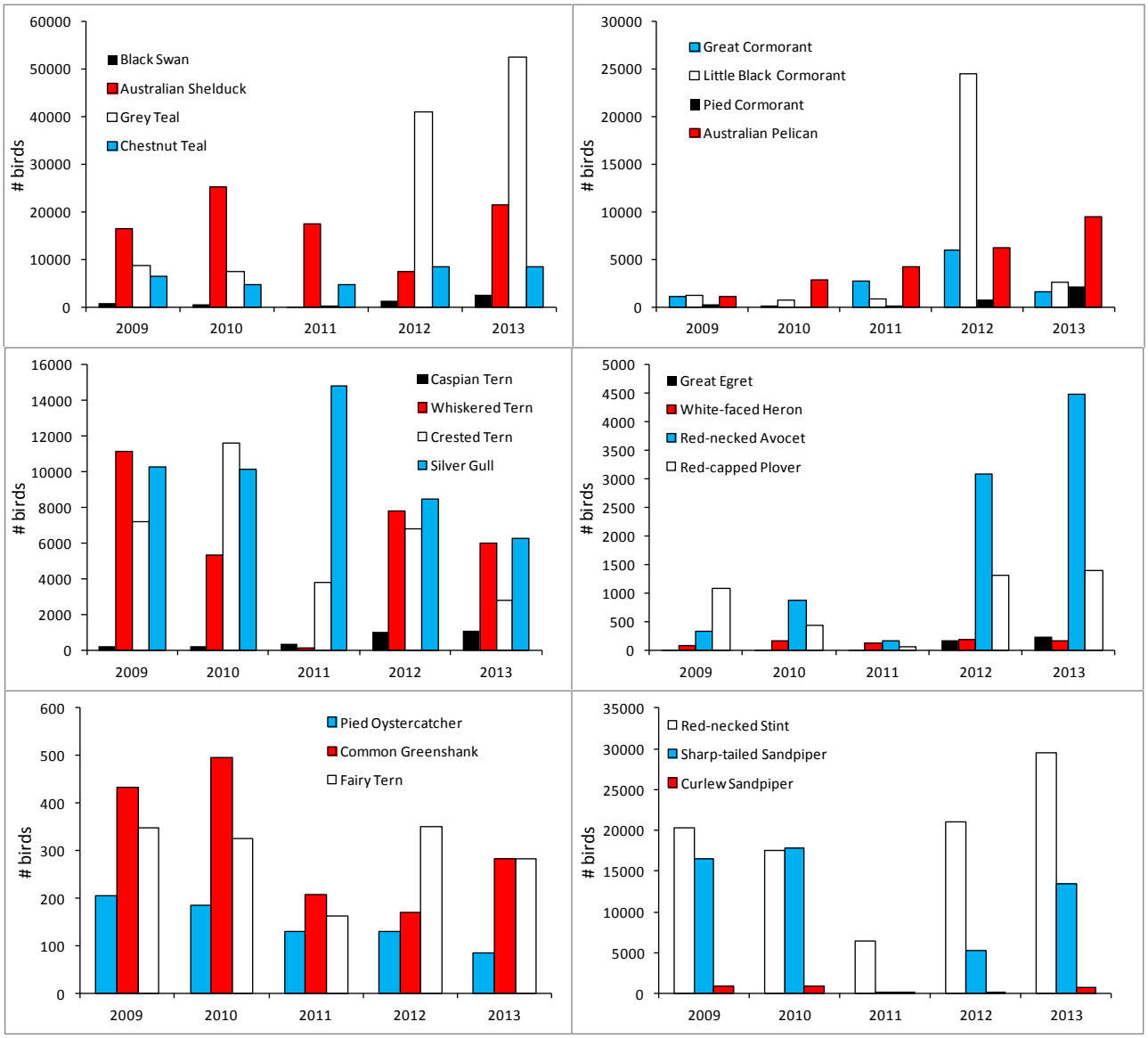

Figure 6. Changes in the numbers of 22 species of waterbirds using the Coorong in summer from 2009-2013. Note that the scales on the y-axes vary from one image to the next.

General Discussion and Conclusions

In general, the abundances of waterbirds using the Coorong and Lower Lakes have increased or been maintained over the last one to three years with a few notable exceptions. Given this, the Condition Monitoring Target B-1 - *to maintain or improve bird populations in the Lower Lakes, Coorong and Murray Mouth* – has been met. However the abundances of many species were higher in 2009 and 2010 and so abundances of waterbirds are still likely to be recovering from low numbers recorded in January 2011.

The Coorong and Lower Lakes supported in excess of 283,000 waterbirds in January 2013 and so this wetland system clearly continues to meet the criteria expected of a Wetland of International Importance. The Coorong supported almost double the numbers of birds compared to the Lower Lakes, as has been the case in recent years. This highlights the importance of the Coorong from a bird perspective numerically. Furthermore, many species of waterbirds, particularly the endemic and migratory shorebirds (stilts, sandpipers, plovers and allies) were largely confined to the Coorong adding further support for the importance of this component of the wetland system. As many of the species using the Coorong are not prominent elsewhere along the Murray Darling system, the Coorong in particular warrants management to secure the resources needed by those species. The Lower Lakes, in turn support a number of waterbird species that rarely use the Coorong, but there are some species (various ducks, cormorants, terns) that readily use both wetland systems. The majority of the bird species currently using the Lower Lakes, however, use other freshwater wetlands elsewhere within the Murray Darling Basin and so are not as unique as the bird communities using the Coorong. From a bird perspective, however, the variously salty wetland systems of the Coorong complement those of the freshwater systems of the Lower Lakes allowing a greater diversity of waterbird species to exist within the region. Having the Coorong and Lower Lakes wetlands juxtaposed increases the range of wetland habitats in close proximity to each other and provides wider foraging opportunities for at least some species.

One of the primary reasons for combining counts of waterbirds using the Coorong with counts for the Lower Lakes has been to better account for potential local shifts of species between these wetland systems where reductions in abundances in one wetland (e.g. Coorong) are offset by increases in the other (e.g. Lakes). The close proximity of freshwater and salty wetlands also potentially increases the range of species using each of the component wetlands and the system as a whole. During the last 5 years, 86 species of waterbirds have been detected using the Coorong and Lower Lakes during summer, albeit about a third of those have only been seen in small numbers and only in some years (Table 4).

Many of the bird populations within the Coorong and Lower Lakes are still in a state of flux, with some species increasing, others declining and others present in comparable numbers to those detected in recent years. There are no simple general patterns to the changes in abundances and even species within the same guild have shown different responses. For example, Great Cormorants and Pied Cormorants continued to increase dramatically between 2012 and 2013, while Little Black Cormorants declined dramatically over the same period. Any number of explanations could be proffered for these differences including a simple succession response – Little Black Cormorants respond initially to the return of water, and then the larger species respond perhaps as fish populations change. Alternatively factors outside the Coorong and Lower Lakes may be involved, affecting the species of cormorant differently. Given this there does not seem to be a simple suite or subset of species that could be used as indicators for other species. Future monitoring will need to continue to monitor all species and not focus on a few individual species.

The primary purpose of most monitoring programs, including this one on waterbirds is to detect changes in abundances and distribution that indicate a change in key assets that warrants management. For the bird populations that use the Coorong and Lower Lakes there are no clearly defined baselines or benchmarks, nor any target or expected abundances that have been identified against which the counts in any one year could be compared. This is particularly true for the Lower Lakes where there have been no systematic assessments of overall abundances of waterbirds in the region prior to 2009. In 2009 and 2010 water levels in the Lower Lakes were at unprecedentedly low levels (below sea level) and so it is unlikely that the bird abundances using the Lower Lakes in those years were typical of the bird abundances in years prior to this. As such the 2009 and 2010 counts do not provide a suitable baseline. Although there is some historical information on the distributions of waterbirds using the lakes and their local abundances in some years, most of these date back prior to the 1970s and to times before the arrival of the European Carp (Paton 2010). These were also times when water levels in the Lakes were not surcharged to the same extent as they are today (Paton 2010). So, even if there were complete historical data sets on bird use, those data are unlikely to be representative of the conditions that existed in more recent times immediately prior to the millennium drought, and that are likely to be re-established in the future. Thus, there is no simple baseline or benchmark against which to judge the current distributions and abundances of waterbirds in the Lower Lakes. The expectation is that the numbers of various waterbirds will stabilize around some sustainable number with some variation in abundances. As yet those conditions do not appear to have been reached as a number of species, including Great Egret, Pied Cormorant, Great Cormorant and Purple Swamphen have continued to increase following the re-establishment of more typical water levels in the latter half of 2010. Populations of these species may still be recovering from the perturbations caused by the excessively low water levels of 2009 and 2010.In fact amongst the waterbirds using the Lower Lakes, there are a number of species whose abundances have steadily increased each year over the last 3-5 years and these species may still be increasing suggesting that these populations have not stabilised yet, Further monitoring, therefore, is required to determine if these species are still recovering or whether their populations have now fully recovered.

The counts of waterbirds using the Lower Lakes over the last five years have shown dramatic changes, many of which were probably not unexpected. During 2009 and 2010 when water levels were extremely low large numbers of Red-necked Stints and Sharp-tailed Sandpipers (as well as other shorebirds) used the Lower Lakes. In these years there were extensive mudflats covered by shallow water a few centimetres deep. These types of mudflats covered with shallow water were all but eliminated from the margins of the Lower Lakes once water levels were re-established, so the disappearance of the shorebirds was not unexpected. At present water levels in the Lower Lakes are managed at or above 0.6m AHD during summer, and at these levels few opportunities exist for shorebirds. There is clearly merit in exploring options to lower the water levels in the Lakes to provide some habitat for shorebirds. This would increase the value of the Coorong and Lower Lakes for these birds in the future. Historically there have been many more waders around the shorelines of the Lower Lakes (when water levels were managed at lower levels) than were present in 2011, 2012 and 2013. A range of other species including crakes and rails may also benefit if water levels in the Lower Lakes were a little lower.

Some historical data on the abundances of shorebirds in the Coorong do exist back to the 1980s and these provide a longer term basis for assessing changes (Paton 2010). However these data are not available for all species and often not at the scale of the whole Coorong. For the last 14 years there has been an annual census of the waterbirds using the Coorong conducted and these counts document changes in bird use over the last decade at least. The early counts in this sequence provide some information before the effects of the millennium drought changed the ecological characteristics of the Coorong. The ecological changes in the Coorong are related to flows over Barrages to the Murray Mouth. Flows to the Murray Mouth ceased in 2002 and for the next 8 years

and the Murray Mouth was kept open by continual dredging until reasonable flows returned in late 2010. With the lack of flows the salinities rose to unprecedented levels in the southern Coorong and water levels have dropped prematurely in spring exposing extensive beds of the aquatic plant *Ruppia tuberosa*. This resulted in the seed banks of this annual plant being all but eliminated such that even today the species has not re-established (Paton & Bailey 2013a, b). Other key food resources also changed during the last decade, as the high salinities established and exceeded the tolerances of chironomids and hardyhead fish, both of these key food resources were eliminated from the southern Coorong. At the same time, and perhaps fortunately, brine shrimps established in these high salinities and provided alternative food resources for some species in the southern Coorong from 2006-2010. With the return of flows of freshwater over the Barrages, the salinities dropped within a few months allowing chironomids to recolonise the southern Coorong, with hardyhead fish populations following a year later. Brine shrimps disappeared within about six months of the resumption of flows over the Barrages, almost as quickly as they had appeared.

Despite all of the changes in the types and abundances of key food resources during the middle and late 2000s, the Coorong was still supporting substantial numbers of waterbirds throughout the drought. This all changed, however, when the unregulated flows first reached the Coorong in spring 2010. Water levels in the Coorong increased dramatically and to such an extent that the mudflats normally used by waders and other waterfowl were covered by too much water, effectively excluding the birds. Given this, the substantial reductions in the abundances of many waterbird species that were detected in summer 2011 were not unexpected (Table 4). A clear management recommendation for the future is a need to minimise the likelihood of too much water being held within the Coorong, particularly during summer when the numbers of birds using the Coorong is highest. This is likely to occur if the Mouth and or the channels that lead to the Mouth from the Barrages are constricted to any extent due to incursions of marine sands. During periods of low flow when the Mouth and channels are prone to incursions of marine sands prompt introduction of dredges may be warranted. These should not be restricted to the region of the Mouth but should also involve dredging the channels to prevent submerged sandbars from choking the channels during periods of low flows. This dredging of channels should probably continue for a while once flows return, and this can be modified to just dislodge the consolidated sands into the water column with the flow of water dispersing the sediment out to sea.

As with the Lower Lakes the trends in the numbers of birds of different species counted in recent years in the Coorong are yet to fully recover from the perturbations caused during the millennium drought, a drought that was made more severe by the extraction of water upstream (Paton 2010). Any notion that waterbird populations may have recovered in the Coorong is easily countered by several species that have been steadily declining in abundances over the last five years, and others that are still much lower in abundance than they were prior to the drought. Ongoing annual monitoring is therefore required to determine if and when the various waterbird species have recovered to their pre-drought population sizes. As the counts can vary from one year to the next and the causes of those changes are not fully understood, multiple years of monitoring will be required to determine recovery, just as multiple years of data are needed to set reasonable baselines.

The variability in the numbers of birds counted from one year to the next remains a challenge for assessing the status of waterbirds within the Coorong and Lower Lakes. Ultimately the various factors that cause changes in numbers of different bird species using the wetlands of the Coorong and Lower Lakes needs to be understood if the wetlands and hence waterbirds are to be effectively managed in the future. This will require: (i) the maintenance of counts of waterbirds using the Coorong and Lower Lakes in summer, as well as counts at other times of the year; (ii) counts of waterbirds using other wetland systems; (iii) targeted autecological studies on key species of waterbirds; and (iv) incorporation of behavioural data with census data and habitat features to allow habitat suitability models to be developed for a range of species. Simply recording the activities of

the birds when they are counted can add considerably to assessing habitat quality as illustrated for a number of species using the Coorong and Lower Lakes. In January 2013, most of the species of shorebirds (sandpipers, stints, stilts, plovers) were spending most of the day foraging. This is a time when the birds are not preparing to migrate and have close to maximal daylight, yet are spending over 90% of their time apparently foraging. When birds spend large amounts of time foraging the quality of their foraging habitats are poor.

At present government agencies charged with responsibilities for managing wildlife under Federal and State legislation show a reluctance to even maintain monitoring programs. In the case of the Coorong and Lower Lakes there is another pressing reason for maintaining the existing monitoring programs as a minimum. *Ruppia tuberosa* is a key asset in the Coorong providing food for birds and habitat for fish, yet this aquatic plant has failed to re-establish over much of the South Lagoon despite experiencing several years of favourable salinities. This widespread failure to re-establish is linked to the loss of an adequate seed bank and exacerbated by inadequate flows in spring. A translocation program, however, is now underway to facilitate recovery, and monitoring of both the plants and the bird responses to the translocation is warranted to assess the success of the program. If this plant species cannot be re-established and once established cannot maintain itself, then the ecological character of the Coorong will have changed. Changes in the waterbird communities should be expected with this fundamental change in ecological character.

Acknowledgements

This work was commissioned by the South Australian Department of Environment, Water and Natural Resources (River Murray Operations Branch) through *The Living Murray* initiative with funding provided by the Murray-Darling Basin Authority. Prior to 2008, funding for the annual census of water birds and their resources in the Coorong was provided by the South Australian Department for Environment and Heritage (2000-2006), the Nature Foundation of South Australia (2007), and Earthwatch Australia (2001-2007). These earlier censuses were conducted with the assistance of staff, students and volunteers from the University of Adelaide, and Earthwatch Australia volunteers. The Department of Environment, Water and Natural Resources provided permits for this monitoring, with the monitoring conducted under Animal Ethics approvals from the University of Adelaide. Adrienne Frears and Kirsty Wedge provided administrative support. We thank Lynn Pedler, Tristan O'Brien, Andrew Barker, Lydia Paton, Fiona Paton, Tom Hunt, Teagan McKillop, Tom Bradley, Alastair Wood, Andrew Baker, John Sommer, Sally Nobbs, Grace Hodder, Donna Belder and Gareth Oerman for assistance with this annual waterbird survey.

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Appendix

Table A1. Locations of monitoring sites used for assessing benthic food resources for birds along the Coorong. Eastings and northings are Map 54H in GDA94 units to the nearest 5m. These locations give the shoreline at the sites where monitoring took place, with plankton, fish-trawls and mud samples taken out into the water beyond the shoreline.

Code	Site name	Lagoon	Distance from Mouth (km)*	Easting	Northing
N58		Estuary	-2	305485	6065430
N51		Estuary	5	314235	6063230
N45	Pelican Point	North	11	321110	6058955
N39	Marks Point	North	17	326235	6055395
N29	Long Point	North	27	333980	6048395
N19	Noonameena	North	37	342625	6042195
N12		North	44	347990	6037310
N08		North	48	350595	6034405
N02	Magrath Flat	North	54	354895	6029500
S06	Villa dei Yumpa	South	62	360455	6024900
S11	Braeside	South	67	363125	6022560
S16		South	72	367175	6018210
S21		South	77	370405	6013460
S26	Policemans Point	South	82	372680	6009030
S31	Gemini Downs	South	87	377445	6004300
S36	Salt Creek	South	92	377730	6000930
S41	Tea Tree Crossing	South	97	378780	5996640

*distances are negative for sites NW of the Murray Mouth and positive for sites SE of the Murray Mouth