CHANGES IN DISTRIBUTION AND ABUNDANCE OF AUSTRALIAN PIED AND SOOTY OYSTERCATCHERS ON HIGHLY DISTURBED BEACHES OF THE SOUTH-EASTERN FLEURIEU PENINSULA, SOUTH AUSTRALIA.

G. KEITH JONES

25 Coppin Street, Glengowrie, S.A. 5044.
Email: docjones@bigpond.net.au

This 4-year study examines human activity along the beaches of the south-east Fleurieu Peninsula and at the River Murray Estuary, South Australia and associated distribution and abundance of Australian Pied (*Haematopus longirostris)* and Sooty (*H. fuliginosus)* Oystercatchers between June, 2011 and May, 2015. The relative abundance of the two species as well as the numbers of people, dogs, off-road vehicles (ORV's) and beach wrack were monitored twice-monthly at a total of ten sites over this area. During the study period, the distribution and abundance of *H. longirostris* significantly shifted from the ocean beaches to the River Murray Estuary. Throughout the monitoring period *H. fuliginosus* counts on the ocean beaches showed similar annual cycles, but counts increased significantly at the Murray River Estuary. At the same time, most forms of human activity increased, significantly for numbers of people at the sites on weekends, and most rapidly for all forms of activity at the River Murray Estuary. Both species exhibited strong seasonal variation in their abundance in all regions, with a tendency for low abundance coinciding with the period when birds moved to other habitats to nest and rear juveniles, with few significant correlations with human activities on the birds' seasonal abundances. However, statistically significant negative correlations were observed between *H. longirostris* abundance and ORV's at the Murray River Estuary, *H. fuliginosus* abundance and the activity of people along the Goolwa Beach and for the same species with ORVs on weekends / public holidays. Possible reasons for the spatial shift in their distributions and increasing abundances at the River Murray Estuary, include: a) changes in the distribution and biomass of their preferred food (Pipis, *Plebidonax deltoides*), either caused by natural fluctuations or increasing recreational pipi fishing effort on the ocean beaches; b) an increase in area of intertidal sand flats in the River Murray Estuary, due to a significant drop in the environmental flow of water though the barrages in the last two years of the study, and / or; c) variable levels of annual recruitment from birds outside the study area.

INTRODUCTION

Australian Pied, and Sooty Oystercatchers (*H. longirostris* and *H. fuliginosus*, resp.) are two of the more conspicuous resident shorebirds of most of the Australian coastline. In South Australia (SA), *H. longirostris* occurs in habitats ranging from the intertidal mud flats of estuaries and embayments (e.g. Coorong Lagoon, Paton *et al.* 2009, Paton 2011; the upper gulfs, Carpenter & Langdon 2014, and NE Kangaroo Island, Dennis & Baxter 2006) through to the ocean beaches (e.g. Younghusband Peninsula, Wilson 2000). In contrast, *H. fuliginosus* usually inhabits rocky outcrops of the mainland and islands (e.g. Finlayson 1938; Bonnin 1982), but is also seen in smaller numbers, often intermixed with *H. longirostris*, on beaches (e.g. Kangaroo Island, Dennis & Baxter 2006, and the upper gulfs; Carpenter & Langdon 2014). The two species also differ in their breeding areas. *H. longirostris* nests during September – January amongst the upper parts of beaches, usually above high tide (e.g. southern Yorke Peninsula: author *pers. obs.*), amongst the marram grass of sand dunes, or the samphire wetlands of low islands (e.g. Coorong Lagoon: Sutton 1933). *H. fuliginosus* nests during October to January on many of the inshore and offshore islands of SA (Morgan 1916, Hornsby 1978, Carpenter 2009).

The International Union for Conservation of Nature (IUCN) conservation status for both species is listed as least concern (Taylor *et al.* 2014; Hansen *et al.* 2014, resp.), with no evidence of recent declines in Victoria and Tasmania. In New South Wales, *H. longirostris* is cited as endangered and in SA the species has been categorised as near threatened under the SA National Parks & Wildlife (NPW) Act, 1972. In SA, within the Coorong Lagoon and along the Coorong Ocean Beach, upwards of 400 birds have been counted in each summer from 2000 to 2008 (Wainwright & Christie 2008), thereby, meeting the requirement of Criterion 6 of the Ramsar Convention (i.e. > 1% of its global population (Paton *et al.* 2009, Taylor *et al*. 2014)).

The distribution and abundance of oystercatchers are influenced by both natural and anthropogenic causes. Natural effects include the distribution and biomass of *H. longirostris'* primary food source on beaches (pipis / cockles) (Owner & Rohweder 2003, Taylor *et al*. 2014) or, for *H. fuliginosus*, the presence of beach wrack (Taylor *et al*. 2014). Anthropogenic influences on *H. longirostris* populations include the many forms of human activity on beaches along eastern Australian coast (Newman & Patterson 1986, Owner 1997, Fisher *et al.* 1998, Bryant 2002), and similar species elsewhere (Lambeck *et al.* 1996, Norris *et al.* 1998, Davis *et al.* 2000). Human activity has been identified as potentially adversely influencing habitat use (Dennis & Masters 2006), and includes: a) general beach recreational use (holiday-makers, walkers, people exercising dogs, commercial and recreational harvesting of pipis / cockles and shore line fishing); b) residential development nearby; c) vehicle access to beaches, including off-road vehicles (ORV's) and horses, and; d) the presence of grazing feral / domestic animals. Where a beach regularly scores more than one of these types of disturbances, it is categorised as being a highly disturbed one to shorebirds (Dennis & Masters 2006).

This paper reports on the results of a 4-year monitoring program undertaken to record numbers and analyse changes in the distribution and relative abundance of oystercatchers and associated human activity along the beaches of the south-eastern (SE) Fleurieu Peninsula (Middleton to the eastern most part of Goolwa Beach, i.e. Sir Richard Peninsula Beach) and the River Murray Estuary, between June 2011 and May 2015. The study area is adjacent to a part of the Local Government Council of Alexandrina, in which the population has grown by 31% since 2001 / 2002 to approximately 25,000 residents in 2012 / 2013, with a further predicted increase at a similar rate to about 33,000 by 2031 (Alexandrina Council 2014). The beaches are also visited by significant numbers of holiday visitors mainly Adelaide residents. For example, in the summer of 2013 / 14, more than 60 % of surveyed recreational Pipi gatherers along the Goolwa Beach resided in inner Adelaide (Hall *et al.* 2014).

METHODS

Study area

The 18 km of south-facing beach between Middleton and the mouth of the River Murray is at the western end of the high energy, 140 km long Coorong Beach (Figure 1). Throughout the year, the beach is subjected to moderate to high energy south-westerly (SW) swell, and during spring and summer, SE to SW winds tend to produce longshore currents and movement of sand, resulting in relatively wide beaches of up to 30 metres during the summer. In contrast, the SW to northerly winds during winter reverses the current, shifts sand offshore, thereby making the beaches much narrower, with waves often working against the front of the sand dunes (Ferguson 2013). The SE winds during summer generate upwelled water of high productivity along the South Australian coast and this together with outflows from the River Murray are suggested reasons for the high abundances of the filter-feeding surf clam, commonly known at the Goolwa Pipi (*Plebidonax deltoides*) along the Coorong Beach. This species is the subject of a managed commercial fishery along the eastern Coorong Beach (Ferguson 2013) and a growing recreational fishery in the study area (Hall *et al.* 2014).

At times along the Middleton part of the study area extensive drifts of dead seagrasses and algae ("beach wrack") are washed up and remain for up to a fortnight at a time, but are less often seen along the Sir Richard Peninsula Beach. The Middleton Beach also has several eroded limestone platforms extending to about mid tide level, and at the far western part of this beach, there is a grey sandstone outcrop exposed at mid to low tide levels (Middleton Point). Above the high tide mark at the Goolwa and Sir Richard Peninsula Beaches primary sand dunes occur, with extensive growths of marram grass. Two proclaimed conservation areas (Tokuremoar Reserve and Sir Richard Peninsula Conservation Park) adjoin the western and eastern Goolwa Beaches, respectively. There is a multitude of access points to the beaches, including numerous car parks at Middleton and Goolwa (total capacity of more than 400 vehicles, with overflow onto side streets), walking tracks through

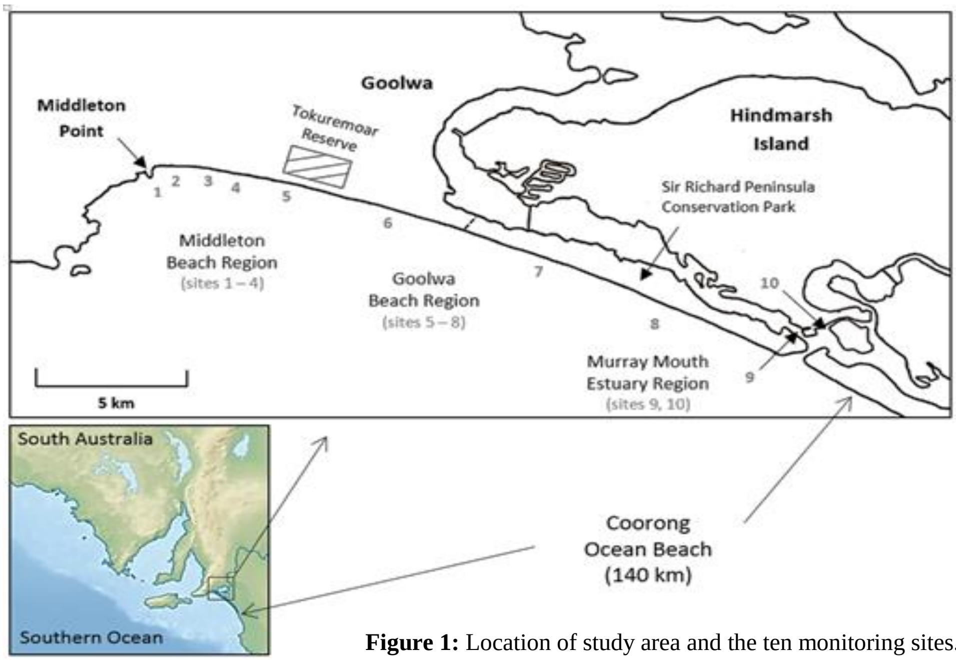

Figure 1: Location of study area and the ten monitoring sites.

the sand dunes from the car parks behind the dunes at Goolwa and the Sir Richard Peninsula, as well as ORV access from the main Goolwa Beach Car Park to the Sir Richard Peninsula Beach and extending as far as the Murray Mouth.

The waters immediately inside the Murray Mouth are relatively sheltered, with several low sand islands occurring (Figure 1). Human access to the shores of the estuary include car parks at Sugars Beach and the Murray Lookout on Hindmarsh Island, boat access from the Beacon 19, Mundoo Channel and Sugars Beach boat ramps, and ORV access from the ocean beach by way of the Goolwa Main Beach Car Park. The shape and size of the islands in the estuary have altered significantly since the construction of the barrages in the early 1940’s (Bourman *et al.* 2000), and continue to change with the annual variation in flow of fresh water through the barrages (MDBA 2013). In recent years of low barrage flow (2003 – 2010 and since early 2015), extensive dredging inside the mouth has been and is currently being done to ensure the mouth is kept open. Spoil is dumped on the ocean beach, immediately to the west of the mouth and inside the study area.

Survey method

Ten sites between Middleton and the Murray Mouth (Figure 1) were chosen where oystercatcher numbers and human activity could be cost-effectively monitored between June, 2011 and May, 2015 (Table 1). For most sites, car parks adjacent to the sites were chosen, making access to the beaches easy. At Sites 7 and 8, access to the ocean beach was via walking tracks through the dunes on Sir Richard Peninsula.

Table 1. Locations and habitat types at the 10 sites used to monitor oystercatcher numbers and human activity.

Site #	Site Name	GPS Position	Habitat type
1	Middleton Point	$35^0$30’48.4”S, $138^0$42’39.2”E	Grey Sandstone Outcrop, Ocean Beach
2	Chapman Rd, Middleton	$35^0$30’49.2”S, $138^0$43’09.8”E	Ocean Beach
3	Skye Street, Middleton	$35^0$30’53.5”S, $138^0$43’35.2”E	Eroded intertidal limestone platform, Ocean Beach
4	Middleton Cliffs	$35^0$30’57.3”S, $138^0$44’14.6”E	Limestone cliff, overlooking Ocean Beach
5	Tahiti Tce, Middleton	$35^0$30’57.3”S, $138^0$44’20.2”E	Ocean Beach, sand dunes
6	Beach Rd, Goolwa	$35^0$31’.22.9”S, $138^0$46’23.7”E	Ocean Beach, sand dunes
7	Barrage Beach	$35^0$32’25.8”S, $138^0$48’46.3”E	Ocean Beach, sand dunes
8	Beacon 19 Beach	$35^0$32’33.4”S, $138^0$50’08.6”E	Ocean Beach, sand dunes
9	Sugars Beach, Hindmarsh Island	$35^0$32’58.8”S, $138^0$52’44.2”E	Intertidal sand flats inside the western Murray mouth.
10	Murray Mouth Lookout, Hindmarsh Island	$35^0$33’00.3”S, $138^0$59’27.1”E	Intertidal sand flats, between Hindmarsh and Bird Islands.

Whenever possible, surveys were undertaken twice monthly with all sites monitored on the same or following day, usually around the low tide level during daylight hours. Time and travel constraints mean that sites 9 and 10 adjacent to Hindmarsh Island were usually surveyed on the following day. Survey days were chosen randomly, to cover within each of weekdays, weekends and public holidays. Within a distance of about 200 metres on either side of the entry point, all shorebird species were identified and counted using 10 x 42 Bushnell binoculars and / or a Nikon Spotting Scope (RAIII 65A WP angled, 20-60x zoom).

Human activity within survey areas was also recorded, three types were identified a) numbers of people, beach walkers, swimmers, surfers, recreational pipi-gatherers and recreational line fishers, b) numbers of dogs (leashed and un-leashed combined) and c) the numbers of stationary or moving ORV’s. ORV activity on Sir Richard Peninsula Beach and at the Murray Mouth was only monitored from October 2011 onwards. The behaviour (resting or foraging) of oystercatchers was observed, and where possible the type of food consumed was recorded. Observations on any nesting activity above the high water mark on beaches or adjacent samphire flats in the estuary were made; however, the sand dunes were not monitored. On several occasions, Australian Pied Oystercatchers with bands and / or flags on their legs were observed using the scope. These were noted but as the birds could not be approached to within about 15 metres, it was often not possible to record code details on the flags. Observations of banded and flagged oystercatchers were reported to the Victorian Wader Studies Group (D. Trudgen).

The presence of “beach wrack” on the beach was recorded, using one of four codes; 1: no wrack, 2: light wrack, 3: medium wrack or 4: heavy wrack. Estimated wind speed and direction, and tidal state were also recorded.

Data analysis

All data were entered to excel spreadsheets and initially analysed to investigate the effect of day-type (weekday versus weekend / public holidays) on annual human activity (people, dogs and ORVs) and the relative abundance of both species of oystercatchers. Data from all sites were pooled. To determine any association between human activities and oystercatcher abundances, mean daily counts of human activity (± s.e.) were rank correlated with the annual relative abundances of oystercatchers (mean count ± s.e.) per day surveyed (Zar 1984), assuming that variables were independent.

To investigate intra-annual variation in human activity and oystercatcher abundance, the data were aggregated into three regions, each differing in habitat type; Sites 1 – 4, Middleton Beach (shore reef and ocean beach); Sites 5 – 8, Goolwa and Sir Richard Peninsula Beaches (ocean beach); Sites 9 and 10, Murray Mouth (estuary). The data were further aggregated to two monthly periods, and for inter-annual variation, the period June – May for each of the four monitoring years, 2011/12 - 2014/15. Paired student *t*-tests were again used to test for any statistically significant differences in intra-and inter-annual means, and ranked correlation analyses for associations between relative abundance of oystercatchers and the various types of human activity.

Environmental data (wind direction and speed and the occurrence of beach wrack) were analysed for seasonal (2 monthly) and annual differences. Data for combined sites were analysed for wind direction and speed, and the occurrence of beach wrack was analysed only for the most heavily affected Middleton Beach region. Correlation coefficients between the seasonal presence / absence of beach wrack and seasonal abundances of *H. fuliginosus* for combined years at the Middleton Beach region were similarly calculated.

RESULTS

Wind direction and speed and "beach wrack".

Throughout the survey period, winds from the S – SW quarter were most prevalent during the period October – March (Figure 2). For the rest of the year (April – September), winds from the N – NE quarter were more prevalent. Mean wind speeds did not vary substantially throughout the year (mean 16.6 + s.e. 1.4 km / hr; range of monthly means 14.1 – 18.0), with the highest mean speed occurring in June / July and the lightest mean speed in April / May. Over the four years, the weather pattern varied with an increased prevalence of N – NE winds and diminishing prevalence of S – SW winds (Figure 3). However, mean wind speed did not show any trend with average speed varying between 14.3 and 18.4 km / hr (mean 16.6 + s.e. 1.7 km / hr) over the four years.

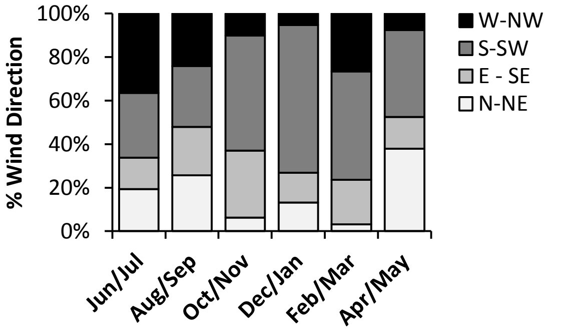

Figure 2: Seasonal percentage compositions of wind directions (90^0 intervals) at all survey sites, at 2 monthly periods, June/July – April/May, combined years.

Beach wrack increased towards the western end of the study area; being highest at Middleton Beach and lowest at the Murray Mouth Estuary. For all regions, beach wrack mainly occurred during the warmer months, for example, at Middleton Beach, beach wrack occurred mainly from November – May (Figure 4), and this was evident for all years of the study (unpubl. data).

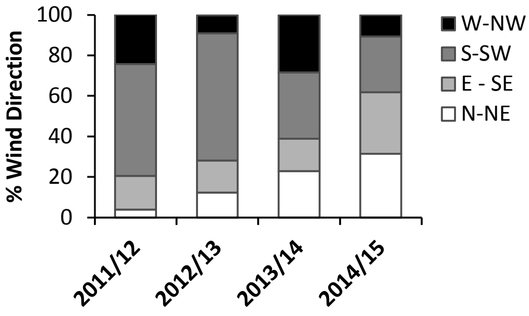

Figure 3: Annual percentage compositions of wind directions (90^0 intervals) at all survey sites (2011/12 – 2014/15).

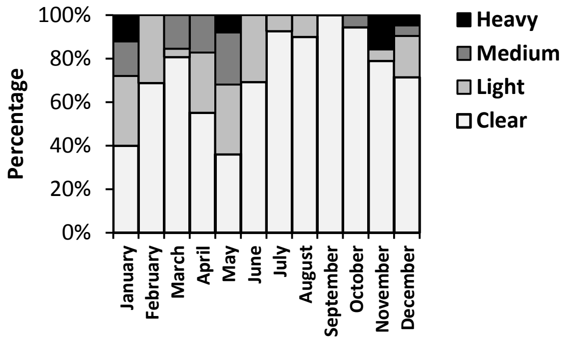

Figure 4: Percentage occurrence of beach wrack (clear – heavy) at Middleton Beach, combined years.

Annual human activities and oystercatcher abundances by day-type.

A total of 312 weekdays and 236 weekends / public holidays were surveyed throughout the monitoring period (Table 2). Mean counts of people, dogs and ORVs were generally higher on weekends than for weekdays, with more people present on average on weekends (Student paired *t*-test, $p < 0.05$, 2-tailed test). Mean annual weekend counts of both people and ORV's consistently increased over the four year period, with only the rates for dogs remaining about the same.

Table 2: Mean annual count of people, dogs, off road vehicles (ORV's) and oystercatchers for each site survey for a) weekdays and b) weekends/public holidays between 2011/12 – 2014/15.

a) Weekdays

		Mean Count / Site (+ s.e.)				
Year	**No. days surveyed**	**People**	**Dogs**	**ORVs**	**Australian Pied Oystercatchers**	**Sooty Oystercatchers**
2011/12	71	11.10	0.90	0.20	6.01	2.15
2012/13	64	4.69	0.36	0.48	2.08	1.80
2013/14	67	8.98	0.76	0.34	1.78	1.48
2014/15	110	10.52	0.77	0.39	6.76	2.01
2011-15	312	9.13	0.71	0.36	4.56	1.88
		+2.19	+0.23	+0.12	+2.60	+0.29

b) Weekends/Public Holidays

Mean Count / Site (+ s.e.)						
Year	**No. days surveyed**	**People**	**Dogs**	**ORVs**	**Australian Pied Oystercatchers**	**Sooty Oystercatchers**
2011/12	49	14.63	0.73	0.16	2.06	1.94
2012/13	104	19.44	1.23	1.52	4.48	1.39
2013/14	53	33.17	3.38	1.60	2.02	2.04
2014/15	30	31.90	1.53	5.46	2.13	0.97
2011-15	236	23.11 +9.18	1.65 +1.15	1.76 +2.28	3.13 +1.21	1.60 +0.50

For both species of oystercatchers, mean counts per site across all years showed non-significant lower counts on weekends than weekdays (*H. longirostris*, p = 0.4433; *H. fuliginosus*, p = 0.4653).

Counts of *H. fuliginosus* showed a significant decrease with increasing counts of ORV's on weekends (r = -0.8418, p<0.05) and *H. longirostris* showed a weak negative but non-significant trend (Table 3). Counts for dogs and people did not show a significant correlation with abundance of either species.

Table 3: Correlation coefficients, n = 4) between annual mean counts for people, dogs and ORV's at each site and annual mean abundances for each oystercatcher species from 2011/12 – 2014/15.

	Rate of people observations		**Rate of Dog observations**		**Rate of ORV observations**	
Oystercatcher species	Week days	Week ends	Week days	Week ends	Week days	Week ends
H. longirostris	0.7472	-0.3848	0.6151	-0.5836	-0.4719	-0.1644
H. fuliginosus	0.4415	-0.2309	0.3297	0.3531	-0.4246	-0.8418 * (p< 0.05)

H. longirostris – intra- and inter-annual abundances by region.

There was an eastward spatial shift in relative abundances of *H. longirostris* over the duration of the study, with highest counts at Middleton and Goolwa Beaches up to Dec / Jan, 2011, and thereafter, a substantial rise in numbers at the Murray Mouth Estuary (Figure 5). *H. longirostris* was not observed at Middleton after Oct / Nov, 2012, and declines at Goolwa continued, with birds generally only observed between August and November. At the Murray Mouth, the seasonal fluctuations in abundance showed cyclic patterns throughout much of the study, with relatively high numbers between June and September, relatively low between October and January, and in 2012/13 and 2014/15 thereafter, relatively high numbers in February to May (Figure 5). The regional shift in counts is also seen in the annual fluctuations (Figure 6), with a significant decrease at Goolwa Beach (Paired Student *t*-test, p < 0.0413) and a significant increase at the Murray Mouth Estuary (Paired Student *t*-test, p < 0.0233) between 2011/12 and 2014/15.

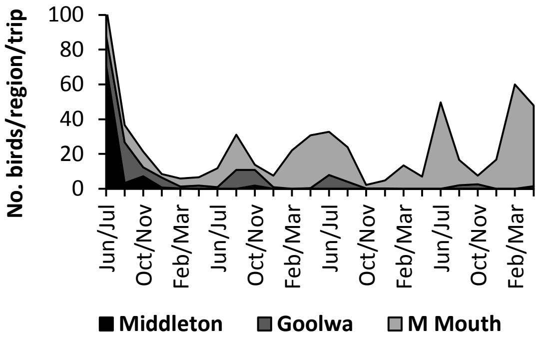

Figure 5: Seasonal fluctuations in total counts of *H. longirostris* for all sites in each of the three regions between June/July, 2011 and April/May, 2015.

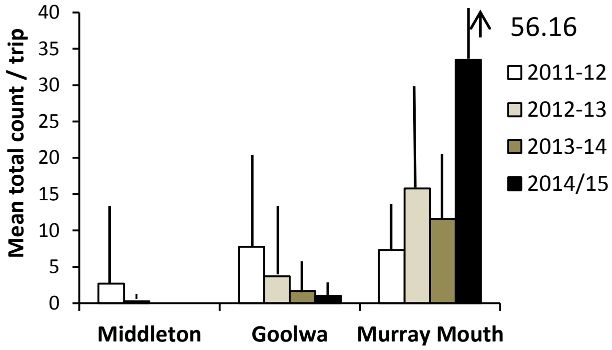

Figure 6: Annual mean total counts (+ s.e.) of *H. longirostris* for each survey at the three regions, 2011/12 – 2014/15, with associated standard errors.

H. fuliginosus - intra- and inter-annual abundances by region.

Annual cycles in relative abundance of *H. fuliginosus* were evident in all regions, however, the timing of fluctuations differed slightly between regions (Figure 7). At Middleton Beach, in most years, highest numbers were observed in February – April (except June / July 2011), and lowest numbers between June and January. At the Goolwa Beach, in most years, numbers peaked at similar times to those at Middleton, however, the seasonal troughs in abundances were generally shorter (October – January). Finally, for the Murray Mouth region, the amplitude of the cycles were greatest of all regions, with highest numbers typically observed

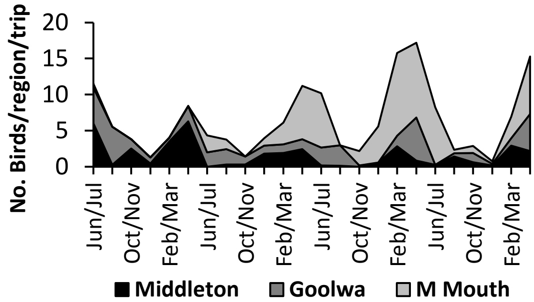

Figure 7: Seasonal fluctuations in total counts of *H. fuliginosus* for all sites in each of the three regions between June/July, 2011 and April/May, 2015.

between February and July and lowest numbers between October and January (Figure 7).
Although, the annual mean of the total counts at Middleton and Goolwa Beaches didn't show any significant decrease over the four years, the abundances at the Murray Mouth Estuary increased significantly between 2011/12 and 2014/15 (Paired Student *t*-test, $p < 0.036$) (Figure 8).

At Middleton Beach, where beach wrack was most commonly observed, mean total counts in each season of *H. fuliginosus* were significantly correlated with medium levels of beach wrack (correlation coefficient, $r = + 0.4760$, $p < 0.05$, 12 d.f.). When this beach was clear, mean total counts showed a non-significant decline ($r = -0.3091$).

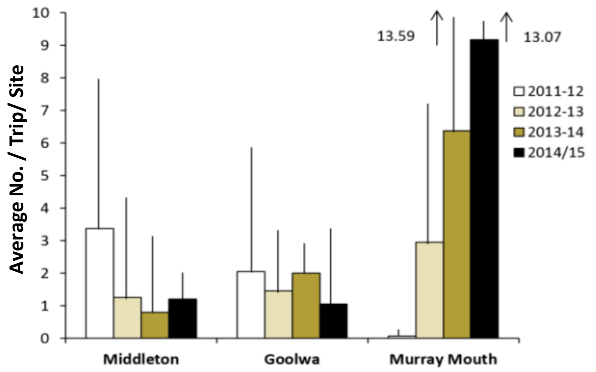

Figure 8: Annual mean total counts (± s.e.) relative abundances of *H. fuliginosus* for each survey at the three regions, 2011/12 - 2014/15, with associated standard errors.

Human Activity – people, dogs, ORV's – intra- and inter-annual variation.

In all three measures of human activity, peaks in annual cycles of total counts in each region occurred during the warmer months (December – March) and lowest activity occurred between June and September (Figures 9 a, b & c). Highest person and dog numbers occurred in the summer of 2013/14, however, over the duration of the monitoring program all types of human activity increased (0.3% to 42.7% per year) (Table 4). Although they began at a lower level, the percentage annual increase in human activity at the Murray Mouth was the highest of all regions.

Table 4: Temporal changes in measures of human activity at the three regions, 2011/12 – 2014/15, expressed as linear equations (where Y = mean numbers of people, dogs, ORVs, resp., x = bi-monthly period), and % annual change (in parentheses).

Region	People	Dogs	ORVs
Middleton Beach	Y = 0.006x+12.75 (+0.3%)	Y = 0.113x+9.5 (+7.1%)	N.A.
Goolwa Beach	Y = 0.6312x+10.54 (+35.9%)	Y = 0.021x+1.36 (+9.3%)	Y = 0.0219x+2.19 (+6.0%)
Murray Mouth Estuary	Y = 0.3814x+5.51 (+41.5%)	Y = 0.0189x+0.27 (+42.7%)	Y = 0.1156x+2.25 (+30.8%)

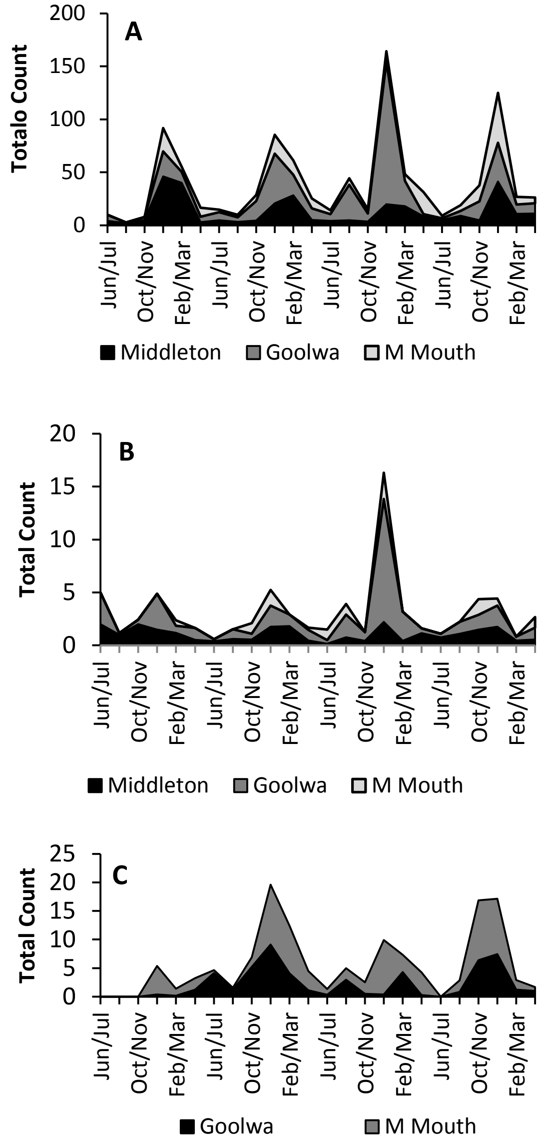

Figure 9: Seasonal fluctuations in total counts of a) people, b) dogs and c) ORV's at the three regions; between June/July, 2011 and April/May, 2015 for people and dogs at all regions and between October/November, 2011 and April/May, 2015 at Goolwa and the Murray Mouth Regions for ORV's.

Correlations between seasonal oystercatcher abundances and human activities.

Most correlations between oystercatcher abundances and the various forms of human activity were negative, inferring that when oystercatcher abundances were high, human activity was low; however, the only statistically significant negative associations were between ORV's and *H. longirostris* at the Murray Mouth, and between people and *H. fuliginosus* at Goolwa Beach (Tables 5a & b, resp.). The significant positive correlation between *H. longirostris* abundance and dogs at Middleton Beach was largely driven by a single observation of high *H. longirostris* abundance and relatively high numbers of dogs.

Tables 5a & b: Correlation between a) *H. longirostris* and b) *H. fuliginosus* seasonal abundances and measures of human activity (2011/12 – 2014/15 (24 degrees of freedom).

a) *H. longirostris*

Region	People	Dogs	ORVs
Middleton	-0.1587 (ns)	0.3561 (Sig, P < 0.05)	-
Goolwa	-0.2113(ns)	-0.1947 ns	-0.0245 ns
Murray Mouth Estuary	-0.2137 (ns)	-0.2064 ns	-0.3723 (Sig, P < 0.05)

b) *H. fuliginosus*

Region	People	Dogs	ORVs
Middleton	-0.0497 (ns)	0.1194 (ns)	-
Goolwa	-0.3315 (Sig, P < 0.05)	-0.2210 (ns)	-0.1594 (ns)
Murray Mouth Estuary	-0.1683 (ns)	-0.0880 (ns)	-0.1805 (ns)

DISCUSSION

The habitats studied here play important roles in the ecology of both species of oystercatchers, where foraging and resting / flocking occurs. Other important habitats not found in the study area are used for nesting (samphire beds and sand dunes for *H. longirostris* and rocky offshore islands for *H. fuliginosus*).

On the western part of the ocean beach at Middleton, S – SW winds during the summer / autumn months appeared to indirectly influence the abundance of *H. fuliginosus*, as, at that time of the year the winds directed floating dead seagrass and algae onto the beach, with this species flocking and foraging amongst the beach wrack between February and May. It was noticed that their totally black / dark brown coloured plumage blended with the similar colour of the wrack, possibly making them less vulnerable to scavenging Silver (*Larus novaehollandiae*) and Pacific Gulls (*L. pacificus*) competing for similar types of food.

Between 2011 and 2015, the annual increase in relative abundance of both species and shift in distribution and abundance of *H. longirostris*, from the ocean beaches at Middleton and Goolwa to the sand flats of the Murray Mouth Estuary have been the most apparent observations of this study. There are several contributing factors that may have influenced this spatial shift to the Murray Mouth Estuary; however, the present study has not been able to isolate the main cause.

Firstly, there was an increase in area of sand-flats available for both species to rest/feed inside the Murray Mouth in 2013 and 2014. In the two previous years (2011, 12), the River Murray Estuary experienced the highest barrage flows (up to 2,500 GL / month) since the early 1990s (MDBA, 2013), resulting in regular inundation of the sand-flats inside the mouth, no doubt diminishing the size of resting and feeding habitats for the two species, whereas in the two latter years, the sand-flats were regularly exposed. Similarly, previous long-term monitoring of *H. longirostris* in the River Murray Estuary resulted in relatively higher mean counts between 2007 and 2009, when no environmental flow through the barrages occurred, compared with the period between 2000 and 2006, when environmental flows took place (Paton 2011).

Secondly, natural or human induced fluctuations in the biomass and spatial distribution of Goolwa Pipis *P. deltoides* and beach worms (Phylum Annelidiae) could have altered the birds' distributions. Both these food items were commonly foraged by the two species during the study (author, *pers. obs.*). Mass mortality events of Pipis, caused either by sudden drops in salinities from River Murray flows through the mouth (Clarke 1985) or the large build-up of beach wrack coinciding with dodge tides (i.e. little tidal movement for more than 24 hrs) on very warm days causing inter-tidal Pipis to "cook", are known to occur along the Middleton and Goolwa Beaches from time to time (e.g. November, 2011; Sites 1 – 5; author, *pers.obs.*). Such events could trigger the movement of oystercatchers to more favourable feeding areas. Long-term studies on the *P. deltoides* populations on the eastern side of the Murray Mouth have found highly variable levels of recruitment and biomass of *P. deltoides* along the eastern part of the Coorong Beach (Young-husband Peninsula) (Ferguson 2013), and during 2011/12 and 2012/13, the relative biomass was higher there, than for the previous four years (2007/08 – 2010/11). The Oystercatchers may have been attracted to this higher biomass in recent years. Although no similar long-term fishery independent monitoring of the *P. deltoides* population has been done in the study area (Sir Richard Peninsula Beach – Middleton Beach), in 2013/14, the survey of the recreational Goolwa Pipi fishery along these beaches did find that the average size of Pipis increased with eastward progression along the beach, i.e. towards the Mouth (Hall *et al.* 2014). Other studies along northern NSW beaches have found that the densities of *H. longirostris* were positively correlated to the size and density of *P. deltoides* (Owner & Rohweder 2003), and so, the larger size of Pipis nearer the Mouth may have contributed to this spatial shift in abundance of *H. longirostris*.

Additionally, there has been a recent increase in level of recreational harvesting *P. deltoides* along the Goolwa and Middleton Beaches (Hall *et al*. 2014), whereas no pipi harvesting occurs inside the Mouth. These ocean beaches are the most popular ones in South Australia used by recreational Pipi gatherers for bait and human consumption (Jones, 2009). Since 2010/11, the wholesale price of commercially harvested Pipis has increased four-fold (Ferguson 2013), resulting in this recreational activity becoming a more cost-effective method to gather bait or consume, than purchasing them (Hall *et al*. 2014). The impact of harvesting Pipis and other bivalves on the distribution of *H. longirostris* has been observed elsewhere in Australia. For example, at SE Tasmanian monitoring sites, Taylor *et al.* 2014 found that *H. longirostris* shifted its distribution from sites where the cockle (*Katelysia scalarina*) beds had been heavily exploited to sites in the Derwent Estuary, where no harvesting was occurring.

Finally, influxes of *H. longirostris* from other parts of Australia could also have contributed to their higher relative abundances adjacent to the Murray Mouth, as I observed small numbers of banded birds that had dispersed from Westernport and Corner Inlet, Victoria in July, August 2012 at the River Murray Estuary and in February, 2013 on eastern Goolwa Beach (VWSG unpubl. data). However, it is unknown how regular these pulses of recruitment are from other areas, and how much they contribute to this part of the population. The birds within the study area are probably the western most contingent of a larger population of *H. longirostris* observed along the extensive Coorong Ocean Beach as well as the more sheltered Coorong Lagoon (Wainwright & Christie 2008). On several occasions, I have seen pairs of *H. longirostris* flying from the sand-flats inside the Murray Mouth to the Coorong Ocean Beach, to the east of the river mouth.

Both species exhibited strong seasonal fluctuations in abundances for all regions, with low relative abundances appearing to coincide with their movements to nesting/juvenile rearing areas. During the study, no nesting was observed above high tide levels along the Middleton and Goolwa Beaches, but the adjacent sand dunes were not investigated. Nesting *H. longirostris* have been reported in October / November amongst the samphire vegetation of low-lying islands within the Coorong Lagoon (Sutton, 1933, S. Grundy, *pers.obs*.), and the drop in *H. longirostris* abundance at the Murray Mouth sand flats at this time of the year possibly coincided with their dispersal to these nesting areas. Similar timing of seasonal fluctuations in abundance has been reported for *H. longirostris* in Tasmania, with localised movements from winter flocking areas at sheltered coastal sites to summer nesting areas on adjacent ocean beaches (Taylor *et al.* 2014).

In contrast to *H. longirostris*, the relative abundance of *H. fuliginosus* at Middleton and Goolwa Beaches showed no significant decline, even though their abundance increased at the Murray Mouth. Overall, their abundance was lower than for *H. longirostris*, which may have been related to the absence of any monitoring at adjacent rocky coastal parts of the mainland (western Middleton reefs and Port Elliot) and nearby offshore rocky islands (Pullen and Granite Islands). In other parts of southern Australia, these latter habitats are preferred nesting sites for *H. fuliginosus* (e.g. Bonnin 1982; Bryant 2002; Finlayson 1938; Hornsby 1978). Abundances at all regions consistently peaked in April / May, thereafter, dropping to lowest numbers at similar months to those for *H. longirostris*. Similarly, this could be due to their seasonal movements to preferred nesting sites on offshore islands and the undisturbed coastal rocky shores of the mainland in these months. However, disturbance to *H. fuliginosus* by human activity should not be overlooked, as significant negative correlations were recorded for people's activity (including pipi gathering) at the Goolwa Beach (Table 5b) and overall, on weekends by ORV's (Table 3). On a number of occasions, at times of high human activity along this beach, I observed *H. fuliginosus* flying directly from the Middleton Beach site 3 to the eastern part of the Goolwa Beach (Sir Richard Peninsula, site 7), thereby detouring out to sea and around the most consistently disturbed Goolwa Town Beach (Site 6) and the site of highest level of recreational Pipi gathering (Hall *et al.* 2014). Also, at Point Middleton (Site 1), *H. fuliginosus* were often disturbed at times when surfers launched their boards off the rocks.

However, the consistently highest levels in all measured forms of the human activities in December, January may not have had a direct disturbing effect on either species, as this coincided with near to the end of the period when the birds were nesting and rearing juveniles at other habitats. This may explain why there were relatively few significant negative correlations between seasonal human activities and the seasonal abundances. For example, although highest abundances of both species occurred at the Murray Mouth in last two years, this area was where human activity increased most rapidly, albeit from an initially low starting point. It was at the River Murray Estuary, that high levels of ORV activity was significantly negatively correlated with seasonal abundance of *H. longirostris*. ORV's are used along the eastern Goolwa Beach (Sir Richard Peninsula), mainly by recreational Pipi gatherers, shore-based recreational rod-and-line fishers as well as general sight-seers at the Mouth. The Goolwa Town Beach (site 6) was the area of highest recreational pipi gathering effort in 2013/14, but not by ORV's (Hall *et al*. 2014).

Finally, to further understand the potential reasons for this spatial shift of *H. longirostris* from the ocean beaches at Middleton and Goolwa to the Murray Mouth Estuary, and the increase in abundance of *H. fuliginosus* at the Murray Mouth over the past 4 years, future research needs to be directed at 1) comparing the seasonality of oystercatcher abundances at other sites of high and low disturbance, 2) ongoing fishery-dependent and independent monitoring of the preferred food (Pipis) of oystercatchers along the Goolwa / Middleton Beaches to assess the links between human activity, oystercatcher activity and food (Pipi) abundance, 3) relating the River Murray environmental flow through the barrages to relative abundances of Oystercatchers and food abundance at the Mouth and the Coorong Ocean Beach, and 4) determine the relative contributions of locally and distantly bred birds that have dispersed from other parts of SA including the eastern side of the Coorong Ocean Beach or beyond, through focussed monitoring surveys and banding / flagging programs at key areas of flocking.

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REFERENCES

Alexandrina Council. 2014. Environmental Action Plan 2014 – 2018. 80 pp. Alexandrina Council web-site www:alexandrina.sa.gov.au (accessed 10 Oct, 2015).

Bonnin, M. 1982. The Baudin Rocks, 1968 – 1982. *SA Ornithologist* 29 (1): 23 - 4.

Bourman, R.P., C.V. Murray-Wallace, A.P. Belperio & N. Harvey. 2000. Rapid coastal geomorphic change in the River Murray Estuary of Australia. *Marine Geology* 170: 141 – 68.

Bryant, S. 2002. Conservation assessment of beach-nesting and migratory shorebirds in Tasmania. *Natural Heritage Trust Project. No.* 11990: 123 pp.

Carpenter, G.A. 2009. Coastal birds of the far west coast of SA. *SA Ornithologist* 35 (7): 196 – 98.

Carpenter, G.A. & P. Langdon. 2014. Seabirds and shorebirds of Spencer Gulf. Part A. Waterbirds of northern Spencer Gulf. Pp. 181-190. *In:* S.A. Shepherd, Madigan, S.M., Gillanders, B.M., Murray-Jones, S., Wiltshire, D.J. (Eds.) Natural History of Spencer Gulf. Occasional papers of the Royal Society of South Australia.

Clarke, S.M. 1985. Fish Kill – Cockles. *SAFIC*, 9(1): 12

Davis, M.B., T.R. Simons, M.J. Groom, J.L. Weaver & J.R. Cordes. 2000. The breeding status of the American Oystercatcher on the east coast of North America and breeding success in North Carolina. *Waterbirds* 24(2): 195 – 202.

Dennis, T.E. & C.I. Baxter. 2006. Resident and migratory birds of coastal marshland habitats in Bay of Shoals and Western Cove area of Kangaroo Island, SA. *SA Ornithologist* 34: 267 – 75.

Dennis, T.E. & P. Masters. 2006. Long-term trends in the Hooded Plover (*Thinornis rubricollis*) population on Kangaroo Island, South Australia. *SA Ornithologist* 34: 258 – 266.

Ferguson, G.J. 2013. Pipi (*Donax deltoides*) Fishery. Fishery Stock Assessment Report for PIRSA Fisheries and Aquaculture. *SARDI Research Report Series No*. 731, September, 2013: 76 pp.

Finlayson, H.H. 1938. Notes on some birds seen on Flinders Island and other islands off the Eyre Peninsula coasts, Feb – March, 1937. *SA Ornithologist* 14(6): 41 – 6.

Fisher, F., M. Hockings & R. Hobson, R. 1998. Recreational Impacts on waders on Fraser Island. *The Sunbird* 28: 1 – 11.

Hall, K., G. Khageswor & K. Jones. 2014. South Australian Recreational Pipi Fishery Estimates of harvest 2013-14 – Goolwa Onsite surveys. *Fisheries Victoria Internal Report Series* No. 60: 22 pp.

Hansen, B.D., C.D.T. Minton, A.E. Harrison & R. Jessop. 2014. Conservation Assessment of the Sooty Oystercatcher, *Haematopus fuliginosus*. *International Wader Studies* 20: 161 – 176.

Hornsby, P.E. 1978. Notes on the birds of Pearson Island. *SA Ornithologist* 27(8): 280 – 284.

Jones, K. 2009. 2007/08 South Australian Recreational Fishing Survey. *South Australian Fisheries Management Series Paper No*. 55: 84 pp.

Lambeck, R.H.D., J.D. Goss-Custard & P. Triplet. 1996. Oystercatchers and man in the coastal zone. In Goss-Custard, J.D. (Ed.) *"The Oystercatcher: from individuals to populations."* pp. 289 – 326. (Oxford University Press: Oxford.)

Murray Darling Basin Authority. 2013. Approach for estimating salt export from the River Murray System to the Southern Ocean. Report prepared by the Water Resources Group, MDBA. Technical Report 2013/09: 21 pp.

Morgan, A.M. 1916. An ornithological trip in St. Vincent and Spencer Gulfs. *SA Ornithologist* 2(6): 141 – 51.

Newman, O.M.G. & R.M. Patterson. 1986. Seven Mile and Five Mile Beaches. *Tasmanian Bird Report* 15: 21 – 25.

Norris, K., R.C.A. Bannister & P.W. Walker. 1998. Changes in the number of oystercatchers *Haematopus ostralegus* wintering in the Burry Inlet in relation to the biomass of cockles *Cerastoderma edule* and its commercial exploitation. *Journal of Applied Ecology* 35: 75 – 85.

Owner, D. 1997. The ecology and management of the pied oystercatcher *Haematopus longirostris* in northern NSW B.Sc. (Hons) Thesis, Southern Cross University, Lismore. (Cited in Owner & Rohweder, 2003.)

Owner, D. & D.A. Rohweder. 2003. Distribution and habitat of Pied Oystercatchers (*Haematopus longirostris*) inhabiting ocean beaches in northern New South Wales. *Emu* 103: 163 – 169.

Paton, D., D.J. Rogers, B.M. Hill, C.P. Bailey & M. Ziembicki. 2009. Temporal changes to spatially stratified waterbird communities of the Coorong, South Australia: Implications for the management of heterogenous wetlands. *Animal Conservation* 12: 408 – 17.

Paton, D.C. 2011. The Coorong Lagoons: a Critical Refuge for Waterbirds. *In*: At the End of the River: the Coorong and Lower Lakes. Publ. ATF Press p. 147 – 183.

Sutton, J. 1933. Inspection of some island sanctuaries in the Coorong. *SA Ornithologist* 12(1): 19 – 28.

Taylor, I,R., M. Newman, P. Park, B. Hansen, C.D.T. Minton, A. Harrison & J. Jessop. 2014. Conservation Assessment of the Australian Pied Oystercatcher, *Haematopus longirostris*. *International Wader Studies* 20: 116 – 128.

Wainwright, P. & M. Christie. 2008. Wader surveys at the Coorong and S.E. coastal lakes, South Australia, February 2008. *Stilt* 54: 31 – 47.

Zar, J.H. 1984. Biostatistical Analysis. Publ. Prentice-Hall International, Inc. 717 pp.