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# The South Australian Ornithological Association Inc. (Birds SA)

**FOUNDED 1899**

Birds SA is the trading name of The South Australian Ornithological Association Inc.

The principal aims of the Association are to promote the study and conservation of Australian birds, to disseminate the results of research into all aspects of bird life, and to encourage bird watching as a leisure activity.

The *South Australian Ornithologist* is supplied to all members and subscribers, and is published twice a year. In addition, a quarterly *Newsletter* reports on the activities of the Association, announces its programs and includes items of general interest.

Meetings are held at 7.45 pm on the last Friday of each month (except December when there is no meeting) in the Charles Hawker Conference Centre, Waite Road, Urrbrae (near the Hartley Road roundabout). Meetings feature presentations on topics of ornithological interest. Visitors are welcome.

The Association has a library at the meeting venue and books are available to all members for loan. It also maintains an image library and an audio library.

Regular day trips are arranged to places of ornithological interest, both during the week and at weekends, and weekend campouts are held several times a year.

# The decline in Holarctic shorebirds using Dry Creek Saltfields, South Australia, from 1985-86 to 2015-16

**COLIN ROGERS AND JOHN COX**

***Abstract***

*Dry Creek Saltfields was one of the primary roost sites for migratory Holarctic shorebirds in Gulf St Vincent, South Australia, until their numbers sharply declined between 1992 and 2000. This decline is linked to an Australia-wide drop in shorebird numbers arriving from Asia but was especially noticeable in south-east coastal areas during the Millennium Drought of 1997-2009 when it is probable many birds avoided the arid interior and became diverted to the south-west. A numerical examination of ten species that had regularly used Dry Creek Saltfields since 1985 revealed all were locally declining, with no indication of a recovery after the drought, and their numbers had collapsed by 2016. This collapse was primarily caused by changes to the saltfields environment which are an additional factor to the general drop in shorebird numbers arriving from Asia. Saltfields production ceased in 2013, after which important roosting areas for shorebirds were allowed to dry out and water regimes changed, causing a loss and degradation of habitat suitable for shorebirds. Adjacent freshwater wetlands, which were important attractions for some shorebirds that usually moved into the saltfields later during the summer, have also become severely degraded through changes in water usage, developments and other disturbances detrimental to shorebirds.*

## INTRODUCTION

Many shorebirds that breed during the northern summer in Asia and Alaska migrate southwards to spend the southern summer in Australia (Battley and Rogers 2007). They travel down the East-Asian Australasian Flyway (EAAF) and stop at many locations on the way (Conklin *et al.* 2014). After arrival in Australia, most generally follow east or west coastal routes before arriving at destinations in southern Australia, but many also move south across the continent on a broad front making short hops using ephemeral wetlands when conditions are suitable (Lane 1987: 31-32, Figure 2.1).

The most notable species which regularly, but not exclusively, use the trans-continental route are Pacific Golden Plover, *Pluvialis fulva*, Black-tailed Godwit, *Limosa limosa melanuroides*, Sharp-tailed Sandpiper, *Calidris acuminata*, Curlew Sandpiper, *Calidris ferruginea*, Red-necked Stint, *Calidris ruficollis*, Common Greenshank, *Tringa nebularia*, and Marsh Sandpiper, *Tringa stagnatilis* (Badman and May 1983; Lane 1987: 32, Table 4), whereas more maritime feeders such as Grey Plover, *Pluvialis squatarola*, Whimbrel, *Numenius phaeopus*, Eastern Curlew, *Numenius madagascariensis*, Bar-tailed Godwit, *Limosa lapponica baueri*, Ruddy Turnstone, *Arenaria interpres*, Great Knot, *Calidris tenuirostris*, and Red Knot, *Calidris canutus*, generally follow the coastal routes (Lane 1987).

As part of a population monitoring program (PMP), counts of shorebirds were undertaken over the years at many but not all coastal sites in Australia, with some understandable bias towards human population centres (Gosbell and Clemens 2006). In particular, there were no PMP sites in the Gulf of Carpentaria, which was identified as one of the three primary shorebird sites in Australia (Lane 1987: 2-3), and the interior of the continent was largely unmonitored. The only PMP sites shown for South Australia (SA) were West Eyre Peninsula, Gulf St Vincent, The Coorong and the South-East Coast.

Gulf St Vincent, SA, was recognised to be an important feeding ground for shorebirds (Lane 1987) and along its eastern shores the Dry Creek Saltfields (DCS) at St Kilda (34° 42′ S, 138° 30′ E) are located just north of Adelaide (Figure 1). They were constructed in 1940, mostly east of the existing mangrove belt and over the landward samphire-fringed tidal pools and saltbush plains that were previous roosting sites for the shorebirds that primarily feed at low tide on the extensive mudflats to the west. Since then, the DCS have acted as an alternative high-tide roost and were listed by Lane (1987) as one of the primary roost sites for Holarctic shorebirds in the Gulf. They are part of a much larger eco-system of mudflats and mangroves that extends along the coast north to Clinton Conservation Park and then south down the east coast of Yorke Peninsula to Price. Historically, shorebird monitoring has referred to this area as Gulf St Vincent (Close and McCrie, 1986).

The numbers of Holarctic shorebirds occurring in Australia have significantly declined since the early 1990s (Wilson 2000, Table 7) and possible reasons for their decline in central coastal districts of SA are discussed below, but the principal focus of this paper is on the decline of migratory shorebirds using DCS. These saltfields ceased production in 2013 when water regimes changed along with a degradation and loss of habitat for shorebirds.

## METHODS

### Counts

Counts of shorebirds were usually made by two methods. Method A: regular and comprehensive counts conducted by teams of people at high tides as part of the PMP; and Method B: irregular and incomplete counts conducted by individuals at high tides (Close and McCrie 1986: 146). Both systems have their advantages and disadvantages.

Counts using Method A were usually undertaken annually at high tide on a designated date by several observers of varying experience. To be useful these formal counts should have been made consistently. However, it appears that the regularity and frequency of counts using Method A was not maintained in SA for much of the period. Harris (1994) had no counts for Gulf St Vincent for the seasons 1990-91 to 1992-93, but had results for 1994-95 (Harris 1995), while Skewes (2004) noted that Gulf St Vincent was not counted in 2001-02.

In addition, depending on the time of year, such counts using Method A often missed species that had several roosts which were not necessarily visible on the date and time of a formal count. Eastern Curlew and Black-tailed Godwit are prime examples of species that formed independent roosting flocks at the DCS throughout the season but moved between several roosts as tide heights varied during the day and, depending on local conditions, used different sites over the season. Such species were easily missed or under-counted on the particular day. Counts using Method B alleviated this problem by monitoring these species at irregular but continuous intervals over the season and often captured higher numbers of some that flocked in the austral autumn shortly before northward migration, whereas counts using Method A were usually conducted nearer mid-Summer and consequently recorded lower numbers of the same species (see results below).

In the early part of the sample period, the most notable problems with counts using Method B were the very large numbers of Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper and Common Greenshank that were impossible for one person to accurately count during one high-tide period and they were sometimes noted only to be present in large numbers. Regular counts of these species are therefore only available from 1999-00, when it became apparent that Holarctic shorebird numbers were falling (Wilson 2000), until 2015-16.

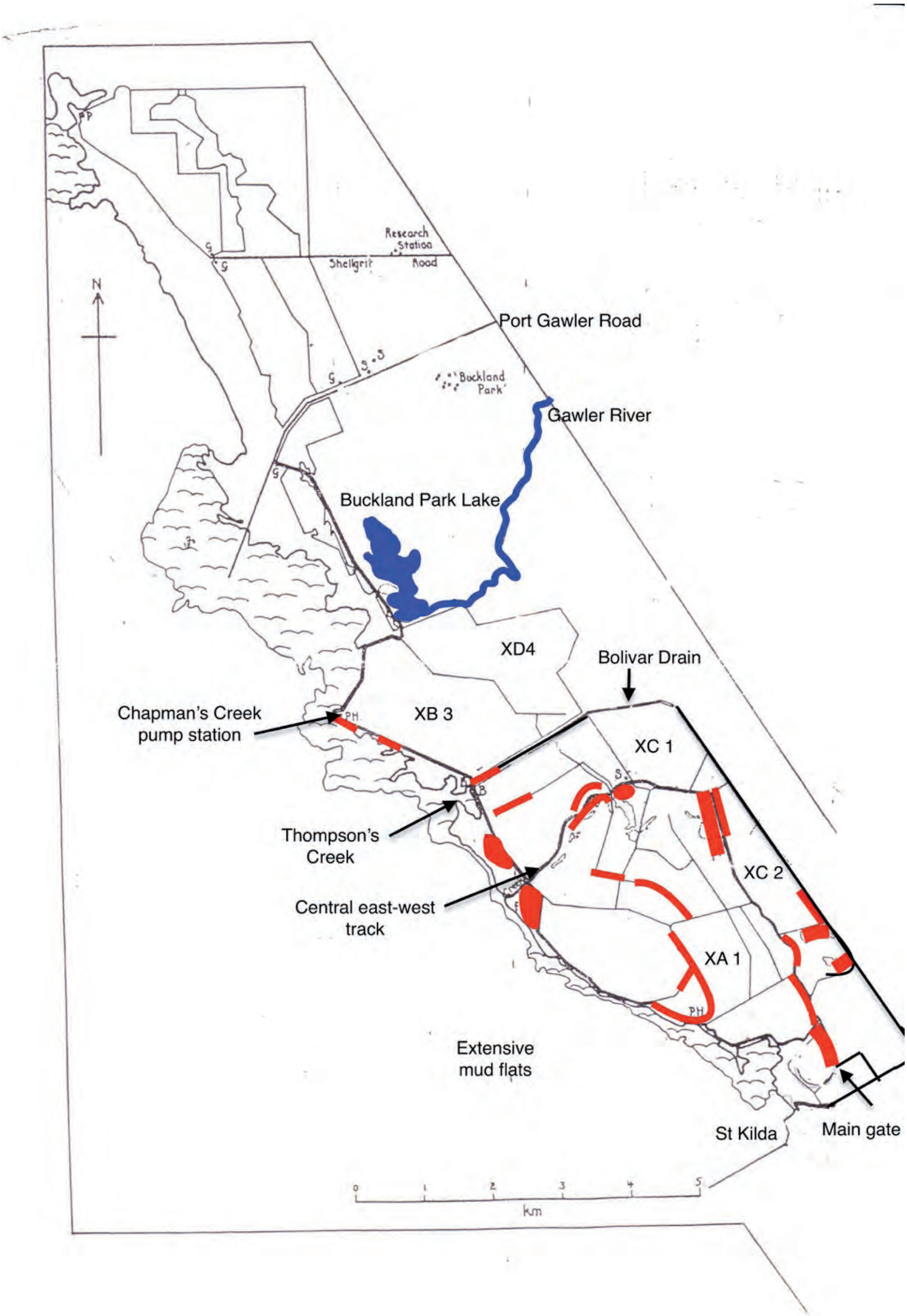


**Figure 1. Map of the Dry Creek Saltfields. The main roost areas for Holarctic shorebirds from 1985-86 to 2015-16 are shaded red, freshwater blue.**

In an attempt to overcome the disadvantages of both methods, a database was compiled by the authors that combines the published reports reliant on Method A with their personal records of shorebirds, and those of John Hatch, gathered during hundreds of visits to the DCS that effectively span the period 1985-86 to 2015-16 using Method B.

Most Holarctic shorebirds arrive in SA about August-September and depart by mid-April to mid-May of the following calendar year. Therefore, for convenience, the period used in this study applies to the season beginning on 1 September and ending on 30 April.

The Method B counts were conducted in the area shown in Figure 1 and also in the DCS from St Kilda seven kilometres southwards to Globe Derby Park. However, it should be noted that PMP counts were concerned with counting all shorebirds in Gulf St Vincent, rather than just the DCS, and there is some variation in the area covered. For example, Wilson (2000, Table 5) did not include Buckland Park Lake in Gulf St Vincent counts but included Greenfields Wetlands Stage 3 which abuts the southern edge of DCS at Dry Creek, perhaps because Buckland Park Lake has often remained dry for whole seasons since the 1990s. Nevertheless, when water-levels were suitable many shorebirds could be easily counted on the lake from adjacent DCS tracks, although early in the season when the lake was full they would usually be absent from any counts using Method A, but would be picked up by later counts or Method B as shorebirds moved into the DCS when the lake normally dried out by late January or February.

**Species**

While 36 species of migrant Holarctic shorebirds (Appendix I) were recorded in DCS over the period 1985-86 to 2015-16 the ten species examined below were selected on the basis that reasonable numbers consistently used the DCS as a roosting and feeding area for most of this period. It is interesting that several species commonly recorded roosting further north in Gulf St Vincent at Port Prime, Thompson Beach, Clinton Conservation Park and Price Saltfields did not use DCS as a primary roost site during those years and occurred mainly as transient visitors, sometimes in small temporary roosting flocks. They include Bar-tailed Godwit, Whimbrel, Great Knot and Red Knot and, as noted above, they follow an almost exclusively coastal route to Gulf St Vincent. In comparison, seven of the ten species that consistently used the DCS generally followed the trans-continental route.

**RESULTS**

From 1985 to 2016 the major roost and feeding sites for Holarctic shorebirds at DCS were found between the Chapman Creek Pump Station and St Kilda Road. Within this area large numbers of smaller sandpipers roosted near the main gate and along the eastern pans (Figure 1). Species such as Sharp-tailed Sandpiper, Curlew Sandpiper and Red-necked Stint also actively fed at these sites and all three were regularly encountered throughout DCS, including feeding or roosting on tracks. In contrast, larger shorebirds such as Eastern Curlew, Black-tailed Godwit, Grey Plover and Pacific Golden Plover were usually restricted to roosting at a selection of one or two sites on mangrove ponds, islands near the central east–west track or lightly used tracks south of the drain and Thompson Creek.

The numbers used in Charts 1-10 represent the highest count per species available for the seasons 1985-86 to 2015-16 from Methods A or B. Using the highest count for each year eliminates the seasonal pattern that exists in migrant shorebird numbers in Australia noted by Close and McCrie (1986) and Alcorn, Alcorn and Fleming (1994) and allows identification of longer-term trends in the number of shorebirds using DCS. This produces an almost continuous series for six species that occurred in smaller numbers, but a truncated series for the four species that initially occurred in larger numbers.

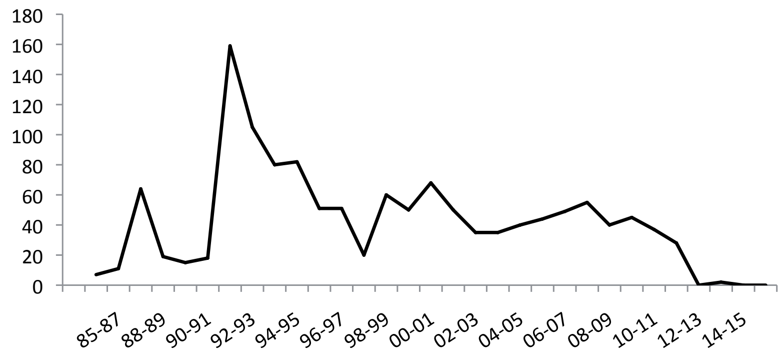


**Chart 1. Grey Plover. Counted using Methods A and B.**

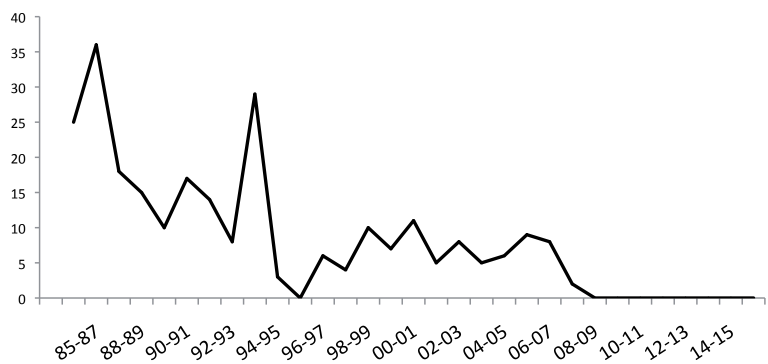


**Chart 2. Pacific Golden Plover. Counted using Methods A and B but often missed by Method A.**

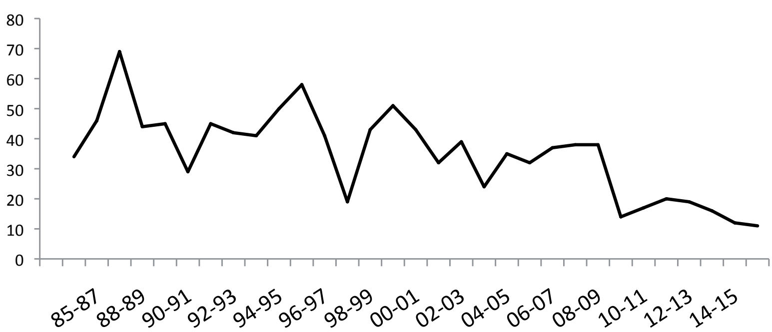


**Chart 3. Eastern Curlew. Only reliably counted using Method B.**

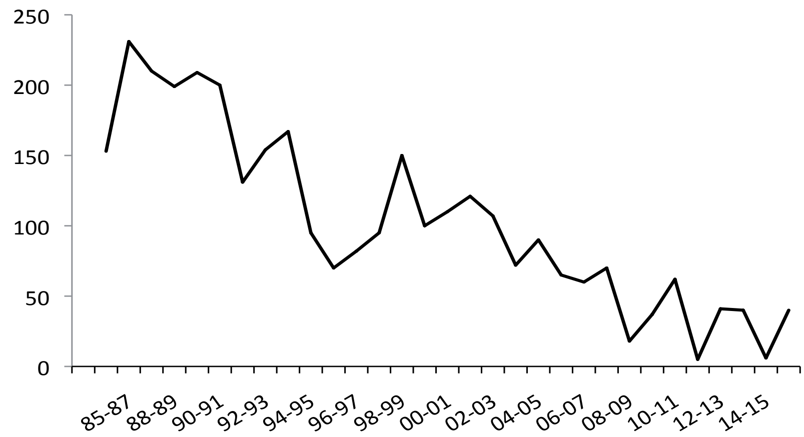


**Chart 4. Black-tailed Godwit. The series for the Black-tailed Godwit is probably the most accurate as they are easily counted using Method B but often missed by Method A. For example, see Close (2008). Although Black-tailed Godwits were seen in 1996-97 and 2000-01, no proper counts were undertaken during those seasons.**

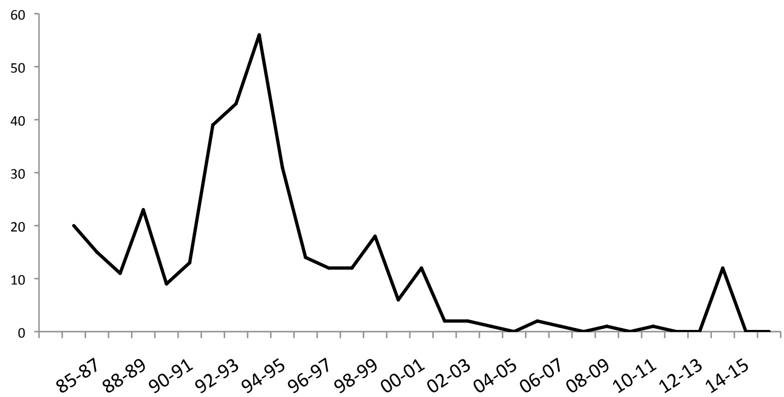


**Chart 5. Ruddy Turnstone. Counted using Methods A and B and like Grey Plover showed a surge in numbers using the DCS in the 1991-92 to 1994-95 seasons before falling to very low numbers by 2002-03. The numbers for 2013-14 represent a small transient flock.**

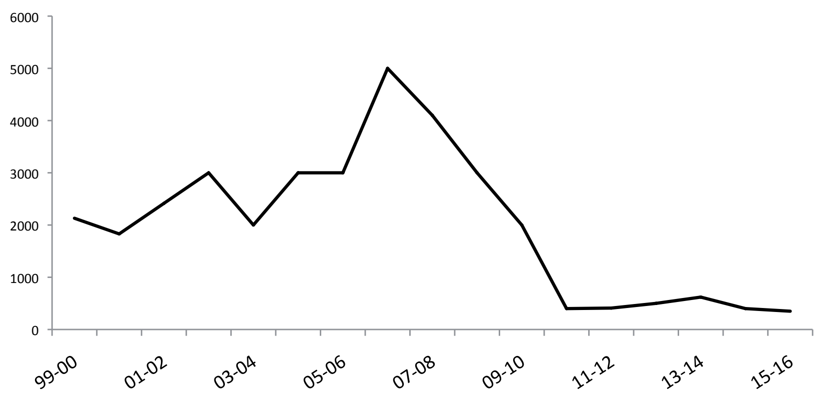


**Chart 6. Sharp-tailed Sandpiper. Counted using Methods A and B.**

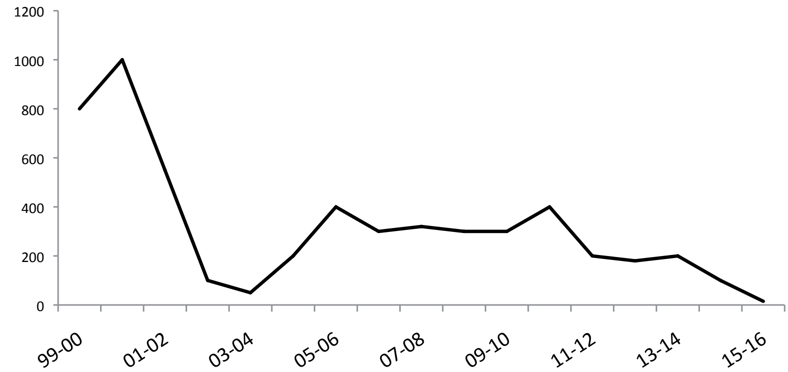


**Chart 7. Curlew Sandpiper. Counted using Methods A and B. The sharp decline between 2001-02 and 2002-03 was due to factors on the Asian leg of the EAAF flyway.**

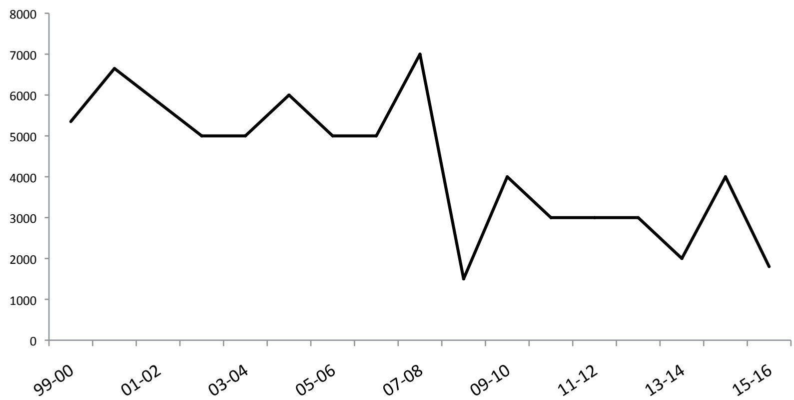


**Chart 8. Red-necked Stint. Counted using Methods A and B but subject to count error when in large flocks.**

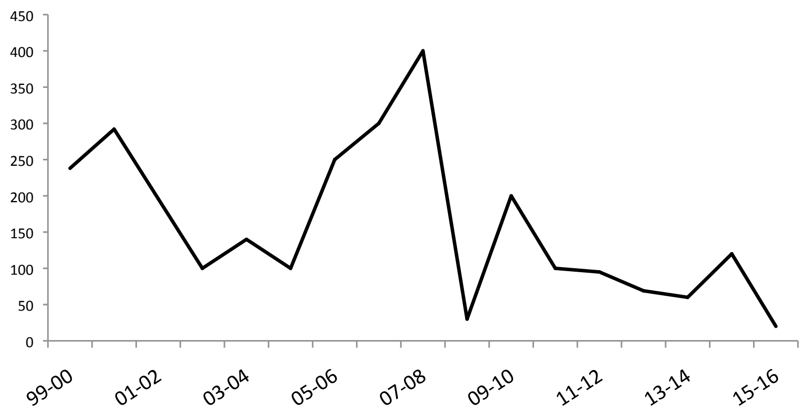


**Chart 9. Common Greenshank. Counted using Method B.**

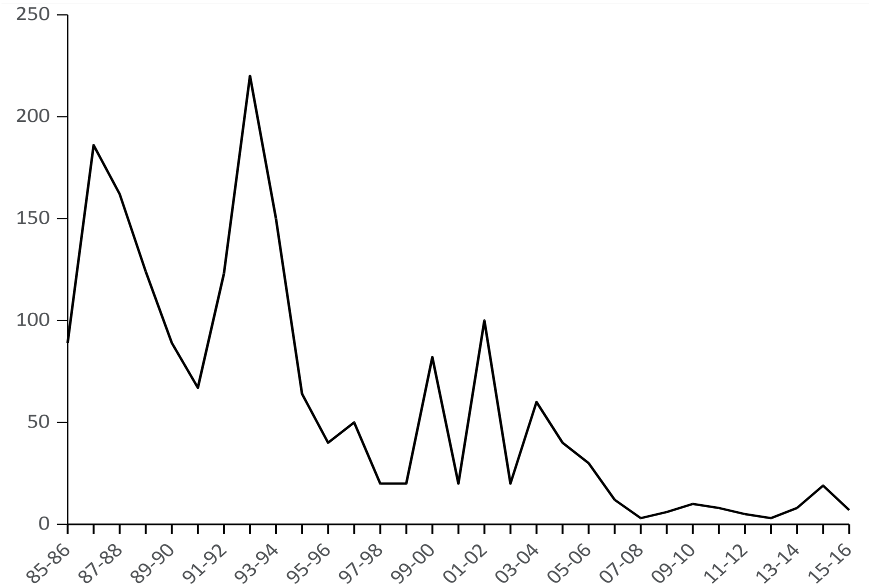


**Chart 10. Marsh Sandpiper. Counted using Method B but often difficult to locate and prone to dispersive local movements.**

The results illustrated in Charts 1-10 indicate that some species have continuously declined in number in DCS since the 1980s, but at an increased rate prior to 1995-96. Others sharply declined before 2000. These declines then led to a collapse in the numbers of Holarctic shorebirds using DCS by 2016.

For unknown reasons, the numbers of Grey Plover roosting in DCS dramatically increased in the early 1990s, but by the end of the decade had stabilized to within the range of 20 to 70 individuals until 2012-13 when they effectively abandoned the site. Close (2008, Table 1) noted a 52% decline in their numbers in Gulf St Vincent between the periods of 1979-85 and 2000-08.

Pacific Golden Plover numbers varied between 10 and 36 individuals during the late 1980s, prior to a dramatic decline in 1995-96. During the period 1997-1998 to 2007-2008 numbers varied between 5 and 12 but were often difficult to locate. For example, Wilson (2000, Table 7) had a zero PMP count for this species in Gulf St Vincent in 2000 whereas Chart 2 reveals there were seven or eight present in DCS located using Method B. Numbers fell to zero after the 2007-08 season but the reason for the departure of this species from DCS is unknown.

Counts of Eastern Curlew illustrated in Chart 3 do not show the volatility of other species but exhibited a slow decline from numbers fluctuating around 45 until 2001-02. Over the period 2001-02 to 2008-09 numbers in the range 30 to 40 were recorded but in 2009-10 they dropped to below 20 and have not recovered.

The steadily declining trend in the number of Black-tailed Godwits roosting in DCS (Chart 4) obscures a seasonal pattern that can be discerned only by counts using Method B and is applicable to other shorebird species that travelled overland and south to the central coast of SA. These counts revealed a trend of lower numbers early in the season, which gradually increased to peak numbers later in the season shortly before northward migration. Cox (1990) recorded that in September 1986 the Black-tailed Godwit flock consisted of 56 birds, by October there were 86, November 102, with the flock steadily increasing to 155 by February 1987 until reaching the peak number of 231 in April. The following season was similar, with 48 in September 1987 and gradually

**Figure 2. Black-tailed Godwit coming into roost at DCS, 27 March 2016. Image Colin Rogers**

increasing to 210 by April 1988. This seasonal trend was still apparent until 2015-16 even though Black-tailed Godwit numbers had also severely declined in DCS, from a peak of over 200 in the late 1980s to less than 50 by 2011.

Counts of Ruddy Turnstone peaked at over 50 in the mid-1990s but then declined steadily until 2004-05 and have since seldom been recorded. The reason for the peak in the mid-1990s is unknown (Chart 5), but it coincides with that of Grey Plover: Close (2008, Table 1) showed there was a significant increase in Ruddy Turnstone numbers in Gulf St Vincent from 1979-85 to 2000-08.

Sharp-tailed Sandpiper numbers peaked at DCS in 2006-07, but then declined steadily until 2010-11 and thereafter stabilized at around 500 (Chart 6). The earlier lower numbers could reflect some diversion of this species into Greenfields Wetlands Stage 3 where 2000 were counted, with 2000 also in DCS (Wilson 2000, Table 7)! A rise to 5000 in 2006-07 represented a recovery to only 50% of the numbers counted in the 1980s (Close and McCrie 1986, Table 1) and a significant decline in numbers therefore occurred prior to the 1999-00 season. The numbers for the 2015-16 season suggest that this species is no longer a common bird in DCS.

After 2000-01 Curlew Sandpipers suffered a significant decline on the Asian leg of the EAAF that was reflected in their numbers at DCS which fell from 1000 in 2000-01 to less than 100 in 2002-03. By 2005-06 numbers had recovered to 400 and they fluctuated between 300-400 before falling to 200 in 2011-12 and then falling below 100 in 2015-16 (Chart 7). Nevertheless, the significant decline in Curlew Sandpiper numbers occurred before 1999-00 because 2700 were counted in DCS from February 1979 to May 1981 (Close and McCrie 1986).

From 1999-00 to 2007-08 Red-necked Stint numbers varied from 5000 to 7000, but in 2008-09 they fell below 2000. Numbers then stabilized to around 3000 until 2015-16 when they fell back to 1800. However, the major decline in numbers occurred before 1999-00 because 23 000 were counted at DCS in 1979-81 (Close and McCrie 1986).

Common Greenshank numbers in DCS have also significantly declined, from the low hundreds in 2007-08 to less than 50 in 2015-16. A significant increase from about 100 to 400 occurred during 2004-05 to 2007-08, followed by a dramatic decline in 2008-09. Numbers then stabilized again in the region of 100 but dropped below 50 in the 2015-16 season. For comparison, a maximum of

450 was counted between February 1979 and May 1981 (Close and McCrie 1986, Table 1).

Over 200 Marsh Sandpipers were counted at DCS in the early 1990s, after which their numbers varied on a declining trend until 1996-97, with some stabilization in the lower range until 2003-04. Since 2005-06 numbers have remained at less than 20 (Chart 10). In contrast to these numbers from DCS, it is the only species of Holarctic shorebird which has reportedly increased in Gulf St Vincent between 1981 and 2000 (Wilson 2000, Table 7), which may reflect on the mobility of this species between sites and/or a consequence of undercounting using Method A in previous years because only 58 were located in Gulf St Vincent in 1981. However, a significant proportion of the initial decline in DCS reflected a redistribution from DCS to other sites in Gulf St Vincent. In particular, 45 Marsh Sandpiper were counted in Greenfields Wetlands with only 82 in the DCS in February 2000 (Wilson 2000). Close (2008, Table 1) similarly showed Marsh Sandpipers increased by 22% in Gulf St Vincent over the period 1979-85 to 2000-08 but the numbers used may also reflect a redistribution within the Gulf and some earlier undercounting using Method A.

The above counts of Holarctic shorebirds stand in sharp contrast to the statement by Purnell, Peter and Clemens (2013: 4) that DCS supports the "..greatest abundance of 'migrant' shorebirds in the region [Gulf St Vincent] (15, 000 on average)". Holarctic shorebirds have not been recorded in such numbers at the DCS since the 1980s. The reason for this difference is that Purnell, Peter and Clemens (2013) combined Australian nomadic breeding species with the Holarctic shorebirds and thereby significantly inflated the numbers of 'migrant' shorebirds because many thousands of Banded Stilt, *Cladorhynchus leucocephalus*, and many Red-necked Avocets, *Recurvirostra novaehollandiae*, also frequented these saltfields in 2013. Wilson (2000, Table 7) clearly restricted the term 'migrant' to Holarctic shorebirds.

## DISCUSSION

A feature of trends in the numbers of Holarctic shorebirds visiting the DCS, visible in some charts that cover the whole period and evident in comparisons with Close and McCrie's (1986) and Wilson's (2000) data, is the sudden decline in numbers that occurred between 1992 and 2000. Similar patterns were observed at Corner Inlet in Victoria where Minton *et al.* (2012) concluded; "... most of these declining species show strong evidence of a step-wise sudden decrease in numbers rather than a gradual decline. The timing of these decreases has varied between species, with most of the major changes occurring between the 1992 and 2000 period."

**Possible factors contributing to the decline of Holarctic shorebirds visiting DCS**

The results illustrated in Charts 1 to 10 indicate that a complex interaction between local and external factors influenced the numbers of Holarctic shorebirds using DCS from 1985-86 to 2015-16. Close (2008) noted there were few obvious causes for the decline in Holarctic shorebird numbers in Gulf St Vincent at that time, so the cause(s) must lie on the Australian and/or Asian legs of the flyway. An interpretation of the declining trends should therefore consider factors on all sectors of the EAAF.

**(i) Asian leg of the flyway**

Piersma *et al.* (2016) provided a depressing assessment of the health of the EAAF and Clemens *et al.* (2016) suggested there had been a significant decline in shorebird numbers reaching Australia from the Asian leg of the flyway but there are some puzzling aspects about their data.

The lack of PMP sites in the Gulf of Carpentaria showed Australia-wide data to be incomplete and Clemens *et al.* (2016) had no information on migratory shorebirds from that region (supplementary materials Figures S1 to S4). In addition, they sourced their data from Bamford *et al.* (2008), who Schuckard (2008) criticised for failing to consider the relevant literature. Bamford *et al.* made no reference to Close and McCrie (1986) and significantly underestimated the numbers of Red-necked Stint and other migrant shorebirds recorded for DCS in the 1980s.

In view of the incomplete data it is therefore not possible to clarify the extent to which any continental decline in migrant shorebird numbers affected the decline at sites in SA. Nevertheless, the significant decline of coastal species such as Eastern Curlew, Bar-tailed Godwit and Grey Plover in Gulf St Vincent was noted by Wilson (2000: 19) who wondered if such declines indicated a deterioration in the Gulf as habitat for shorebirds. Furthermore, although continental data for most species are incomplete, the Eastern Curlew has decreased in number at almost all Australian PMP sites (Clemens *et al.* 2016: 126, Figure 1), which indicates a causal factor in Asia or on the Asian leg of the flyway.

**(ii) Australian leg of the flyway**

There are no PMP sites in central Australia and monitoring of shorebirds across the continent is almost non-existent with only intermittent and opportunistic records available. Even so, many ephemeral wetlands of inland SA, such as those at Coongie Lakes or Lake Harry near Maree, have attracted thousands of migrant shorebirds for many weeks in spring and early summer (Badman and May 1983; pers. obs.). Most would have arrived from the north during a southwards migration across the continent and only stopped to feed until the wetlands dried or otherwise became unsustainable with the advancement of summer.

It is during summer that numbers of the same species steadily increase at sites in southern coastal regions, such as DCS, until autumn when they depart (see above Results: Black-tailed Godwit). By then, many of the inland wetlands are normally dry and shorebirds on their return northwards migration must at least make longer flights or fly directly over the continent. Some may only partially migrate because 12 000 small shorebirds, the majority stints and probably first year birds, were noted on Lake Eyre in the winter of 1984 (Lane 1987: 35).

By comparison, the coastal elements are well-covered, even if not completely. Clemens *et al.* (2016: 126-128 and supplementary material) used PMP data and concluded that population trends of Holarctic shorebirds were not uniform across Australia. For example, the numbers of Red-necked Stint and Sharp-tailed Sandpiper increased in the north of Australia and decreased in the south (below 28°S), while at PMP sites in SA their numbers increased at Streaky Bay, Baird Bay, Sceale Bay, and Eyre Island after 1996, but declined significantly in Gulf St Vincent, Kangaroo Island and the Coorong. Therefore, in the mid-1990s, the numerical decline of migratory shorebirds using DCS was, at least in part, due to a State or continent-wide process that diverted birds away from their traditional sites in the south-central coastal regions of SA.

A proximate and plausible explanation on a scale large enough to have caused such a diversion of shorebirds away from their regular sites in SA is the Millennium Drought (MD) of 1997-2009 (Bureau of Meteorology 2015) and this drought may have affected species that used the trans-continental sector of the Australian flyway. Lane (1987, pp. 34-35) outlined the impact of drought or changes in rainfall patterns on the food supply that drives Holarctic shorebird movements across central Australia. Many species showed site fidelity but responded to changes in food availability induced by rainfall.

The rainfall patterns of 1997-2009 (Figure 3) indicate that many shorebirds then arriving in northern Australia, particularly in the north-west and east to Gulf of Carpentaria where well above average precipitation occurred, would most likely have stayed to feed at northern ephemeral wetlands, as indicated by the increase in Sharp-tailed Sandpiper and Red-necked Stint numbers north of 28°S (Clemens *et al.* 2016). Any migrant shorebirds from the north that attempted the

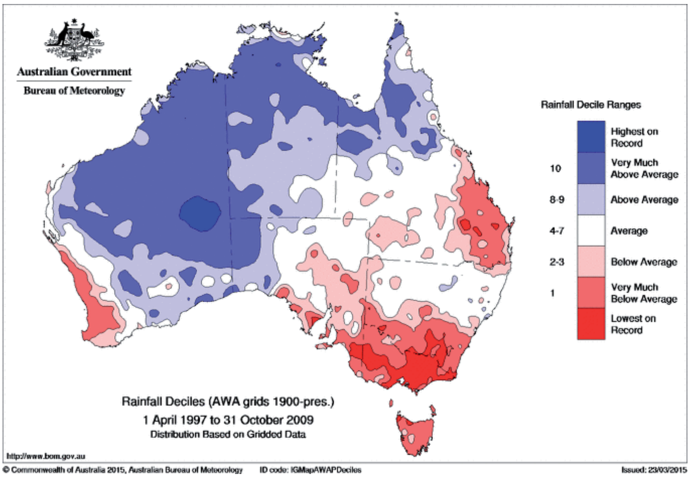


**Figure 3. Rainfall across Australia during the Millennium Drought 1997-2009.**
**Source: Bureau of Meteorology (2015)**

trans-continental route would have avoided the drought conditions in central and southern Australia and exhibited a bias towards the south-west. In SA, such conditions would have tended to increase shorebird numbers on western Eyre Peninsula, as noted by Clemens *et al.* (2016), and reduce the numbers further east at traditional sites in south-central coastal regions.

The long period of drought between 1997 and 2009 significantly impaired the trans-Australian route as reduced rainfall across the northern areas of SA and southern Queensland left many of ephemeral wetlands dry. The lack of convenient stop-over locations in northern SA meant that many migrant shorebirds either remained at key sites in northern Australia or diverted to other sites in SA and Australia.

**(iii) Local factors**

The most noticeable change in DCS occurred in 2013 when salt production ceased and some of the eastern pans were allowed to dry out (Figures 4 to 6). This action significantly reduced the roosting and feeding areas for species like Sharp-tailed Sandpiper, Curlew Sandpiper and Red-necked Stint in pans XC 2 and XC 2 south. In addition, the water pumped through the remaining pans was of lower salinity in areas near the St Kilda Road and maintained at higher levels throughout, causing increased erosion of banks and tracks and the inundation of some roost sites previously used by shorebirds.

While the numbers of Sharp-tailed Sandpiper, Red-necked Stint and Curlew Sandpiper have sharply declined, Pacific Golden Plover has not been recorded in DCS since 2007-08 and Grey Plover most likely stopped roosting there when water-levels rose after salt production ceased in 2013. It is possible that both species have re-located to other sites in Gulf St Vincent. Since 2013, the remaining Eastern Curlews and Black-tailed Godwits have roosted on eroded tracks rather than the mud-spits or islands previously preferred. Other shorebirds that occurred annually in small numbers are now no longer seen in the DCS. For example, the Terek Sandpiper, *Xenus cinereus*, has not been recorded since 2013. Pectoral Sandpiper, *Calidris melanotos*, Long-toed Stint, *Calidris subminuta*, and Wood Sandpiper, *Tringa glareola*, are now seldom seen although numbers have been regularly recorded in nearby freshwater wetlands. Therefore, along with numbers, species diversity in DCS has also decreased.

Areas adjacent to DCS have also changed. Buckland Park Lake abuts the saltfields (Figure 1) and frequently filled with water from the Gawler River until the late 1980s, but that frequency declined before and during the MD with


**Figure 4. Aerial view of main shorebird roosting areas in DCS with the dry pans, XC 1 and XC 2 visible down the eastern boundary. They are no longer suitable for shorebirds, as indicated in Figure 6. Source: Google maps, satellite**

**Figure 5. Part of a massed flock of Sharp-tailed Sandpipers with some Red-necked Stints and Curlew Sandpipers roosting in pan XC 2 south on 28 January 2008. Image Colin Rogers**

water flow into the lake sometimes restricted by increased upstream retention. Moreover, associated earthworks have caused severe levels of silt to accumulate in southern parts of the lake. Hence, throughout the period of the MD Buckland Park Lake seldom held water and was generally unusable for shorebirds such as Sharp-tailed and Marsh Sandpipers, that were normally attracted to the lake early in the season, but during the MD they would not have been present, to later move into DCS.

Some increase in habitat suitable for Holarctic shorebirds was initially gained in the 1990s with

**Figure 6. Pan XC 2 south, the location of the roost shown in Figure 5, as it appeared in the 2015-16 season.** **Image Colin Rogers**

the construction of a few smaller freshwater wetlands near DCS. The original intention was to create stormwater retention and filtration basins with associated wildlife habitat. Nevertheless, these sites are also dependent on rainfall and most now have steep-sided heavily vegetated banks that attract only a few shorebirds when water-levels are low.

Two exceptions are Greenfields Wetlands Stage 3 (Magazine Road) and the northern half of Barker Inlet Wetlands which have extensive areas of shallow water and mudflats that attracted large numbers of Holarctic shorebirds, particularly those with a preference for freshwater. However, these sites are also under threat: at Greenfields Stage 1 the operating emphasis is now placed on water-recycling and water pumped from there and into underground aquifers has drastically reduced the flow into Greenfields Stage 3, with the consequence that areas crucial for shorebirds now remain dry for most of the summer; while in Barker Inlet Wetlands a six-lane highway is currently being constructed through the shorebird habitat of the northern half.

## CONCLUSIONS

Holarctic shorebirds numbers had dramatically fallen in Gulf St Vincent by the 1990s and as this decline involved species which used the coastal and trans-continental legs of the Australian flyway the causal problems are most likely to be in Asia or on the Asian leg of the EAAF. In Australia the MD of 1997-2009 probably diverted those species using the trans-continental route to the south-west and away from the south and south-east coasts, but after the drought ended and a more regular rainfall pattern resumed there was no indication of a recovery in shorebird numbers at DCS up to 2015-16. This aspect indicates that local factors were also a contributory cause of the decline.

These factors include the effective loss of Greenfields Stage 3, together with a reduced area of saltpans in DCS, where the loss of roosting sites and changes to the water regime have rendered these saltfields unattractive to Holarctic shorebirds. Nevertheless, the importance of Buckland Park Lake, and other nearby freshwater wetlands, for the attraction of some species to Gulf St Vincent is apparent. Despite the decline in the importance of DCS, seven species of shorebirds that use the trans-continental route will be attracted to the area if freshwater habitat at Buckland Park Lake and other nearby sites is maintained and managed with some degree of protection. The rehabilitation of some roosting and feeding areas in a reduced DCS, by way of managing water-levels correctly, and reviving the ponds adjacent to Bolivar would also benefit migratory shorebirds.

In DCS many Australian native shorebirds still occur in good numbers, including Banded Stilt, Red-necked Avocet, White-headed Stilt, *Himantopus leucocephalus*, Red-capped Plover, *Charadrius ruficapillus*, and Red-kneed Dotterel, *Erythrogonys cinctus*. Areas of deeper water remain attractive to numbers of other waterbirds. In particular, Blue-billed Duck, *Oxyura australis*, Musk Duck, *Biziura lobata*, Hoary-headed Grebe, *Poliocephalus poliocephalus*, and Great Crested Grebe, *Podiceps cristatus*, prefer ponds XB 3 and XD 4. Whiskered Terns, *Childonias hybrida*, and Crested Terns, *Thalasseus bergii*, also roost in large numbers in the evening on posts in pond XA 1. The DCS therefore remains an important refuge for waterbirds within Gulf St Vincent even if numbers of Holarctic shorebirds have declined significantly.

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## REFERENCES

Alcorn, M., Alcorn, R. and Fleming, M. 1994. *Wader Movements in Australia.* Australasian Wader Studies Group, RAOU Report 94. Royal Australian Ornithologists Union, Melbourne.

Badman, F. J. and May, I. A. 1983. Waders in Northern South Australia. *South Australian Ornithologist* 29: 29-39.

Bamford, M. D., Watkins, D., Bancroft, W., Tischler, G., and Wahl, J. 2008. *Migratory Shorebirds of the east Asian-Australian flyway: population estimates and internationally important sites.* Wetlands International Oceania, Canberra.

Battley, P. F. and Rogers, D. I. 2007. Migration. In *Shorebirds of Australia.* A. Geering, L. Agnew and S. Harding (eds). CSIRO, Melbourne.

Bureau of Meteorology. 2015. http://www.bom.gov.au/climate/updates/articles/a010-southern-rainfall-decline.shtml

Conklin, J. R., Verkuil, Y. I. and Smith, B. R. 2014. *Prioritizing migratory shorebirds for conservation action on the East Asian–Australasian Flyway.* WWF-Hong Kong, Hong Kong.

Clemens, R. S., Rogers, D. I., Hansen, B. D., Gosbell, K., Minton, C. D. T., Straw, P., Bamford, M., Woehler, E. J., Milton, D. A., Weston, M, A., Venables, B., Weller D., Hassell, C., Rutherford, B., Onton, K., Herrod, A., Studds, C.E., Choi, C-Y., Dhanjal-Adams, K. L., Murray, N. J., Skilleter, G. A., and Fuller, R. A. 2016. Continental-scale decreases in shorebird populations in Australia. *Emu* 116: 119-135.

Close, D. H. 2008. Changes in wader numbers in the Gulf St Vincent, South Australia, 1979–2008. *The Stilt* 54: 24–27.

Close, D. H. and McCrie N. 1986. Seasonal fluctuation of waders in Gulf St Vincent, 1976-85. *Emu* 86: 143-154.

Cox, J. B. 1990. Observations of a Hudsonian Godwit in South Australia. *South Australian Ornithologist* 31: 48-50.

Gosbell, K. and Clemens, R. 2006. Population monitoring in Australia: some insights after 25 years and future directions. *The Stilt* 50: 162-175.

Harris, K. 1994. Population monitoring counts. *The Stilt* 25: 12-19.

Harris, K. 1995. Population monitoring counts. *The Stilt* 27: 27-29.

Lane, B. 1987. *Shorebirds in Australia*. Nelson, Melbourne.

Minton, C., Dann, P., Ewing, A., Taylor, S., Jessop, R., Anton, P. and Clemens R. S. 2012. Trends in shorebirds in Corner Inlet, Victoria, 1982-2011. *Stilt* 61: 3-18.

Piersma, T., Lok, T., Chen, Y., Hassell, C. J., Yang, H.-Y., Boyle, A., Slaymaker, M., Chan, Y-C., Melville, D. S., Zhang, Z.-W., and Ma, Z. 2016. Simultaneous declines in summer survival of three shorebird species signals a flyway at risk. *Journal of Applied Ecology* 53: 479-90.

Purnell, C., Peter, J. and Clemens, R. 2013. Shorebird Population Monitoring within Gulf St Vincent: July 2012 to June 2013. *Annual Report*. Birdlife Australia, Melbourne.

Schuckard, R. 2008. Review of 'Migratory Shorebirds of the east Asian-Australian flyway: population estimates and internationally important sites'. by Bamford, M.D. *et al.* (2008). *Notornis* 55: 226-228.

Skewes, J. 2004. Report on population monitoring counts. *The Stilt* 46: 86-92.

Wilson, J. R. 2000. *South Australian Wader Surveys: January and February 2000*. Australasian Wader Studies Group, Melbourne and South Australian Ornithological Association, Adelaide.

**Colin Rogers**
**6 Flavel Avenue**
**Woodforde, South Australia 5072**

**John Cox**
**28 Devon Drive**
**Salisbury, South Australia 5108**

## Appendix I

**Holarctic migratory shorebirds seen by one or both authors at Dry Creek Saltfields from 1985-86 to 2015-16.**

Grey Plover, *Pluvialis squatarola*
Pacific Golden Plover, *Pluvialis fulva*
American Golden Plover, *Pluvialis dominica*
Little Ringed Plover, *Charadrius dubius*
Greater Sand Plover, *Charadrius leschenaultii*
Oriental Plover, *Charadrius veredus*
Whimbrel, *Numenius phaeopus*
Little Curlew, *Numenius minutus*
Eastern Curlew, *Numenius madagascariensis*
Bar-tailed Godwit, *Limosa lapponica*
Hudsonian Godwit, *Limosa haemastica*
Black-tailed Godwit, *Limosa limosa*
Ruddy Turnstone, *Arenaria interpres*
Great Knot, *Calidris tenuirostris*
Red Knot, *Calidris canutus*
Sanderling, *Calidris alba*
Sharp-tailed Sandpiper, *Calidris acuminata*
Curlew Sandpiper, *Calidris ferruginea*
Pectoral Sandpiper, *Calidris melanotus*
Long-toed Stint, *Calidris subminuta*
Red-necked Stint, *Calidris ruficollis*
Little Stint, *Calidris minuta*
White-rumped Sandpiper, *Calidris fuscicollis*
Baird's Sandpiper, *Calidris bairdii*
Broad-billed Sandpiper, *Limicola falcinellus*
Buff-breasted Sandpiper, *Tryngites subruficollis*
Ruff, *Philomachus pugnax*
Latham's Snipe, *Gallinago hardwickii*
Terek Sandpiper, *Xenus cinereus*
Common Sandpiper, *Actitis hypoleucos*
Grey-tailed Tattler, *Tringa brevipes*
Lesser Yellowlegs, *Tringa flavipes*
Common Greenshank, *Tringa nebularia*
Wood Sandpiper, *Tringa glareola*
Marsh Sandpiper, *Tringa stagnatilis*
Red-necked Phalarope, *Phalaropus lobatus*

A Common Redshank, *Tringa totanus*, in 1983 is the only additional species seen at DCS.

# Notes on the distribution and taxonomy of White-eared Honeyeaters in South Australia

**ANDREW BLACK**

***Abstract***

*A phylogeographic division within the White-eared Honeyeater,* Nesoptilotis leucotis, *at the Eyrean Barrier has prompted taxonomic revision. The division occurs within the long acknowledged inland subspecies* N. l. novaenorciae, *such that previously recognised subtle differences in plumage and morphology within it are now seen to be of biogeographic and taxonomic significance. Type specimens of that subspecies are from Wongan Hills, Western Australia and its name will apply also to western South Australian populations, unless they prove diagnosably distinct, when a new name would be needed for them. Eastern mallee and Kangaroo Island populations belong, with the nominate subspecies, to the eastern phylogroup but are differentiated from them and may be recognised as* N. l. depauperata *and* N. l. thomasi *respectively. The subspecies* N. l. novaenorciae *and* N. l. depauperata *are allopatric, separated across the northern reaches of Spencer Gulf and southern Lake Torrens by terrain devoid of suitable habitat.*

**INTRODUCTION**

At present, most authorities (e.g. Menkhorst *et al.* 2017) recognise three subspecies within the White-eared Honeyeater, *Nesoptilotis leucotis* (Latham, 1802), following Schodde and Mason (1999). They include firstly an eastern Australian forest form *N. l. leucotis* in southeast Queensland (Qld) and New South Wales (NSW) east of the Great Divide, and in southern Victoria and the South East of South Australia (SA). A western/inland subspecies *N. l. novaenorciae* (Milligan 1904), is named for White-eared Honeyeaters that occur in the wheatbelt mallee and eucalypt woodlands of southern Western Australia (WA) and extreme south-western SA and, as a separate population, between Eyre Peninsula, the Flinders Ranges, Mid North, Yorke Peninsula, Murray Mallee and inland of the Great Divide in Victoria, NSW and Qld. The third subspecies *N. l. thomasi* (Mathews 1912) is a Kangaroo Island endemic (Baxter 2015). The species' Australian distribution, as recorded in the Atlas of living Australia (ALA), is shown on the map Figure 1.

Schodde and Mason (1999) separated the two mainland subspecies by size and plumage, the nominate being larger, brighter above, more intensely yellow over the belly and with broader cream tips to tail feathers, but found that their presumed zone of contact through the upper South East of SA and inland slopes of the Great Divide required clarification. Higgins, Peter and Steele (2001) found, as had Ford (1971) that plumage differences between the three subspecies were subtle but that *N. l. novaenorciae* had shorter wings and tails than *N. l. leucotis*. Within subspecies *N. l. novaenorciae* itself, they reported (*pace* Ford 1971) an east to west decrease in size, confirming Schodde and Mason's (1999) finding that birds from Eyre Peninsula were smaller than those from inland eastern Australia, and shared with the smallest WA specimens a smaller tail/wing ratio and brighter yellow bellies.

Schodde and Mason (1999) found that *N. l. thomasi* was intermediate in size between the mainland subspecies but darker, duller and greyer than either, both above and below, with a more restricted area of yellow on the belly. Higgins, Peter and Steele (2001) found that they were closer to *N. l. novaenorciae* with respect to plumage but approached the nominate in size.

Dolman and Joseph (2015) included the White-eared Honeyeater in a phylogeographic study of 12 southern Australian bird species and identified two phylogroups, separated by 21 nuclear base pair differences in the mitochondrial gene ND2 (net divergence 2.23%). They found that the two clades showed both phylogeographic and spatial discontinuity and thus represented Evolutionarily Significant Units (ESUs). Further, they had diverged across the Eyrean Barrier, a periodic Pleistocene arid intrusion at the longitude of present day Spencer Gulf and the Lake Torrens and Lake Eyre basins (Ford 1987).

The western phylogroup comprised 16 samples from Eyre Peninsula, the Great Victoria Desert (Maralinga area) and southern WA, and the eastern phylogroup of 35 samples were from either side of the Great Divide in NSW, from south-eastern Qld, Victoria, the South East of SA, the Murray Mallee and Kangaroo Island. They reasoned that their findings were taxonomically significant and warranted a revision that recognised either intraspecific or even specific division at the Eyrean Barrier.

They could not exclude significant gene flow between the two phylogroups and therefore proposed that the two ESUs, respectively distributed west and east of the Eyrean Barrier, redefine the circumscriptions of subspecies *N. l. novaenorciae* and *N. l. leucotis*, the latter including *N. l. thomasi*. They predicted that quantitative analysis of plumage and morphometrics, coupled with more extensive genetic sampling, would reject the historical basis for plumage variation in the species.

The principal aim of this study is to test alternative views of how *N. l. novaenorciae* and *N. l. leucotis* might be recognised taxonomically by reviewing the distribution of named subspecies and examining variation in morphometrics, plumage and voice among them. Particular attention is paid to the critical region corresponding to the Eyrean Barrier, i.e. to populations traditionally assigned to subspecies *N. l. novaenorciae* from either side of Lake Torrens and Spencer Gulf. The focus is therefore on SA populations but their extension into adjacent States is necessarily taken into account.

## METHODS

Adult White-eared Honeyeater specimens in the South Australian Museum, Adelaide (SAMA) include 16 (11 male, 5 female) *N. l. novaenorciae* from Eyre Peninsula and farther west, including Maralinga and 17 (9 male, 8 female) from the SA and Victorian mallee; 13 (7 male, 6 female) *N. l. leucotis* from South East SA and southern Victoria; and 11 (9 male, 2 female) *N. l. thomasi* from Kangaroo Island. The following were measured: bill length (skull attachment to tip) and depth (at feathered limit), to nearest 0.1 mm; and straightened wing (from carpus to tip of longest primary) and tail (insertion to tip of longest rectrix) lengths, to nearest 1 mm.

Plumage characters addressed were: dorsal tone, extent of black on throat and upper breast and of pale tipping to rectrices, and brightness and extent of yellow of underparts.

Songs of White-eared Honeyeaters recorded by David Stewart from across its range will be reported separately (Black and Stewart in preparation).

Distributional records of the species in SA were obtained from the published literature and the database of the Department for Environment and Water, incorporating records of Birds SA, Biological Survey SA and Birdlife Australia (courtesy Helen Owens, DEW).

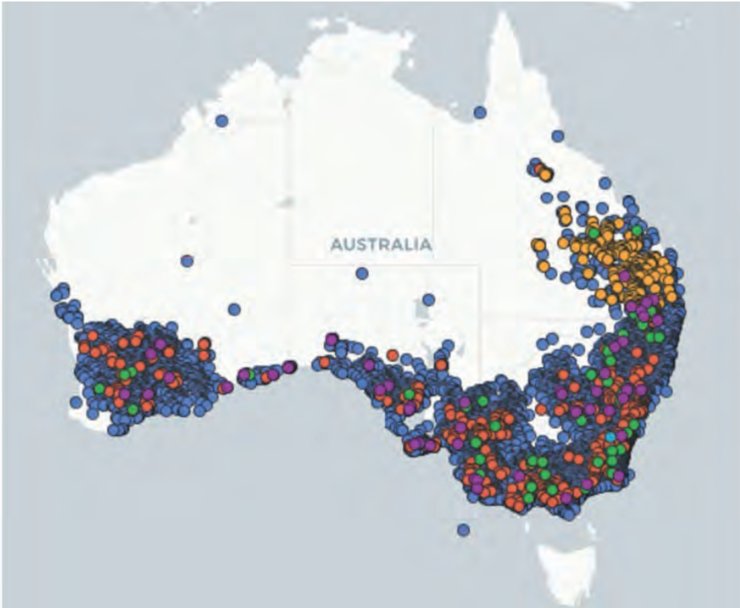


Figure 1. Map from the Atlas of living Australia (www.ala.org.au ), showing records of the White-eared Honeyeater. There are outlying records of doubtful validity, such as those on Yorke Peninsula, and an apparently continuous distribution between Eyre Peninsula, the Flinders and Mount Lofty Ranges and the Murray Mallee.

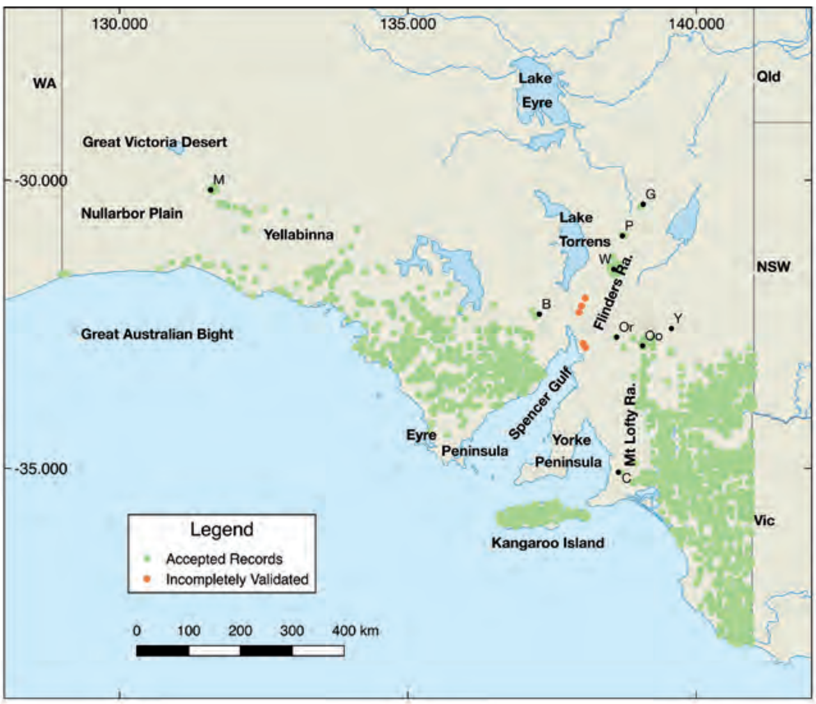


Figure 2. Map showing records of the White-eared Honeyeater in South Australia, derived from the database of the Department for Environment and Water. Outlying records, if uncorroborated, have been omitted. Also shown (as orange circles) are records from the South Flinders Ranges, where evidence for the species' presence remains inconclusive. Places referred to in the text are shown as: B = Baxter Range, C = Cherry Gardens, G = Gammon Ranges Plateau, M = Maralinga, Or = Orroroo, Oo = Oodla Wirra, P = Patawarta, W = Wilpena Pound, Y = Yunta.

## RESULTS

### Distribution

A review of distributional records in SA (Figure 2; compare with Figure 1) shows that the species is extensively represented on Eyre Peninsula, west to the Head of the Great Australian Bight and through the Yellabinna, northwest to Maralinga, where they appear to be resident (Black and Badman 1986; AB personal observations, specimens in the Australian National Wildlife Collection, Canberra and SAMA). There are also records in the coastal mallee south of the Nullarbor Plain, an extension of its WA distribution.

Records from the Gawler Ranges (Paton 1975; Joseph and Black 1983; Blaylock *et al.* 2017) occur east to the Baxter Range, Cariewerloo Station (C. Baxter 17 February 1993; P. Langdon pers. comm.). There is a distributional gap between that most easterly Eyre Peninsula mallee outlier and Wilpena Pound (H. P. Haselgrove in Glover 1972; SAMA B29303; H. Bakker 14 August 1975), including Edeowie Gorge (5 June 1982) and Mount Ohlssen-Bagge (12 April 1993) (Carpenter *et al.* 2003). There have been many subsequent reports from the Wilpena Pound area.

Other confirmed records from the Flinders Ranges are from further north, Patawarta (AB 11 April 1993; D. Hopton 17 March 1999) and the Gammon Ranges Plateau (G. Carpenter, L. Pedler 23 October 1999). Reference to the species from the South Flinders Ranges (Condon 1968; Higgins, Peter and Steele 2001 and online database maps Birdata and ALA) are uncorroborated by experienced local observers (W. Klau, B. Haase, P. Langdon). Paton (1980) did not include the species from her list of birds known from the Flinders Ranges at the time.

The closest published records south of Wilpena are a single reference to the Orroroo district (Gray 1931) and observations at the base of the Olary Spur near Oodla Wirra (Darke 1929; Bonnin and Rix 1980) and Spring Dam south of Yunta (Mack 1970). From there it extends through Pitcairn Station (AB Waite Hill, 23 April 1984), along the eastern flank of the North Mount Lofty Ranges into the northern Murray Mallee.

The species is not reliably reported from Yorke Peninsula (Terrill and Rix 1950; Condon 1962, 1968) and sporadic claims from the Adelaide Plains (Higgins, Peter and Steele 2001) and Mount Lofty Ranges are largely confined to the eastern margins of the latter at the mallee interface. They include specimen records from near Woodchester (SAM B14152) and Hartley (SAM B18594) and vagrant records at Cherry Gardens (Ragless 1961), Strathalbyn (Eckert 2000) and Charleston Conservation Park (Carpenter *et al.* 2003). The Murray Mallee distribution appears to continue uninterrupted and without a recognised subspecific boundary into the South East and Victoria.

### Plumage

Specimens of *N. l. novaenorciae* from west of Spencer Gulf show differences in plumage compared with those from the eastern mallee. Most obviously, they are brighter and more extensively yellow below, whereas eastern specimens are duller and have paler bellies (Figure 3). In this respect the underparts of eastern birds show greater distinction from the more brightly plumaged nominate subspecies, with which they are in extensive but incompletely evaluated contact (Schodde and Mason 1999). Western birds are also very slightly yellower and brighter dorsally than both eastern mallee birds and those of the nominate subspecies (Figure 4). Western birds generally have a smaller black bib, covering chin and throat, whereas in eastern birds this black area often extends to the upper breast, as in the nominate subspecies.

The Kangaroo Island isolate, *N. l. thomasi,* is duller and greyer above and below than all mainland populations (Figures 3 and 4). Pale cream tipping of less than 4 mm to some tail feathers was evident in specimens of *N. l. leucotis*

**Figure 3. Ventral view of male specimens SAMA B28176, east of Kimba EP; SAMA B 55328, south of Pinnaroo; SAMA B25251, south of Naracoorte; and SAMA B3041, Kangaroo Island. Note the more extensive and brighter yellow underparts of the Kimba and Naracoorte specimens compared with the specimen from Pinnaroo, and the darker and greyer Kangaroo Island specimen.**

**Figure 4. Dorsal view of specimens, as in Figure 1. The Kimba specimen is brighter and subtly yellower and the Kangaroo Island specimen is duller and greyer. Both images Philippa Horton**

but barely recognised among the other three groups.

**Morphometrics**

Previous reviewers have found significant sexual dimorphism in all populations and comparisons are made here only among males because of their generally larger sample sizes. Western populations of *N. l. novaenorciae* have wings of similar length to those of the eastern mallee (mean 91.9 mm *vs* 92.4 mm), but shorter tails (mean 86.5 mm *vs* 89.8 mm) and a smaller tail/wing ratio (mean 0.94 *vs* 0.96). All these parameters are smaller than those of the nominate subspecies (respectively wing 97.3 mm, tail 96.0 mm and ratio 0.99). That trend accords with the findings of Schodde and Mason (1999).

The Kangaroo Island subspecies, *N. l. thomasi,* has shorter wings (mean 93.6 mm) than the nominate but tails of similar length (mean 96.1 mm), and the highest tail/wing ratio of all (1.03). Bill size and shape vary considerably but bills are relatively thicker in western than in eastern mallee populations (mean length/depth ratios 3.7 and 4.0 respectively) and are slenderer in the nominate and Kangaroo Island subspecies (ratios 4.2 in each).

The differences detected among these relatively small samples are at trend level only but support the findings of earlier reviews of the species (see Discussion).

**DISCUSSION**

Reid, Carpenter and Pedler (1996) wrote that the Wilpena District was the species' known northern distributional limit in the Flinders Ranges. There are now records from further north, and Wilpena is therefore the southern-most verified record in the Flinders Ranges, as commonly construed.

Condon (1962, 1968) included the South Flinders Ranges in the distribution of White-eared Honeyeater, perhaps on the basis of Terrill and Rix's (1950) most northerly records from Oodla Wirra (Darke 1929) and Orroroo (Gray 1931).

The present isolation of Flinders Ranges (Wilpena) birds from mallee populations further south might not necessarily be a natural occurrence; a more continuous distribution in mallee along the eastern flank of the South Flinders Ranges might have been interrupted by clearance and unsustainable grazing at that margin of agricultural development during the late 19th century.

The White-eared Honeyeater is almost entirely restricted to eucalypt forest and woodland with a dense shrub understory and, in SA, the subspecies *N. l. novaenorciae* occupies mallee virtually exclusively (Higgins, Peter and Steele 2001; G. Carpenter pers. comm.).

Between observations in the Baxter Range and Wilpena, over 200 km to the northeast, is a restricted area of Western Myall, *Acacia pauperiflora,* open woodland and an extensive region of arid low open shrubland, much of it in depressed saline terrain, surrounding Lake Torrens and the northern reaches of Spencer Gulf. There are no conclusively verified records of White-eared Honeyeaters across that gap or from the South Flinders Ranges (*contra* Condon 1968; Glover 1972) which, at their closest, are about 70 km due east of the Baxter Range (Figure 2).

The restricted Flinders Ranges population is represented by a single museum specimen (SAMA B29303 as above) that appears typical of eastern mallee specimens. This isolate has not been included in genetic studies, but it has tenuous connections with eastern mallee populations. Furthermore, the Flinders Ranges lie to the east of the Eyrean Barrier, an indication that its relict population is more likely to belong to the eastern phylogroup.

The western and eastern phylogroups appear from the above assessment to be geographically separate, the intervening environment providing no suitable habitat for this mallee-dependent honeyeater. The Pleistocene biogeographic barrier responsible for division among White-eared Honeyeaters has resulted in subtly differentiated but genetically distinct populations that remain in allopatry on either side of an environmentally hostile present-day barrier.

The genetic divergence between mainland populations of the White-eared Honeyeater across the Eyrean Barrier creates a division within the species requiring taxonomic resolution. Dolman and Joseph (2015) questioned whether the divergence was of such magnitude that cryptic speciation had occurred, but could not exclude significant gene flow between the two populations. For that reason, pending further sampling and multi-locus analysis, they acknowledged the division at subspecific level.

**A review of infraspecific divisions within the species**

The first to recognise variation in the White-eared Honeyeater was Milligan (1904) who described a western form *Ptilotis novae-norciae* with type-locality the Wongan Hills, WA. He found it to be smaller and duller than the eastern bird, more greyish-olive than yellowish-olive dorsally and having less black on the throat and narrower white cheek stripes. Mathews (1912) described *Ptilotis leucotis depauperata* with type-locality Coonalpyn in the Upper South East of SA, as smaller and lighter coloured below than *Ptilotis leucotis leucotis* but did not compare it with *novae-norciae*. Neither author offered an opinion concerning limits of their new taxon's distribution.

Condon (1968) included all White-eared Honeyeaters in SA in the nominate subspecies, believing that the subspecies *novaenorciae* was restricted to southwest WA. Ford (1971) detected little distinction in plumage across the species' range but found that birds from Eyre Peninsula and the eastern mallee were nearer in size to WA birds and therefore distinct from the larger birds of the east coast. That distinction between a smaller and duller western and inland subspecies and a larger and brighter nominate subspecies in the east has prevailed (Schodde and Mason 1999) until Dolman and Joseph's (2015) finding of a genetic division, which led them to an alternative recognition of *N. l. novaenorciae* and *N. l. leucotis* west and east, respectively, of the Eyrean Barrier.

Morphometric findings in this study accord with those of Schodde and Mason (1999) and Higgins, Peter and Steele (2001), with only subtle and statistically insignificant or untested differences between the three given subspecies (or four populations, as herein). Those differences therefore do not provide diagnosable distinction of utility for taxonomic purposes. It is in the also subtle and unquantified plumage variables that diagnoses are provided.

The genetic divergence at the Eyrean Barrier allows for an interpretation of previously identified (Schodde and Mason 1999) and here confirmed minor morphometric but diagnosable plumage differences between populations of *N. l. novaenorciae* west of and east of Spencer Gulf. To the west they are slightly smaller but distinctly brighter than eastern mallee birds, the latter being smaller and duller than populations of the nominate subspecies.

Mainland White-eared Honeyeaters therefore include, in addition to the nominate subspecies, three individual and plausibly separate populations previously assigned to *N. l. novaenorciae*. They are, from west to east:

- Population 1, in WA's semi-arid woodlands and wheatbelt, extending south of the Nullarbor Plain into far western SA;
- Population 2, separated from Population 1 narrowly near the Head of the Bight and across the Nullarbor Plain, in the south-eastern Great Victoria Desert (Maralinga, Yellabinna), Gawler Ranges and Eyre Peninsula; and

- Population 3, genetically (Dolman and Joseph 2015) and geographically separated across the Eyrean Barrier, occupying the Flinders Ranges (as argued here) and eastern mallee.

Population 1 has not been part of this study but has been shown by previous reviewers (Ford 1971; Schodde and Mason 1999; Higgins, Peter and Steele 2001) to be the smallest of all. It also appears to be duller than the eastern mallee population (see images in Dolman and Joseph's 2015 supplementary material) and would consequently be distinctly duller than Population 2, the brightest of all in this review.

From the evidence presented, the name *N. l. novaenorciae* can apply legitimately only to the western phylogroup, i.e. Populations 1 and 2. Should those two populations prove diagnosably distinct, *N. l. novaenorciae* would apply only to Population 1 and a new name would be needed for Population 2.

Population 3, east of Spencer Gulf, is in a separate phylogroup that includes Kangaroo Island birds as well as the nominate subspecies of chiefly forest habitats. The interaction of mallee and forest populations along an extensive contact zone has not been analysed fully (Schodde and Mason 1999), and published evidence of differentiation between the two in size and plumage might reflect a selective response to environmental gradients, rather than differentiation in allopatry (Dolman and Joseph 2015; R. Schodde pers. comm.).

Evidence of potential pertinence to that question has been published by Lamb *et al.* (2018), who confirmed the identification of two phylogroups by Dolman and Joseph (2015) but found divergence also within the eastern phylogroup, a small largely eastern clade, and another larger and more widespread clade. Their distribution is not strictly concordant with that of the two named subspecies but supports the hypothesis of earlier division within eastern populations.

Moreover, this study affirms previous reviews that have found eastern inland and eastern subcoastal populations to be phenotypically distinct. Therefore, whether their differentiation has resulted from local selection or from sustained separation followed by secondary contact, or both, long held taxonomic recognition of the eastern mallee population is retained, pending more thorough examination of its interaction with the nominate subspecies. The name *Nesoptilotis leucotis depauperata* Mathews, 1912 is available for that smaller, duller inland population.

It would be desirable that future DNA sequencing includes a Flinders Ranges sample, to clarify its subspecific status. Being situated east of the Eyrean Barrier, the Flinders Ranges avifauna include many eastern Bassian elements and its relict population is therefore provisionally aligned with eastern mallee populations, with which it may have been connected through eastern arms of the South Flinders and North Mount Lofty Ranges before European settlement.

The Kangaroo Island population is also part of the eastern phylogroup but is differentiated from mainland forms and is substantially isolated from them, the species being unrepresented in the Mount Lofty Ranges. This review therefore supports continued recognition (*pace* Dolman and Joseph 2015) of the subspecies *N. l. thomasi*.

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## GAZETTEER

Localities mentioned in the text, including those shown on the map (Figure 2).

Baxter Range 32° 20′ S, 137° 17′ E
Charleston Conservation Park 34° 55′ S, 138° 57′ E
Cherry Gardens 35° 04′ S, 138° 39′ E
Coonalpyn 35° 42′ S, 139° 51′ E
Edeowie Gorge 31° 29′ S, 138° 31′ E
Gammon Ranges Plateau 30° 28′ S, 139° 02′ E
Hartley 35° 12′ S, 139° 01′ E
Maralinga 30° 10′ S, 131° 35′ E
Mount Ohlssen-Bagge 31° 33′ S, 138° 36′ E
Orroroo 32° 44′ S, 138° 37′ E
Oodla Wirra 32° 53′ S, 139° 04′ E
Patawarta 30° 58′ S, 138° 40′ E
Spring Dam 32° 46′ S, 139° 40′ E
Strathalbyn 35° 16′ S, 138° 54′ E
Waite Hill 33° 01′ S, 139° 14′ E
Wilpena Pound 31° 33′ S, 138° 34′ E
Wongan Hills 30° 49′ S, 116° 38′ E
Woodchester 35° 12′ S, 138° 58′ E
Yunta 32° 35′ S, 139° 34′ E

## REFERENCES


Baxter, C. I. 2015. *Birds of Kangaroo Island: a photographic field guide*. ATF Press, Hindmarsh, South Australia.

Black, A. B. and Badman, F. J. 1986. Birds of the Eastern Great Victoria Desert. In *The Great Victoria Desert.* P. Greenslade, L. Joseph and R. Barley (eds). Nature Conservation Society of South Australia, Adelaide, pp 66-94.

Blaylock, B., Black, A., Carpenter, G. and Horton, P. 2017. *A field list of the birds of South Australia.* 5th ed. The South Australian Ornithological Association Inc., Adelaide.

Bonnin, J. M. and Rix, C. E. 1980. *Bird Talk* 2: 11-13.

Carpenter, G., Black, A., Harper, D. and Horton, P. 2003. Bird Report, 1982-1999. *South Australian Ornithologist* 34: 93-151.

Condon, H. T. 1962. A handlist of the birds of South Australia with annotations. *South Australian Ornithologist* 23: 85-151.

Condon, H. T. 1968. *A handlist of the birds of South Australia*. SAOA, E. J. McAlister, Adelaide.

Darke, P. P. 1929. Birds noted in the districts between Peterborough and Cockburn, S.A. *South Australian Ornithologist* 10: 134-135.

Dolman, G. and Joseph, L. 2015. Evolutionary history of birds across southern Australia: structure, history and taxonomic implications of mitochondrial DNA diversity in an ecologically diverse suite of species. *Emu* 115: 35-48.

Eckert, J. 2000. Birds. In *Natural history of Strathalbyn & Goolwa Districts.* Strathalbyn Naturalists Club Inc. Douglas Press, Woodville North, South Australia, pp 25-86.

Ford, J. 1971. Distribution, ecology and taxonomy of some Western Australian passerine birds. *Emu* 71: 103-120.

Ford, J. 1987. Hybrid zones in Australian birds. *Emu* 87: 158-178.

Glover, B. 1972. Bird Report, 1969-70. *South Australian Ornithologist* 26: 26-33.

Gray, J. T. 1931. Birds of the Orroroo District. *South Australian Ornithologist* 11: 103-104.

Higgins, P. J., Peter, J. M. and Steele, W. K. 2001. *Handbook of Australian, New Zealand and Antarctic birds. Volume 5: Tyrant-flycatchers to chats.* Oxford University Press, Melbourne.

Joseph, L. and Black, A. B. 1983. Further notes on birds of the Gawler Ranges. *South Australian Ornithologist* 29: 46-54.

Lamb, A. M., Gan, H. M., Greening, C., Joseph, L., Lee, Y. P., Morán-Ordóñez, A., Sunnucks, P. and Pavlova, A. 2018. Climate-driven mitochondrial selection: a test in Australian songbirds. *Molecular Ecology* 27: 898-918.

Mack, K. J. 1970. Birds of the North-East of South Australia. *South Australian Ornithologist* 25: 126-141.

Mathews, G. M. 1912. A reference-list to the birds of Australia. *Novitates Zoologicae* 18: 171-446.

Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P. and Franklin, K. 2017. *The Australian bird guide*. CSIRO Publishing, Clayton South, Victoria.

Milligan, A. W. 1904. Notes on a trip to the Wongan Hills, Western Australia, with a description of a new *Ptilotis*. *Emu* 3: 217-226.

Paton, J. B. 1975. Birds of the Gawler Ranges. *South Australian Ornithologist* 26: 180-193.

Paton, J. B. 1980. Birds. In *A field guide to the Flinders Ranges.* D. Corbett (ed). Rigby, Adelaide, pp 263-287.

Ragless, G. 1961. (bird records). *Bird Talk* 1: 3.

Reid, J. R. W., Carpenter, G. A. and Pedler, L. P. 1996. Birds. In *Natural History of the Flinders Ranges.* M. Davies, C. R. Twidale and M. J. Tyler (eds). Royal Society of South Australia, Graphic Print Group, Richmond, South Australia, pp 132-148.

Schodde, R. and Mason, I. J. 1999. *The directory of Australian birds*. CSIRO Publishing, Collingwood, Victoria.

Terrill, S. E. and Rix, C. E. 1950. Birds of South Australia: their distribution and habitat. *South Australian Ornithologist* 19: 53-100.

**Andrew Black**
**South Australian Museum**
**North Terrace**
**Adelaide, South Australia 5000**
**abblack@bigpond.com**

# A review of Wedge-tailed Eagle population stability in the Fleurieu Peninsula region of South Australia in 2017

**EMMA ROWE, ROBERT BRINSLEY AND TERRY DENNIS**

***Abstract***

*The Fleurieu Peninsula was comprehensively re-surveyed for Wedge-tailed Eagle,* Aquila audax, *population status and breeding activity across an area of 1,540 km² in 2017. All 29 territories originally found by Dennis (2005) were re-surveyed. Of the original territories 25 (86%) were still occupied, 2 were unconfirmed and 2 were abandoned more than a decade later. An additional 23 territories were identified and in total 48 occupied territories were confirmed, with 44 of these rated as active (incubation, young or other signs of breeding activity). Of the active territories, 38 (86%) were successful in fledging young.*

*A simple estimation of the territory density was calculated as 32.1 km²/pair which was a smaller area than the 53.1 km²/pair found in 2005, due to the higher number of occupied territories found in 2017, some of which had active nest sites as close as ~1.5 km apart.*

*The majority of active nests were on private property, and landowners in general valued the presence of the eagles. Due to the proximity and frequency of various human activities, 13 territories (25%) were considered to be in a high disturbance location in 2017, compared with 9 (31%) in 2005.*

*Based on these findings, the current population status of the Wedge-tailed Eagle on the Fleurieu Peninsula is stable and appears to have continued to adapt to environmental and landscape change in the region.*

## INTRODUCTION

The Wedge-tailed Eagle, *Aquila audax*, is one of Australia's most iconic birds and plays an important ecological role as a top predator and scavenger (Hatton, Olsen and Gruber 2015). It remains widespread and common on the mainland despite former intense persecution, but has declined locally in the south through habitat disturbance in heavily settled and farmed areas (Debus 2012).

Like other agricultural areas of South Australia, the Fleurieu Peninsula has undergone extensive clearance of native vegetation to facilitate agricultural development since European settlement (Nance and Speight 1986). The dramatic modification of the landscape has resulted in widespread habitat disturbance affecting many bird and mammal species, including the Wedge-tailed Eagle, which was thought to have suffered population decline in this region (Paton, Carpenter and Sinclair 1994).

Monitoring raptors is important in order to detect population changes and threatening activities so that appropriate management and conservation strategies may be implemented (Wiersma and Koch 2012). A baseline population survey in 2005 (Dennis 2005, 2006a) followed by a population stability survey in 2006 (Dennis 2006b) confirmed that the Wedge-tailed Eagle population in the Fleurieu Peninsula was adapting to environmental changes at that time.

It was recommended that population monitoring surveys be repeated in the future using the 2005 baseline data as a foundation.

More than ten years later this study describes the systematic re-survey and assessment of the current status and distribution of the Wedge-tailed Eagle on the Fleurieu Peninsula, including vital information on population stability, trend over the last decade and productivity for the 2017 breeding season.

## METHOD

### Survey

In addition to extensive surveys of prospective breeding habitat, former Wedge-tailed Eagle territories on the Fleurieu Peninsula identified in an earlier study (Dennis 2005, 2006a) were all re-surveyed in the 2017 breeding season to determine occupancy and breeding activity. This information was directly compared with the previous survey completed more than 10 years prior (Dennis 2005).

Background information for the 2017 survey was directly available using precise (GPS) nest-site location data gathered during the extensive surveys of 2005 and 2006 (Dennis 2005, 2006b).

A scientific research permit was issued by the Department of Environment, Water and Natural Resources (number Q26620-1).

### Survey area

The Fleurieu Peninsula is defined as the area to the south and west of a line between Port Willunga (35°16’S, 138°28’E) and Goolwa (35°30’S, 138°47’E). However, as was done in the previous survey, to cover likely overlapping Wedge-tailed Eagle territories a small area of the northern Sellicks Hill Range and Southern Mount Lofty Ranges was included by arcing the survey boundary inland to the northeast by approximately 5 km, resulting in a survey area of approximately 1540 km$^2$ (Figure 1).

### Survey timing and strategies to minimise disturbance

During July–December 2016 and January 2017–January 2018 suitable habitat was searched to locate as many eagle territories as possible. All territories located in the 2005 study were surveyed first and additional prospective habitat then searched based on the following: suitability of terrain for nest sites; eagles having been sighted in the area; or from observations reported by others. Monitoring involved two to ten visits to each territory during the study period. Observations began in 2016 to locate territories, due to the large study area and therefore the logistics involved.

During the early breeding season (May- October) extended observations of one to two hours were made throughout the survey area from vantage points overlooking likely habitat. Binoculars were used to minimise disruption to normal behaviours. Expected territorial behaviours included display (territorial) flights and the carrying of nest material.

Actual nest location search effort and approach was deliberately postponed until mid-October (through to December) when active nests contained developed young, hunting and prey-carrying flights were frequent and obvious, and sensitivity to approach lessened. When nest sites were located, observation of nest contents was conducted from a distant elevated position.

When nest sites were approached, data-gathering time was kept to a minimum (<5 minutes) and the area vacated as soon as possible to allow the adults to resume normal behaviour (Olsen 2005). The nest height above ground (by visual estimate) and aspect were recorded, where possible, in addition to the location. The precise location of nest sites was determined by a hand-held GPS (Global Positioning System) unit, or in difficult terrain, by compass bearing and estimate of distance from a fixed point (determined by GPS).

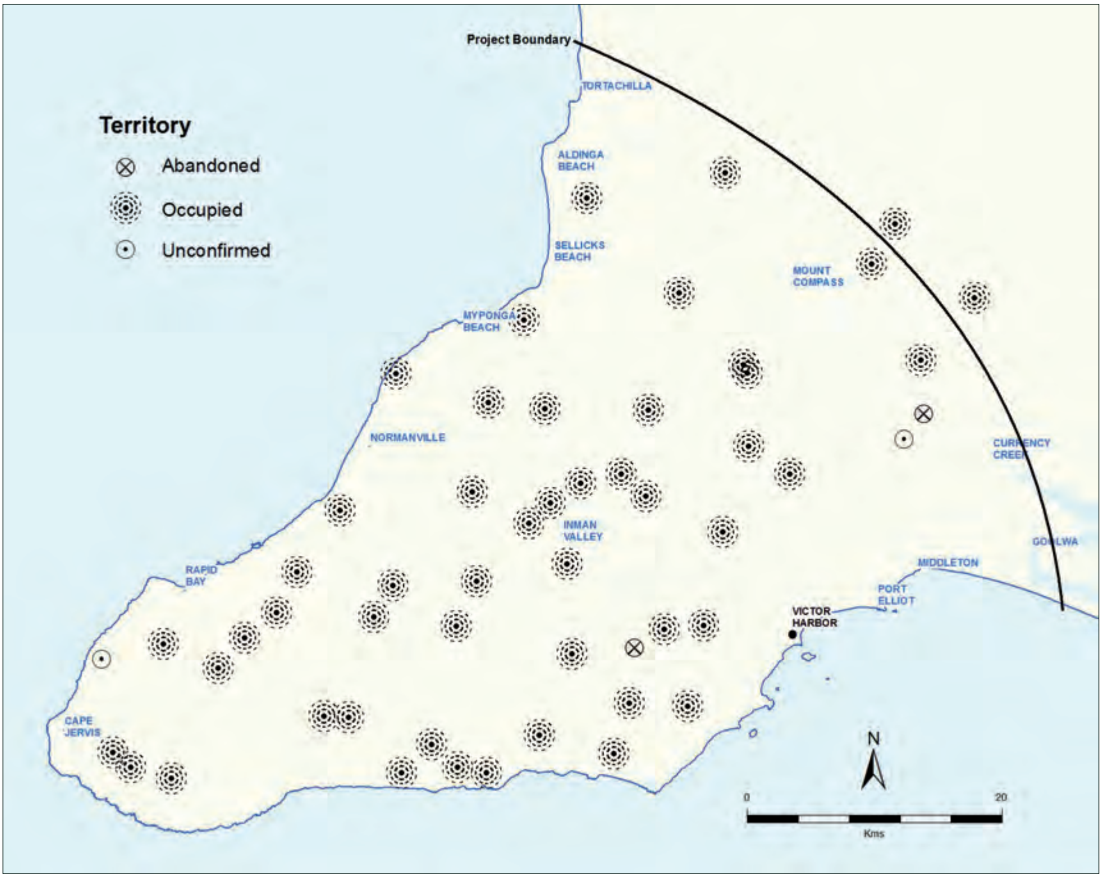


**Figure 1. Map of the Fleurieu Peninsula showing the distribution and status of 52 Wedge-tailed Eagle territories identified within the survey area boundary in 2017, with an additional two territories confirmed nearby in the southern Mt Lofty Ranges.**

**Terminology**

Key terms used throughout this study are defined as follows.

*Occupied territory*: where an adult pair is observed together during the breeding season in the vicinity of the nest(s) with nest repair, territory defence behaviours or copulation observed.

*Active nest or territory*: where incubation behaviour is observed; where young are recorded; where a pair was observed on at least two occasions with a prey- or stick-carrying flight and repeated fast and direct low-level flight toward a freshly lined nest with accumulated faecal spray present.

*Successful nest or territory*: where fledged young are recorded.

*Unconfirmed territory*: a locality where a pair, or a single adult was observed on at least two occasions soaring late in the breeding season (mid-October to mid-December), performing territorial display flights in the same area and distant from known active territories, but where nest searches were unsuccessful and fledged young were not seen.

**Habitat disturbance**

Each territory was assessed for likely disturbance factors and proximity to human activities as was done in the previous survey (Dennis 2006a). A standardised habitat quality assessment method was used, adapted from a similar study assessing landscape characteristics and human disturbance factors in a Bald Eagle, *Haliaeetus leucocephalus*, population (Mathison 1968). This included assessment of:

1. proximity and visibility of roads, tracks, walking trails and dwellings;
2. proximity and visibility of recreational activity or industry;
3. status of surrounding landscape;
4. nest site location, visibility and access.

The specific criteria used to allocate a nest site to a disturbance category are summarised in Table 1.

## RESULTS

### Resident population, territory status and population stability

A total of 52 territories was located within the survey boundary (Figure 1). All 29 occupied territories (28 of these were rated as active) from the 2005 survey (Dennis 2005, 2006a) were studied and 25 (86%) confirmed to be occupied more than 10 years later in the current study. An additional 23 occupied territories were located within the survey area that are either new since the original survey of Dennis (2005) or which may have been missed. Five unconfirmed territories identified in 2005 were confirmed as active in 2017.

In total 48 territories were occupied (Table 2) and 44 of these were rated as active (Table 3) in 2017, where:

- incubation, nestlings or recently fledged young were observed ($n$ = 39);
- recently fledged young were seen on the wing with adults in an occupied territory but no active nest was found ($n$ = 4); and,
- a pair was observed exhibiting territorial displays, prey flights and direct diving into

**Table 1. Criteria used to classify Wedge-tailed Eagle nest sites for levels of human disturbance during the breeding season (May-January). Adapted from Mathison (1968).**

| Low | Moderate | High |
|---|---|---|
| • No road, track, walking trail or dwelling within 1000 m of the nest. | • Road, track, walking trail or dwelling 500 - 1000 m from nest. | • Road, track, walking trail or dwelling <500 m from nest. |
| • Little or no human recreational activity (bushwalking, hunting, mountain bike or 4WD motorbike riding) or industry (commercial tourism, timber or brush cutting, agriculture. | • Human recreational activity or industry may periodically occur within sight of nest during breeding season, 500 - 1000 m distant. | • Human recreational activity or industry frequently occurs within sight of nest during breeding season and often within 500 m. |
| • Surrounding landscape has natural vegetation cover not modified by land treatments. | • Surrounding landscape may be partially modified by grazing. | • Surrounding landscape appreciably modified, e.g. natural vegetation largely cleared, tree felling. |
| • Nest difficult to locate without specific knowledge; location may be known to only a few individuals. | • Nest may be seen from road, bush track or dwelling, but considerable effort required to reach it; location generally not known. | • Nest is readily visible from road, track, walking trail or dwelling, access requires little effort; location is generally known. |

the location of a freshly lined nest with accumulated faecal spray present, but where incubation was not witnessed ($n$ = 1).

Four territories were found to be occupied but could not be confirmed as active. Three of these occupied territories had previously been confirmed as active in 2005. Comparing territory data from the previous study, of the 28 active territories in 2005, 21 were again active, 2 were unconfirmed, 3 were occupied and 2 were found abandoned in this survey.

The precise locations of active nest sites were lodged with Birds SA in a confidential report (Rowe, Brinsley and Dennis 2018). To protect the interests of private landowners and ensure nest site security is retained, these precise locations are not reported here.

**Territory density and productivity**

Using the same formula as was used in the previous survey (Dennis 2005), a simple division of the survey area (1540 $km^2$) by the number of territorial pairs identified (48 occupied territories) equates to 32.1 $km^2$/pair. This is a smaller area per pair than the 53.1 $km^2$/pair found in 2005, due to the higher number of occupied territories found in 2017, some of which had nests in close proximity (e.g. ~1.5 km apart). However, this is over-simplified and unlikely to represent the area of home range by each pair (Figure 1).

Thirty-eight pairs successfully fledged young, with 28 pairs (74%) fledging a single young and 10 pairs (26% ) fledging two young (Table 3) (for more detail see Rowe and Brinsley 2018).

**Nest site selection**

Active nest sites were found in 41 territories and site description notes taken, with the majority being on private property. Four of the active nests found in 2005 were in use in 2017. The nest trees were located in a gully or sloping hillside ($n$ = 20), a creek gully ($n$ = 16) or a copse of open woodland ($n$ = 5). The slope of the gullies or hillsides ranged from ~15°–60° (visual estimate where possible).

**Table 2. Location and status of Wedge-tailed Eagle territories on the greater Fleurieu Peninsula in 2005 (Dennis 2005) and 2017 breeding seasons.**

| | **No. of occupied territories** | | **No. of unconfirmed territories** | | **No. of abandoned territories** |
|---|---|---|---|---|---|
| **Locality** | **2005*** | **2017** | **2005*** | **2017** | **2017** |
| Southern coastal area (Goolwa to Cape Jervis) | 5 | 13 | 1 | 0 | 0 |
| Western coastal area (Cape Jervis to Normanville) | 5 | 6 | 0 | 1 | 0 |
| Western coastal area (Carrickalinga to Port Willunga, including Sellicks Hill Range) | 3 | 6 | 2 | 0 | 0 |
| Yankalilla River catchment | 4 | 6 | 1 | 0 | 0 |
| Myponga River catchment | 1 | 2 | 1 | 0 | 0 |
| Hindmarsh River catchment | 2 | 4 | 1 | 0 | 0 |
| Inman River catchment | 6 | 9 | 0 | 0 | 1 |
| Currency Creek catchment | 2 | 1 | 0 | 1 | 1 |
| Finnis River catchment | 1 | 1 | 1 | 0 | 0 |
| **Total No.** | **29** | **48** | **7** | **2** | **2** |

* data taken from Dennis T.E. (2005)

**Table 3. Location, active status and productivity outcome among Wedge-tailed Eagle territories on the greater Fleurieu Peninsula in 2005 (Dennis 2005) and 2017 breeding seasons.**

| | No. active territories | | No. successful territories | |
|---|---|---|---|---|
| **Locality** | **2005*** | **2017** | **2005*** | **2017** |
| Southern coastal area (Goolwa to Cape Jervis) | 5 | 13 | 3 | 11 |
| Western coastal area (Cape Jervis to Normanville) | 5 | 5 | 4 | 5 |
| Western coastal area (Carrickalinga to Port Willunga, including Sellicks Hill Range) | 3 | 4 | 1 | 3 |
| Yankalilla River catchment | 4 | 6 | 2 | 5 |
| Myponga River catchment | 1 | 2 | 1 | 1 |
| Hindmarsh River catchment | 1 | 4 | 1 | 4 |
| Inman River catchment | 6 | 8 | 5 | 7 |
| Currency Creek catchment | 2 | 1 | 1 | 1 |
| Finnis River catchment | 1 | 1 | - | 1 |
| **Total No.** | **28** | **44** | **18**** | **38^** |

* data taken from Dennis T.E. (2005); ** productivity outcome determined for 22 active territories in 2005; ^ productivity outcome determined for 44 active territories in 2017.

**Table 4. General location and number of Wedge-tailed Eagle territories categorised for disturbance on the Fleurieu Peninsula in 2017 compared with 2005 (Dennis 2006a).**

| | Disturbance Category | | | | | |
|---|---|---|---|---|---|---|
| | Low | | Moderate | | High | |
| **Locality** | **2005*** | **2017** | **2005*** | **2017** | **2005*** | **2017** |
| Southern coastal area (Goolwa to Cape Jervis) | 3 | 9 | - | 2 | 2 | 2 |
| Western coastal area (Cape Jervis to Normanville) | 2 | 4 | 1 | - | 2 | 3 |
| Western coastal area (Carrickalinga to Port Willunga, including Sellicks Hill Range) | - | 2 | 2 | 2 | 1 | 2 |
| Yankalilla River catchment | 4 | 4 | - | - | - | 2 |
| Myponga River catchment | - | 1 | 1 | 1 | - | - |
| Hindmarsh River catchment | 1 | 3 | - | 1 | 1 | - |
| Inman River catchment | 3 | 4 | 2 | 5 | 1 | 1 |
| Currency Creek catchment | - | 1 | - | - | 2 | 2 |
| Finnis River catchment | - | - | - | - | 1 | 1 |
| **Total No.** | **13** | **28** | **6** | **11** | **10** | **13** |

* data taken from Dennis T.E. (2006a)

The majority of nests were in a large, dominant older tree (*Eucalyptus* sp.), with the nest platform having partial canopy cover and placed at or slightly above the level of surrounding foliage. One notable exception was a nest built on top of a low She-oak, *Allocasuarina verticillata,* located within a creek gully, which had no canopy cover.

Estimated height (above ground level) for the nest sites averaged ~10 m ($n$ = 35, range ~3–18 m). As was found in 2005 (Dennis 2005), the nest aspect in this survey (recorded at 36 sites) was found to vary even among those in the same territory. However there appeared to be a preference for a cooler, shaded aspect over a hot, windy aspect: northeast–south ($n$ = 27) and southwest–north ($n$ = 9).

**Habitat disturbance**

Examples of Wedge-tailed Eagle habituation to human activity and infrastructure were found, with several nests in close proximity to regular human activity. Using the standardised criteria, 28 territories were classified as Low disturbance; 11 were classed as Moderate; and 13 were classed as in the High disturbance category in 2017 (Table 4). The two abandoned territories were in a high disturbance and moderate disturbance area respectively.

## DISCUSSION

**Resident population, territory status and population stability**

The population status of the Wedge-tailed Eagle on the Fleurieu Peninsula in 2017 is encouraging, with more occupied and active territories identified in 2017 compared with 2005.

Of the territories located in 2005, many (25) were still occupied more than ten years later. Wedge-tailed Eagles show strong site fidelity with individuals often occupying the same territories for 40 years or more (Hatton *et al*. 2014).

Two occupied territories in 2005 were unconfirmed in this survey. These locations were observed several times and eagles were seen in both territories at each visit, but their behaviour was inconclusive. The two abandoned territories found in 2017 had been previously active, but the nests found by Dennis (2005) were no longer present and there was no suitable habitat for alternative nest structures. A bushfire had destroyed the nest and surrounding habitat in one, and in the other the active nest had disappeared without suitable habitat for alternative sites (despite an old inactive nest still present), therefore it is not surprising that those two territories were abandoned.

Nest-site quality contributes to breeding success (Collins and Croft 2007). There are specific nesting requirements including height and girth of the tree (Hatton *et al*. 2014; Silva and Croft 2007), shelter from weather, shade, security from predators and aspects that provide maximum protection from prevailing winds and bushfires (Foster and Wallis 2010). Active nest trees were found on a significantly different aspect compared with inactive trees in one study (Hatton *et al.* 2014) and thus a territory may be abandoned if a suitable nest tree cannot be found.

In addition to the original territories, more occupied territories were identified in this study. Five of these additional territories were recorded as possible territories in the previous study (Dennis 2005). With an extensive survey covering large distances, such as this, it is not possible or feasible to check every potential site and extensively search for new sites (Hatton *et al.* 2014) given the available resources. With 86% of the 2005 territories still occupied, a further 23 occupied territories identified and a total of 44 territories confirmed as active in 2017, the population can be confirmed as at least stable. Future surveys will be required to monitor the population for stability and/or trend over time.

There was one territory in this study classed as active without evidence of incubation or young. The pair in this territory was observed exhibiting territorial displays and on at least two occasions seen with a prey- or stick-carrying flight and repeated fast and direct low-level flight toward a freshly lined nest (green leaves) with accumulated faecal spray present. It was difficult to see inside the nest bowl and thus signs of incubation may have been missed, or alternatively, the nest may have been lined without breeding activity.

Wedge-tailed Eagles line their nests with green leaves early in the breeding season and continue to line nests during the nestling period (Wiersma and Koch 2012), thus the green lining may be an indicator of incubation or young. However, they have also been reported to line nests in a territory for consecutive years but not use them for breeding (Cherriman, Foster and Debus 2009).

The presence of faecal whitewash is also a strong indicator of an active nest; however, it can be present below a nest used for roosting, a display or feeding platform or a breeding site (Wiersma and Koch 2012).

It was concluded based on both the nest characteristics and the eagles' behaviour that this was an active territory.

A small number of territories ($n$ = 4) were occupied but could not be confirmed as active. Three of these occupied territories had been confirmed as active in 2005; however, the 2005 active nests were no longer present in the previously identified GPS location, alternative nests sites could not be found during search efforts, and incubation or fledged young were not seen in 2017.

**Territory density and productivity**

Using the same formula as was used in the previous survey (Dennis 2005), the area per pair was smaller (i.e. higher density of eagles) than that found in 2005. However, the calculation was over-simplified and unlikely to represent the area of home range. Due to the variable nature of the landscape and with much of the survey area developed for silviculture or other intensive land-use and therefore unsuitable as WTE habitat, it was elected not to perform nearest neighbour density calculations. It is also possible that there may have been territories that were missed. Territories and home ranges are not necessarily regular in shape, as it depends on topography and habitat, and where both nest sites and prey are located (Olsen 2005). For example, ridgelines can be a territory boundary with a pair on either side (Olsen 2005).

In this study along one of the escarpments there was only ~1.5–2 km between each of three active nests (Figure 1). Debus (2017) reported other similar examples in the literature: near Broken Hill in semi-arid western NSW in 1996-99, neighbouring nests were 2–3 km apart along a range system at Mutawintji National Park ($n$ = 80) (Sharp, Norton and Marks 2001) and at Armidale, NSW in 2005 neighbouring nests were 4–7 km apart (Debus *et al*. 2007).

Thirty-eight pairs in this study successfully raised young and favourable seasonal conditions may have contributed to the breeding activity and success in 2017. (see Rowe and Brinsley: in press).

**Nest site selection**

Active nest-site characteristics of the Wedge-tailed Eagle on the Fleurieu Peninsula were similar to those previously described by Dennis (2005) and in the literature.

Four of the active nest sites found in 2017 were also active in 2005. In the other territories active in both 2005 and 2017 the active nest site was either a refurbished old inactive nest or a newly built nest. A Wedge-tailed Eagle pair has between two and three nests on average, and occasionally up to ten in a breeding territory (Olsen 2005).

Traditional nest sites may be occupied for up to 40 years by generations of eagles (Debus 2017). In a Tasmanian study, most nests were used repeatedly if undisturbed, even if they failed to produce young (Olsen 2005), thus it is interesting that not more active nests were in use over a decade later and may reflect adaption to changes in their environment. All except one of the active nests were located in large *Eucalyptus* sp., which is consistent with other studies (Foster and Wallis 2010; Silva and Croft 2007).

In contrast to other nests found in creek gullies (n = 16), the one nest on top of an *Allocasuarina* sp. tree was only ~3 m above ground level. This was exceptional, and studies elsewhere have also found nests in creek-lines to be substantially higher than nests on elevated slopes or ridge habitat (Sharp, Norton and Marks 2001).

Overall, the estimated height (above ground level) for nest sites was consistent with the published estimates (Debus 2017). The nest aspect varied, even among nests within the same territory, but most sites were exposed to morning sun and were sheltered from prevailing weather.

The availability of suitable nest sites plays an important role in determining territory size and spacing (Ridpath and Brooker 1987) and the remaining remnant natural vegetation across the Fleurieu landscape has no doubt shaped the distribution and abundance of the contemporary Wedge-tailed Eagle population. Territory size and spacing has also been linked to the abundance and long-term availability of prey species (Ridpath and Brooker 1987), which have likely increased in abundance with land modification in the study area over time.

**Habitat disturbance**

There is evidence that Wedge-tailed Eagles can become habituated to routine agricultural activity and road traffic (Debus *et al.* 2007), as was seen in this study with some successful territories having regular activity or road traffic in close proximity to the nests throughout the entire breeding cycle.

The most notable examples include:

- the successful territory in which a visually exposed nest was found only ~300 m from the road, in a paddock cut for hay, with farm machinery passing directly under and around the nest;
- the failed territory in which a visually exposed nest (in a large tree within a group of three trees) was located in a very open area only 300–400 m from a busy main road;
- the successful territory in which the nest was clearly visible from a farmhouse only 400 m away and in close proximity to large-scale pine tree felling during the nestling period;
- the failed territory in which a visually exposed nest, only 3 m above ground was in close proximity to a hut and 4WD motorbike track which were both in regular use;
- the successful territory with a visually exposed nest in a tree ~400 m from a busy road and ~300 m from a newly constructed shed with regular farm activity.

Nesting eagles vary in their response to human proximity. In one study 80% of nests were located within view, or within 200 m of roadways or houses (Foster and Wallis 2010); and in another study four nests were less than 500 m from houses (Fuentes, Olsen and Rose 2007). However, if irregular or new human activity occurs at sensitive phases of the breeding cycle such as during incubation, the nest may be deserted (Olsen 2005; Cherriman, Foster and Debus 2009).

During these surveys great care was always taken to avoid the prospect of researcher-induced desertions and also at the later stage of the cycle when human intrusion could potentially result in a branching fledgling taking flight before they have adequate strength and skill.

## CONCLUSION

Currently, based on our 2017 data, the Wedge-tailed Eagle population on the Fleurieu Peninsula appears to be stable and continuing to adapt to a changing landscape and to the variety of commercial land uses across this region.

Communications with landowners highlighted the level of rural community acceptance and intrinsic value placed on the species, across the Fleurieu landscape. There will be emerging challenges for eagles, such as recreational and industrial use of drones, wind-farms and spread of urban development. It is important to continue to monitor and protect breeding habitat from disturbance and emerging threats.

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## REFERENCES

Cherriman, S. C., Foster, A. and Debus, S. J. 2009. Supplementary notes on the breeding behaviour of Wedge-tailed Eagles *Aquila audax*. *Australian Field Ornithology* 26: 142-147.

Collins, L. and Croft, D. 2007. Factors influencing chick survival in the Wedge-tailed Eagle *Aquila audax*. *Corella* 31: 32-40.

Debus, S. 2012. *Birds of Prey of Australia.* 2nd ed. CSIRO Publishing, Melbourne.

Debus, S. 2017. *Australasian Eagles and Eagle-like Birds.* CSIRO Publishing, Melbourne.

Debus, S. J., Hatfield , T. S., Ley, A. J. and Rose, A. B. 2007. Breeding biology and diet of the Wedge-tailed Eagle Aquila audax in the New England Region of New South Wales. *Australian Field Ornithology* 24: 93-120.

Dennis, T. E. 2005. *Population survey of the Wedge-tailed Eagle and White-bellied Sea-Eagle on Fleurieu Peninsula in South Australia, 2005.* Unpublished report to Birds SA.

Dennis, T. E. 2006a. Status and distribution of the Wedge-tailed Eagle on the Fleurieu Peninsula, South Australia in 2005. *South Australian Ornithologist* 35: 38-46.

Dennis, T. E. 2006b. *Wedge-tailed Eagle and White-bellied Sea-Eagle population stability survey on the Fleurieu Peninsula, 2006*. Unpublished report to Birds SA.

Dennis, T. E., McIntosh, R. R. and Shaughnessy, P. D. 2011. Effects of human disturbance on productivity of White-bellied Sea-Eagles *Haliaeetus leucogaster*. *Emu-Austral Ornithology* 111: 179-185.

Foster, A. and Wallis, R. 2010. Nest-site characteristics of the Wedge-tailed Eagle in Southern Victoria. *Corella* 34: 36-44.

Fuentes, E., Olsen, J. and Rose, A. B. 2007. Diet, occupancy and breeding performance of Wedge-tailed Eagles *Aquila audax* near Canberra, Australia 2002–2003: Four decades after Leopold and Wolfe. *Corella* 31: 65-72.

Hatton, F., Olsen, J. and Gruber, B. 2015. Post-fledging spatial use by a juvenile Wedge-tailed Eagle *Aquila audax* using satellite telemetry. *Corella* 39: 53-60.

Hatton, F., Patrick, H. M., Gruber, B., and Olsen, J. 2014. Modelling the nesting habitat requirements of the Wedge-tailed Eagle *Aquila audax* in the Australian Capital Territory using nest site characteristics. *Corella* 38: 63-70.

Mathison, J.E. 1968. Effects of human disturbance on nesting Bald Eagles. *Journal of Wildlife Management* 32: 1-6.

Nance , C. and Speight, D. L. (Eds.). 1986. *A Land Transformed - Environmental Change in South Australia.* Longman Cheshire, Melbourne.

Olsen, P. D. 2005. *Wedge-tailed Eagle*. CSIRO Publishing, Melbourne.

Paton, D., Carpenter, G. and Sinclair, R. 1994. A second bird atlas of the Adelaide Region. Part 1: Changes in the distribution of birds: 1974-75 *vs* 1984-85. *South Australian Ornithologist* 31: 151-193.

Ridpath , M. G. and Brooker, M. G. 1987. Sites and spacing of nests as determinants of Wedge-tailed Eagle breeding in arid Western Australia. *Emu* 87: 143-149.

Rowe E. L. and Brinsley R. F. 2018. Breeding productivity of the Wedge-tailed Eagle *Aquila audax* on the Fleurieu Peninsula, South Australia in 2017. *Corella* 42: 86-90.

Rowe E. L., Brinsley R. F. and Dennis T. E. 2018. *A repeat Wedge-tailed Eagle Population Survey in the Fleurieu Peninsula region of South Australia, in 2017*. Unpublished report to Birds SA.

Sharp, A., Norton, M. and Marks, A. 2001. Breeding activity, nest-site selection and nest spacing of Wedge-tailed Eagles (*Aquila audax*) in western New South Wales. *Emu* 101: 323-328.

Silva, L. M. and Croft, D. B. 2007. Nest-site selection, diet and parenteral care of the Wedge-tailed Eagle *Aquila audax* in Western New South Wales. *Corella* 31: 23-31.

Wiersma, J. and Koch, A. J. 2012. Using surveys of nest characteristics to assess the breeding activity of the Tasmanian Wedge-tailed Eagle. *Corella* 36: 38-44.

**Emma Rowe**
**PO Box 253**
**Woodside SA 5244**
**emma@eaglefeather.com.au**

**Robert Brinsley**
**74 Alfred Street**
**Parkside SA 5063**
**rfbrin@hotmail.com**

**Terry Dennis**
**osprey842@gmail.com**

# A review of Osprey distribution and population stability in South Australia

**S. A. DETMAR AND T. E. DENNIS**

***Abstract***

*Comprehensive surveys of Osprey habitat across all coastal regions of South Australia were undertaken in 2008–10 and in 2015–17. Comparison of results from the two surveys has revealed a significant decline in the population. In 2008–10, 58 occupied territories were found; in 2015–17 only 43 were identified. This represents an overall decline of 26% in the breeding population over the period between surveys. The steepest declines were in the west of the state where the number of occupied territories decreased from 33 in 2010 to 22 in 2017, a decline of 33%; and on Kangaroo Island where 14 occupied territories in 2010 declined to eight in 2015 and 2016, a 43% decline. When recent survey results from the quasi-mainland habitat of Kangaroo Island are combined with mainland data, a decline of 39% is revealed in the number of occupied territories across mainland coastal areas in South Australia; i.e. a combined total of 49 (of 58) territories were found on the mainland in 2008–10 and only 30 (of 43) territories were identified in these habitats in 2015–17 surveys.*

*In addition to the number of abandoned territories we found an underlying level of instability in the contemporary population evidenced by: a) the high number of nest relocations (*n *= 16 of 43; 37%) that had occurred within occupied territories over the period since 2010; and b) the number of probable 'refugee' pairs (*n *= 6; 14% of the breeding population) apparently having moved to start new territories. Although the causes for this population instability and rapid decline are not immediately apparent, because it has occurred widely across the extreme southern edge of the Australasian sub-species' continental distribution, there are likely multiple contributing factors that require further investigation. From these compelling survey results we contend that species and habitat conservation measures are required in the short term to prevent further decline among the remaining Osprey population in South Australia.*

## INTRODUCTION

The taxonomy of the Australasian Osprey has been subject to debate in Australia. Here we use the most widely accepted sub-species designation *Pandion haliaetus cristatus* (*vide* Horton, Blaylock and Black 2013; Monti *et al.* 2015).

The Australasian Osprey occurs over a broad tropical region between New Caledonia and New Guinea to central Indonesia and north to the southern Philippines (Prevost 1983; Poole 1989, 1994; Coates and Bishop 1997). In Australia the majority of the Osprey population is found in coastal and estuarine habitats across northern temperate and subtropical regions of the continent where high population densities occur in remote areas (Johnstone and Storr 1998; Dennis and Clancy 2014).

On southern coastlines, the species is more sparsely distributed, and there is a broad geographical gap in the breeding distribution in the southeast corner of the continent below latitude 35°30′S. The apparent adaptation to tropical regions by the Australasian sub-species implies that the small isolated population in South Australia is likely to be on the extreme southern edge of the species' preferred bioclimatic range (Dennis and Clancy 2014).

In stark contrast to the forested coastal and estuarine Osprey habitat in the tropical north and warm temperate regions of the eastern and northern states (Figure 5), Osprey breeding habitat in South Australia is limited to mostly semi-arid open coastal landscapes with low coastal heath vegetation cover (Dennis *et al.* 2011). In these settings, tree nests are non-existent and typical nest sites are on an exposed cliff feature or associated broken terrain with little or no visual screening, or on near-shore sea-stacks and vulnerable to damage from storm-surge and severe weather events (Figure 2). While unique in Australia as Osprey habitat, these coastal landscape characteristics found across the southern extent of the species' continental range are remarkably similar to *P. haliaetus* habitat in the Cape Verde and Canary Islands off north-west Africa and on the island of Corsica west of Italy. Here nest sites are also on cliffs in open terrain and subjected to frequent disturbance from human activity or approach, resulting in breeding failures (Palma *et al.* 2004; Siverio and Rodriguez 2005; Thibault, Bretagnolle and Domonici 1995).

The South Australian Osprey population was estimated at 52 breeding pairs in 2005 (Dennis 2007a) and was formally up-listed to Endangered species status in South Australia in 2008 (*National Parks and Wildlife Act 1972*). Subsequent data from a comprehensive series of targeted breeding season surveys in 2008-10 confirmed a total of 58 occupied territories across the state, with most of these found on western and southern Eyre Peninsula (Dennis *et al.* 2011). A concurrent habitat threat assessment concluded that some breeding sites on Eyre Peninsula, Yorke Peninsula and Kangaroo Island were vulnerable to failure and displacement to sub-optimal habitat because of ongoing human disturbance (e.g. Figure 3). These surveys and associated research also provided evidence that a substantial decline in the Osprey population, coincident with a contraction in the species' breeding range, had occurred in the 20th century (Dennis *et al*. 2011).

The Osprey is acknowledged world-wide as a sentinel species by which to measure the health and stability of coastal and wetland ecosystems (Poole 1994, 2009; Henny *et al.* 2008; Grove, Henny and Kaiser 2009). In recognition of this, and that results from previous surveys had clearly highlighted the species' apparent tenuous existence in South Australia, another comprehensive multi-year survey project began in 2015. Primarily this project aimed to:

- re-assess the status of Osprey populations in each coastal region of SA (including offshore island habitats) to measure population stability or trend against the available baseline data from previous surveys (2008-10); and

- identify threats likely to adversely impact the quality of the breeding refuge habitat.

## METHODS

Typically, raptor population size is determined from an assessment of the number of territorial or breeding pairs (Newton 1979). As is usual for large raptors, the Osprey is known to form long-term pair bonds and to use the same nesting locations over long time periods, with favoured nest sites used by successive generations (Poole 1989; Clancy 2006; Dennis 2007b). The earlier baseline coastal raptor population surveys in South Australia (2008–10) and the recent surveys reported here were based on these precepts. Therefore, relative stability of territories was assumed. Surveys were targeted to previously determined territory locations and to areas where abandoned or vacant nest sites had been identified previously (Dennis 2005; Dennis *et al*. 2011).

**Survey scope and planning**

With the advantage of known nest site locations from previous research, strategic surveys were conducted over three breeding seasons between May 2015 and December 2017. These were in areas with known and potential Osprey breeding habitat from the Bunda Cliffs in the Great Australian Bight to Kangaroo Island in the south, including offshore islands off both Yorke and Eyre Peninsulas.

**Permits and project approvals**

Annual Scientific Permits No(s) M26377 1-3; Marine Parks Scientific Permit No(s) MR00048 1-3; and Wildlife Ethics Committee Approvals No(s) 4/2015 and 16/2017 were obtained from the South Australian Department for Environment and Water (DEW). The associated Permit Conditions were followed throughout.

**Ground surveys**

Ground surveys were conducted by a combination of vehicle and foot traverse, with the latter employed on remote coastlines where vehicle access to survey sites was not possible or ethical, e.g. Venus Bay peninsula on western Eyre Peninsula.

Disturbance minimisation protocols developed in earlier coastal raptor surveys (Dennis *et al*. 2011) were again observed, including avoidance of sensitive phases of the breeding cycle. Therefore, surveys were invariably undertaken by one of us or a suitably trained volunteer, and mostly confined to the period extending from late October through to mid-December, when pairs in active territories were settled into daily patterns of nest provisioning forays and territory defence. Depending on terrain, nest observations were made at distances >500 m using high-resolution binoculars and/or a tripod-mounted spotting scope, with observation time kept to an absolute minimum. Several near-shore island and sea-stack nest sites could be visually surveyed satisfactorily by spotting scope from the nearest mainland vantage point.

In territories where Ospreys were not seen at the nest or nearby in the core territory, the nest was examined visually for evidence of recent activity (e.g. prey remains, scat spray, nest repair or nest lining activity) and images taken of the nest platform for further detailed scrutiny. This enabled confident classification of territories as: *occupied* – where there was evidence of nest preparation activity or use; or as *abandoned* – where nests showed no signs of activity after repeat surveys over two breeding seasons (including territories with unrepaired storm damaged nests). Known alternative and abandoned nest sites were similarly checked and additional searches carried out to determine if a new site had been established.

**Sea-based surveys**

Typical Osprey nest placements in South Australia are either surrounded by or overlook the sea. Even in remote locations such as islands, pairs are at least partly pre-conditioned to the presence and movement of boats and largely ignore an approaching or slowly passing vessel at distances >150 m. Appropriately timed sea-based surveys were used wherever possible as they are by far the most effective and time-efficient survey method for remote coastlines and island-based habitats, and can be undertaken with minimal or no disturbance to the birds. A dinghy or canoe was used for prospecting surveys in some tidal creeks in mangrove forest areas.

**Data processing and storage**

A standardised survey datasheet was developed and used for each survey site throughout the project. All location data and observation notes were subsequently transcribed from these to an electronic spreadsheet. Images of surrounding terrain characteristics were obtained at all sites and archived for future reference.

**Threats**

Actual and potential threats at occupied and some abandoned territories with potential for re-occupation were recorded using the standardised survey datasheet. Likely threats assessed during surveys included: the level of disturbance from recreation pursuits occurring within or near the core territory; landscape scale habitat degradation, such as vegetation clearance or damage from fire or overgrazing; change of land-use, e.g. from open range grazing to sub-division development; proximity to dwellings and other buildings, tourism destinations, roads, tracks or walking trails; recreational and commercial use of drones; and proximity to land-based or marine industry likely to cause disturbance or affect the availability of prey.

Horizontal distance measurements between nest sites and physical features associated with disturbance in the landscape were measured using mapping programs including NatureMaps, Google Earth and ArcMap.

**Community contact and participation**

With a view to developing greater community awareness concerning threatened coastal raptor conservation issues in South Australia, considerable effort was made to liaise with and involve regional Department for Environment and Water staff, and through them, their respective community networks. In addition, to update local knowledge and garner information on recent observations, contact was made with key community members in coastal regions, including: members of the coastal raptor volunteer network established during the 2008-10 surveys; regional Birds SA members; the executive and members of the Abalone Industry Association of South Australia; and coastal land owners where access permission was required.

**Terminology**

Key terms used throughout are defined as follows.

*Occupied territory:* where an adult pair is observed together during the breeding season in the vicinity of the nest(s) with nest repair or territory defence behaviours observed.

*Active nest or territory*: where incubation behaviour is observed, or where young are recorded.

*Successful nest or territory*: where young are fledged.

*Failed nest or territory*: where eggs fail to hatch, or where eggs or young are lost.

*Abandoned territory:* a territory found unoccupied over two or more consecutive seasons and where nest structures have fallen into disrepair.

*Vacant territory*: where no birds were seen nearby for one season and the nest structure was intact but no evidence of recent repair or occupation was apparent.

*Primary nest:* the most frequently used nest within a territory.

*Alternative nest:* one of sometimes several nest structures within a territory.

*Core territory*: the defended area around a primary nest site.

*Guard-roosts*: nest defence vantage points within the core territory.

## RESULTS

Initial surveys in 2015 found an unexpectedly high number of vacant and abandoned territories in most regions. Follow-up surveys in 2016 were frustrated by adverse weather through July and September, with persistent strong winds, above average heavy rainfall and record cold temperatures, making both ground and sea-based surveys impractical and unethical. These weather conditions culminated in a severe storm event over the period 28 September to 5 October, which resulted in several localised tornados, heavy rains and widespread flooding, extreme gale-force winds and large ocean swells in coastal areas (Bureau of Meteorology 2016). At least eight

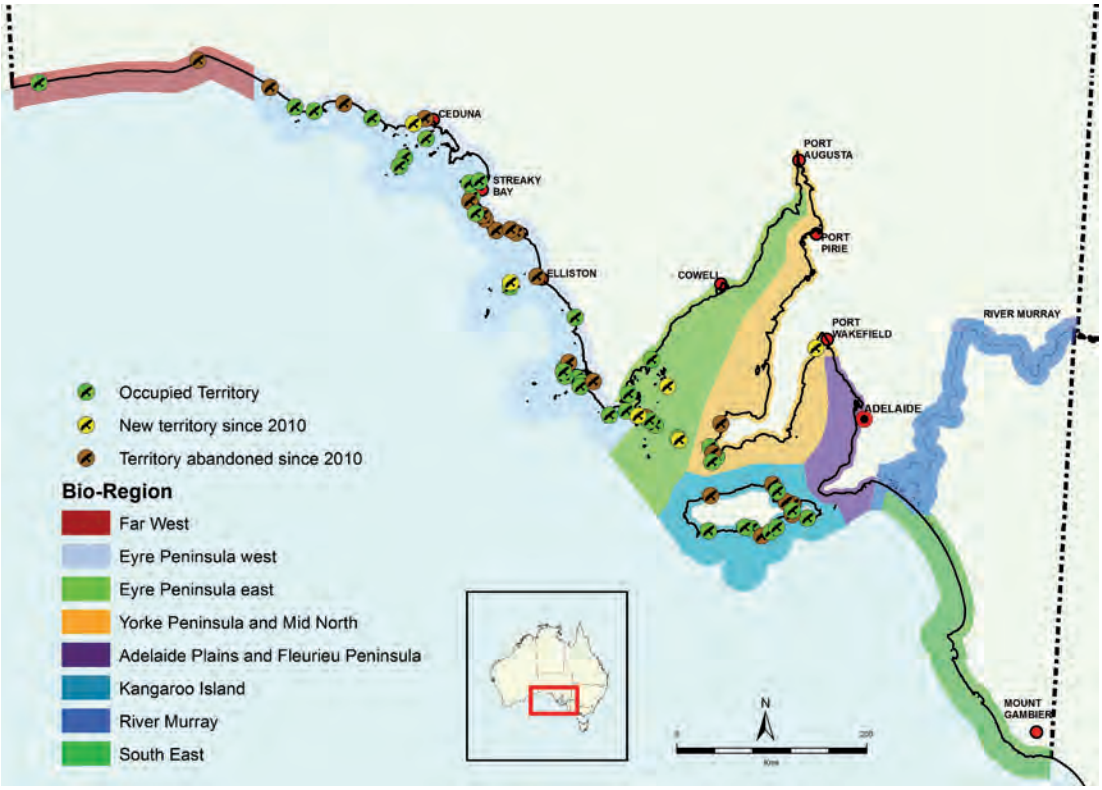


**Figure 1. Map of the South Australian coast showing the current distribution of Osprey territories, including new territories since 2010 and the location of territories that have been abandoned since 2010.**

nests on western Eyre Peninsula and southern Kangaroo Island were severely damaged or completely destroyed. Six of these were located on near-shore sea-stacks and therefore particularly vulnerable in large swell and severe wind conditions; and an artificial nest platform at an oyster farm and a nest in mangroves were swept away. Subsequently, strategic surveys were repeated in 2017 to test the adverse findings from 2015 and 2016 and to increase confidence levels in the survey data overall.

**Survey results**

Between May 2015 and December 2017 the known and potential Osprey breeding habitat west of the River Murray mouth (including Kangaroo Island) was surveyed at least twice in each coastal bio-region (Figure 1) over three breeding seasons, with offshore islands surveyed at least once. A total of 43 occupied Osprey territories were confirmed across all regions (including islands), with the majority on western Eyre Peninsula (Table 1 and Figure 1). When compared with data from the 2008–10 surveys when 58 occupied territories were identified, an apparent overall decline of 26% has occurred in the breeding population (Table 1).

The steepest declines have occurred in the west of the state where the number of occupied territories has decreased from 33 in 2010 to 22 in recent surveys, a decline of 33%; and on Kangaroo Island where there were 14 occupied territories in 2010 and only 8 in recent surveys, a decline of 43% (Table 1).

**Core territory locations**

In the 2008–10 surveys the majority of Osprey territories (60%) had primary nest sites on the mainland or on near-shore sea-stacks and islets <1 km offshore ($n$ = 35 of 58), with the remainder on offshore islands. However, if the quasi-

**Table 1. The number of occupied Osprey territories identified for each coastal bio-region* in South Australia (see map, Figure 1) from surveys over three breeding seasons (2015–17) compared with data from earlier (2008–10) surveys (Dennis *et al.* 2011).**

| Coastal bio-region, South Australia | General locality and number of occupied territories identified in 2015-17 (2008-10) | No. of territories 2008-10 | No. of territories 2015-17 | % Change |
|---|---|---|---|---|
| Far West (Wilson Bluff to Wahgunyah CP) | Bunda Cliffs 1 (2); Head of Bight to Wahgunyah 0 (0) | 2 | 1 | -50.0 |
| Eyre Peninsula west (Wahgunyah CP (western boundary) to Cape Catastrophe) | Mainland 17 (29); Nuyts Archipelago 3 (3); Investigator Group 2 (1); Whidbey Group 0 (0); other islands 0 (0) | 33 | 22 | -33.3 |
| Eyre Peninsula east (Cape Catastrophe to Two Hummocks Point, upper Spencer Gulf) | Mainland 2 (1); Thorny Passage Islands 2 (2); Sir Joseph Banks Group 1 (0); Gambier Group 2 (1); other islands 1 (1) | 5 | 8 | +60.0 |
| Yorke Peninsula and Mid North | Mainland 1 (2); Islands 3 (2) | 4 | 4 | 0.0 |
| Adelaide Plains and Fleurieu Peninsula | Transient and vagrant records only | - | - | - |
| Kangaroo Island | Kangaroo Island 8 (14) | 14 | 8 | -42.8 |
| Murray River (flood plain and wetlands) | Historical and vagrant records only | - | - | - |
| South East | Vagrant records only | - | - | - |
| Cooper Basin | Vagrant records only | - | - | - |
| | **Total** | **58** | **43** | **Av. -25.9%** |

* broadly based on Natural Resource Management Board regions and Birds SA regional boundaries (*vide* Blaylock *et al.* 2017).

mainland Kangaroo Island data are added, the overall proportion of mainland-based territories increases to 84% (*n* = 49 of 58); compared with 70% (*n* = 30 of 43) in recent surveys. Therefore a decline of 39% (i.e. from 49 in 2010 to 30 in 2017) in the number of mainland-based territories has occurred over the period between surveys.

**Nest sites**

In contrast to what is widely understood of Osprey long-term and often multi-generational attachment to favoured primary nest sites (Poole 1989; Marchant and Higgins 1993; Dennis 2007b), we found that among the 43 occupied territories identified, 16 nests (37%) had been relocated since the previous surveys were completed in 2010. Added to this unexpected dynamic, five new territory locations were established, possibly by 'refugee' pairs, accentuating the probability of an underlying level of instability in the population.

Consistent with previous surveys, most nests were on broken sections of coastal cliff and near-shore sea-stacks, often on highly exposed sections of coastline vulnerable to storm events and extreme weather (e.g. Figure 2). Whereas in 2010 six nests were on specially constructed artificial platforms (e.g. Figure 4) only two of these were occupied in 2017, and at one of these the pair was presumed to have relocated <1 km to another purpose-built platform on a disused barge.


**Figure 2. A typical Osprey nest placement in South Australia's open coastal landscapes. The nest, although 'protected' in a National Park, is vulnerable to climatic events (e.g. storm surge) and to disturbance from recreational activities above nest-level. It also can be readily accessed by people and predators (e.g. foxes) at low tide. Image Sharie Detmar**


**Figure 3. An example of a highly disturbed Osprey nest, near Elliston on western Eyre Peninsula. Situated next to a popular surfing location, the nest is in full view from a recently upgraded carpark (210 m distant) and lookout. Added to this, some surfers use the headland as an access/ egress point to the surf-break just offshore. This territory was occupied during the 2008-10 surveys but has been abandoned since. Image Sharie Detmar**

**Figure 4. The resident Osprey pair immediately adopted this up-graded nest platform built by local oyster farmers at Denial Bay in 2013. The original platform, which had been in place since 1991, had been re-built twice after collapsing under the weight of nesting material or from storm damage.** **Image Andrew Brooks**

**Figure 5. In warm-temperate to tropical climes in Australia most Osprey nest placements are in coastal or estuarine forests, often in similar settings to this interstate example. At this nest, in contrast to behaviours near typically exposed nest sites in South Australia, the parents continued feeding the young while vehicle and foot traffic on the road below were totally ignored!** **Image Terry Dennis**

Across all regions only two tree-nests were found. One of these was first located in 2013 situated in Grey Mangrove, *Avicennia marina*, forest flanking a tidal creek complex on western Eyre Peninsula (Dennis and Brooks 2014). The nest was set <3 m above average high-tide level and was subsequently destroyed during peak-tide and storm events in the spring of 2016, but rebuilt nearby and found to be active again in 2017. The other was perched on top of the dense canopy of a Swamp Paperbark, *Melaleuca halmaturorum*, ~3 m in height on a prominence overlooking a sheltered embayment.

Two nesting attempts were made on navigation markers over the survey period. One of these was in Coffin Bay on Eyre Peninsula and the other in Gulf St Vincent: both failed.

**Far West region**

In 2010 there were two occupied territories on the ~200 km long Bunda Cliffs, ~163 km apart between the Head of Bight and Wilson Bluff on the Western Australian border (Figure 1). Only one territory was occupied in recent surveys on the western end of the cliffs, with several other known nest structures to the east having deteriorated or disappeared since 2010. The coastline east of the Head of Bight through the Yalata Indigenous Protected Area to Wahgunyah Conservation Park (CP) is composed of mainly long sandy beaches backed by large dune-fields with few low rocky headlands and near-shore reefs and is devoid of Osprey breeding habitat and activity.

**Eyre Peninsula west region**

Including those on offshore islands, there were 33 occupied Osprey territories recorded in this region in 2010, whereas in recent surveys 22 were recorded, a decline of 33% (Table 1). This region also had the highest density of territories on mainland habitats in previous surveys, with 29 territories found between Wahgunyah in the west to Cape Catastrophe on southern Eyre Peninsula, whereas just 17 occupied territories were found over the same coastline in recent surveys, a decline of 41%. In addition, between Streaky Bay and Elliston there were 11 occupied territories in 2010 and just 4 were found occupied in recent surveys, a decline of 64%.

**Eyre Peninsula east region**

Despite apparently suitable habitat, there is an inexplicable dearth of Osprey breeding territories throughout Spencer Gulf. Previous surveys reported only five occupied territories in this region (as defined in Table 1 and Figure 1), with all but one of those found on offshore islands. Recent surveys identified eight territories with two of these as mainland territories, one being on a near-shore artificial platform and the other, a new territory in a remote area of Lincoln National Park, found by sea-based survey in 2015. In addition, an apparent Osprey pair was recorded in the vast mangrove and tidal creek complex in Franklin Harbor during 2016 surveys, but a nest could not be found to confirm what may yet prove to be a previously unrecorded territory.

**Yorke Peninsula and Mid North region**

Only four occupied territories were recorded in this central coastal region of the state in both the previous and recent series of surveys (Table 1). Three were on islands and the other, a nesting attempt on a near-shore navigation marker in Gulf St Vincent in 2017. The latter is significant as there are no known contemporary or historical Osprey breeding records for Gulf St Vincent. Two highly disturbed mainland nest sites on southern Yorke Peninsula (including one in Innes National Park) have been abandoned since 2010, resulting in the entire mainland coastline of Yorke Peninsula being now devoid of occupied Osprey territories.

**Kangaroo Island region**

A total of 14 occupied Osprey territories were found on Kangaroo Island during surveys in 2008-10; however a series of thorough boat-based and land surveys in 2015 and 2016 found only 8, a decline of ~43% over the intervening period (Table 1).

**Osprey foraging habitats**
Single Ospreys, including sub-adults, were recorded in several areas distant from known breeding territories that are likely important foraging locations. These included: remote coastal areas in the far west of the state; Baird Bay and Franklin Harbour on Eyre Peninsula; upper Spencer Gulf; near Port Broughton and Port Victoria; and Gulf St Vincent, including the eastern coastline of Yorke Peninsula and the Torrens Island–Barker Inlet complex. Single Osprey sightings are also occasionally reported in the Port River channel and over Adelaide metropolitan beaches and further south in the Onkaparinga and Myponga River estuaries.

**Other coastal regions, inland rivers and lakes**
No evidence was found during recent surveys to indicate that Ospreys breed in other coastal regions (e.g. the Fleurieu Peninsula or the South East region), or on inland rivers and lakes in South Australia. Along the River Murray, there were reports during the survey period of single vagrant Ospreys and of two which lingered together through the autumn and early-winter period in 2013 near the Old Customs House on the Victorian border (F. Malor *in litt*.); and for a similar period in 2015 (G. Norman pers. comm.). These eluded detection during subsequent surveys, which included the adjacent Chowilla wetland complex in July and September 2015 and in May 2016. Further upstream on the Murray, a single Osprey was reported as being a new 'resident' at Curlwaa in the Mildura Weekly newspaper on 20 April 2016.

Other inland records during the survey period came from the far northeast of the state, where exceptional rainfall events in central and southwest Queensland had sent floodwaters down Cooper Creek into South Australia, and a single Osprey was observed over several days at Policemans Waterhole near Innamincka in late May 2016 (B. Johnson *in litt*.). At the same time, ~45 km upstream from Innamincka at Bulloo Waterhole near the Dig Tree in southwest Queensland, an Osprey was present over several weeks and was observed carrying sticks to a nest. Although the outcome of this behaviour was not followed-up, at least one Osprey was still present in early August 2016 (Colin Mate, Queensland National Park Service Ranger pers. comm.).

## DISCUSSION

**Population decline**
These survey results indicate that the Osprey breeding population in South Australia in 2017 had declined significantly (~26%) since the previous state-wide surveys were completed in 2010, when 58 occupied territories were identified (Dennis *et al*. 2011). This was similar to an earlier estimate of 52 breeding pairs compiled from surveys in 2003 and 2005 (Dennis 2004, 2007a). While the causes of this rapid recent decline are not immediately apparent, it is likely that multiple contributing factors need to be considered. These include, but are not limited to: increasing levels of anthropogenic disturbance; behaviour; and environment.

**Increasing levels of anthropogenic disturbance**
Osprey productivity is adversely affected at nest sites subject to disturbance and frequent disturbance may result in nest desertions (Levenson and Koplin 1984; Poole 1989; Dennis 2004, 2007b). Many breeding sites, even in remote mainland areas, continue to be subjected to varying levels of direct (human activities) and indirect (habitat degradation) disturbances during the breeding season (Figure 3). These factors combined adversely contribute to the incidence of nest failure, resulting in a fall in population recruitment levels, and inevitably, to a reduction in the number of breeding pairs.

**Behaviour**
Not all Osprey pairs breed every year. A long-term study of Osprey breeding biology on Kangaroo Island (Dennis 2007b) and a nest-monitoring program in northern New South Wales (Bischoff 2001) found a considerable proportion of pairs (averaging 29% and 26% respectively) were inactive (i.e. failed to produce

eggs) each year. Therefore, with surveys conducted toward the end of the breeding season, pairs in some occupied but inactive territories may be absent from the core territory precinct and have escaped detection.

This temporal bias in the survey method may draw a presumption of abandonment and thereby negatively skew survey data. This bias is largely discounted however, as the Australasian Osprey is sedentary and continues to use the nest platform throughout the year as a roost and feeding platform, even when breeding has failed (Bischoff 2001; Clancy 2006; Dennis 2007b). Also, routine thorough examination of the nest platform during ground surveys in apparently unoccupied territories, to detect evidence of recent activity (see Methods section), enabled confident determination of territory status.

**Environment**

The possibility of a perturbation in the near-shore marine environment affecting the availability or quality of prey, causing pairs to fail to reach optimal condition and therefore to forego breeding for one or more seasons cannot be easily ruled out (see Henny *et al*. 2008). Moreover, there may be a previously undetected behavioural dynamic in the southern ecotype, which in response to disturbance or cyclic extreme weather events at a critical phase, triggers an over-riding primary survival response with territorial attachment discontinued or aborted more readily than occurs elsewhere.

Each of these factors, or a combination of them, may have diminished the habitat quality for the small Osprey population in South Australia, thereby adversely affecting territory productivity, and over time, contributing to population decline.

**Population distribution and isolation**

The pattern of sparse distribution and rarity of breeding territories in South Australia continues westward through southern Western Australia, with the nearest known territory to the most westerly one in South Australia being ~700 km distant in the Recherche Archipelago near Esperance (Johnstone and Storr 1998; Dennis 2007a). To the east there is a broad gap in the species' historical breeding range, i.e. from Kangaroo Island to about 180 km south of Sydney in New South Wales at latitude 35°30'S (Clancy 2009). Ospreys are known only as rare vagrants in Victoria and Tasmania (Barrett *et al*. 2003; Dennis and Clancy 2014; DEE 2017).

**Historical distribution**

Recent surveys also confirmed the continued absence of Osprey from former breeding areas in upper Spencer Gulf and along the River Murray (Dennis 2007a; Dennis *et al.* 2011), and again draw attention to the inexplicable relative rarity of breeding activity over apparently suitable habitat in both Spencer Gulf and Gulf St. Vincent. While there is no ready explanation for their disappearance from upper Spencer Gulf, their demise as a breeding species along the River Murray appears to have coincided with the spread of feral European Carp, *Cyprinus carpio,* in the early 1970s (Scott, Glover and Southcott 1980; Dennis 2007a). Carp actively sluice through mud substrates when feeding and are thought responsible for an increase in turbidity in the waterways and swamps along the Murray (King 1995), which may have adversely affected the ability of Ospreys to locate and catch prey. The last reliable breeding record from the River Murray in South Australia was from near Nildottie in 1980 (Robinson 1980).

**Threats**

In remote coastal areas on Eyre Peninsula and in the Far West of South Australia (where many abandoned territories were found), the long-standing practice of gaining access to every beach and coastal feature by 4WD vehicles has resulted in vegetation damage and serious erosion. Many of these tracks closely follow the cliff-edge in direct line-of-sight to nests and guard roosts, inevitably causing disturbance and increasing the risk of nest failures. Human disturbance at critical times near nesting sites can be a cause of desertion, particularly at exposed and accessible nests (Palma *et al.* 2004).

In South Australia's open coastal landscapes, Osprey nest sites are particularly vulnerable to disturbance from human activity or approach, as this invariably occurs in line-of-sight at long distance from the nest or nest guard-roost location and typically above nest level. In Ospreys and other large raptor species, an elevated approach in open landscapes triggers an earlier and stronger response than would occur from below nest-level in forested terrain, invariably causing the pair to loft sooner (Olsen 1998; Romin and Muck 2002). This leaves nest contents exposed to ambient conditions for longer and also to scavengers and nest predators, such as the Pacific Gull, *Larus pacificus,* and Australian Raven, *Corvus coronoides,* in South Australia (Dennis 2007b).

Paradoxically, in some areas (e.g. Kangaroo Island) inter-species kleptoparasitism and spatial conflict with the state-listed (endangered) White-bellied Sea Eagle, *Haliaeetus leucogaster,* may cause breeding disruption and territory displacement (Dennis and Baxter 2006; Dennis 2007b).

Other threats identified in this study potentially increasing the frequency of disturbance incidents at nest sites or degrading habitat quality, included:

- the increase and expansion of recreational activity in coastal areas, such as surfing and fishing;
- poorly sited tourism developments channelling people into remote locations;
- coastal land division resulting in the spread of residential development;
- ill-timed research projects and land management activities coincident with the breeding season on Reserves and other remote areas including islands, e.g. biological surveys and marine mammal research, pest plant control and fuel reduction burn-offs;
- the rapidly increasing recreational, scientific and commercial use of drones as camera platforms etc. over-flying coastal features and islands;
- an increasing use of digital cameras with powerful zoom capabilities by irresponsible or naive enthusiasts to 'collect' bird images of even endangered species (the scale of this activity has caused both Birdlife Australia and Birds SA to update their respective Ethical Birding policies and guidelines for members, in an effort to raise awareness of potential impacts); and
- sea level rise, climate change and associated increase in extreme weather events.

Collectively, these habitat degrading processes and disturbance threats have reduced the breeding refuge quality for the Osprey population in South Australia, thereby contributing to population decline.

**Habitat protection**

South Australia has a Reserve system whereby land is proclaimed under various legislation (e.g. *National Parks and Wildlife Act 1972, Wilderness Protection Act 1992, Crown Land Management Act 2009*) for various purposes, including biodiversity conservation and to protect threatened species habitat. Within the Reserve system (eg. National Park, Conservation Park or Wilderness Protection Area) fewer Osprey territories were found abandoned (11%) than outside of Reserves where the decline has been considerably greater, i.e. from 30 territories in 2008-10 to 18 in 2015-17 (or 40%; Table 2), indicating that the Reserve system may provide a reasonable level of habitat protection.

In 2009, 19 Marine Parks were established in South Australian waters with four zones or

**Table 2. The number of occupied Osprey territories found in 2008–10 and 2015–17 surveys categorised as either located outside the (terrestrial) Reserve system (i.e. National or Conservation Park, or Wilderness Protected Area); or within Reserves. The increase or decrease (change) is calculated for each habitat category over the period between surveys.**

| | Territories outside Reserves | | Territories within Reserves | |
|---|---|---|---|---|
| **Coastal bio-region** | **(2008-10) 2015-17** | **% Change** | **(2008-10) 2015-17** | **% Change** |
| Far West | (1) 0 | -100 | (1) 1 | 0 |
| Eyre Peninsula west | (16) 9 | -44 | (17) 13 | -24 |
| Eyre Peninsula east | (4) 6 | +50 | (1) 2 | +100 |
| Yorke Peninsula and Mid North | (1) 0 | -100 | (3) 4 | +33 |
| Kangaroo Island | (8) 3 | -63 | (6) 5 | -17 |
| **Totals** | **(30) 18** | **Av. -40%** | **(28) 25** | **Av. -11%** |

levels of protection designated within them, with Restricted Access and Sanctuary zones having the highest level of species and habitat protection. The decline of occupied Osprey territories recorded in Marine Parks over the period between surveys was found to be 24%, i.e. from 46 territories in 2008-10 to 35 in 2015-17 (Table 3), which is similar to the overall state-wide decline of 26% (Table 1). Significantly, the number of territories located within the Sanctuary and Restricted Access Zones (*n* = 9) remained stable over the period, affirming the importance of the higher level of habitat protection provided by these zones in species conservation.

**Threat abatement and recovery**

To address the recent rapid population decline, a Species Management Plan or Recovery Plan is required for the Osprey in South Australia. This should define species and habitat protection and conservation strategies, including:

- specific habitat management prescriptions for remaining breeding and foraging habitats, which include breeding refuge protection zones of 1000 m radius (*vide* Dennis 2015; Coast Protection Board 2016) around nest sites;

- systematic population and productivity monitoring programs in key areas;

**Table 3: The number of occupied Osprey territories found in 2008–10 and 2015–17 surveys categorised as either located within or immediately adjacent to a Marine Protected Area (MPA) and those within Sanctuary or Restricted Access Zones within the MPA. The increase or decrease (change) is calculated for each habitat category over the period between surveys.**

| | Territories within or adjacent to Marine Protected Areas (MPA) | | Territories within MPA Sanctuary or Restricted Access Zones | |
|---|---|---|---|---|
| **Coastal Bio-region** | **(2008-10) 2015-17** | **% Change** | **(2008-10) 2015-17** | **% Change** |
| Far West | (2) 1 | -50 | (2) 1 | -50 |
| Eyre Peninsula west | (28) 19 | -32 | (3) 4 | +33 |
| Eyre Peninsula east | (2) 5 | +150 | (0) 0 | 0 |
| Yorke Peninsula and Mid North | (4) 4 | 0 | (1) 1 | 0 |
| Kangaroo Island | (10) 6 | -40 | (3) 3 | 0 |
| **Totals** | **(46) 35** | **Av. -24%** | **(9) 9** | **Av. 0%** |

- pursuit of sponsorship sources (e.g. corporate or industry) to fund further research and for the strategic placement of appropriately designed artificial nest platforms in key areas;

- identification and protection of key foraging locations;

- the development of community awareness and recovery participation programs;

- guidelines for land-owner and land-management agencies to avoid disturbance during sensitive phases of the breeding cycle; and

- prioritise future research directions for the recovery of the South Australian Osprey population.

In addition, formal recognition is required at all levels of Government to ensure that land-use planning, development assessment processes and land management decisions in coastal areas include consideration of impacts to threatened species habitat. In the case of Osprey habitat, this requires formal adoption of the breeding refuge protection zone concept around known primary nest sites (Richardson and Miller 1997; Romin and Muck 2002; Dennis 2015), including for those found abandoned with re-occupation potential. Without this level of habitat protection it is likely that the negative outcomes from disturbance and disruption during breeding will continue to contribute to territory abandonment and further population decline.

## CONCLUSIONS

The comparative survey data presented indicate a recent, irrefutable population decline in the Osprey population in South Australia. When considered together with the evidence of an earlier reduction in range (Dennis 2007a; Dennis *et al.* 2011), these data confirm that significant broad-scale declines have occurred over time, with an apparent radical decline over the period 2010 to 2017.

Because the Australasian sub-species of Osprey may be subsisting somewhat tenuously on the edge of its preferred continental range in South Australia, it may be doubly susceptible to adverse exogenous threats and/or shifts in bioclimatic dynamics. Further research and more frequent site monitoring data are needed to determine whether these declines are an outcome of habitat degradation and/or disturbance, or other, as yet undetected, phenomena.

Regardless of cause, to mitigate further decline in the South Australian Osprey population, decisive and immediate action is required to protect and manage remaining breeding habitat to ensure maximal population recruitment occurs.

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## REFERENCES

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. 2003. *The New Atlas of Australian Birds.* Birds Australia, Melbourne.

Bischoff, T. 2001. Aspects of breeding of the Osprey *Pandion haliaetus* on the mid-north coast of New South Wales. *Australian Bird Watcher* 19: 88-93.

Blaylock, B., Black, A., Carpenter, G. and Horton, P. 2017. *A Field List of the Birds of South Australia*. Fifth edition. The South Australian Ornithological Association Inc., Adelaide.

Clancy, G. P. 2006. The breeding biology of the Osprey *Pandion haliaetus* on the north coast of New South Wales. *Corella* 30: 1-8.

Clancy, G. P. 2009. Return of the Osprey. *Wingspan* 19: 22-23.

Coast Protection Board 2004. *Coast Protection Board Policy Document* (revised 29 July 2016). Coast Protection Board, Adelaide, South Australia.

Coates, B. J. and Bishop, K. D. 1997. *A guide to the birds of Wallacea: Sulawesi, the Moluccas and Lesser Sunda Islands, Indonesia*. Dove Publications, Alderley, Queensland.

Dennis, T. 2015. *Conservation strategies for White-bellied Sea Eagle and Osprey habitat in South Australia's open coastal landscapes*. Unpublished discussion paper prepared for a DEWNR 'threatened coastal raptor habitat management' forum on Kangaroo Island in November 2015.

Dennis, T. E. and Clancy, G. P. 2014. The status of the Osprey (*Pandion haliaetus cristatus*) in Australia. *Journal of Raptor Research* 48: 408-414.

Dennis, T. E. and Brooks A. V. 2014. A recent record of Osprey nesting in mangroves in South Australia. *South Australian Ornithologist* 40: 31-33.

Dennis, T. E., Detmar, S. A., Brooks, A. V. and Dennis, H. M. 2011. Distribution and status of White-bellied Sea Eagle, *Haliaeetus leucogaster,* and Eastern Osprey, *Pandion cristatus,* populations in South Australia. *South Australian Ornithologist* 37: 1–16; plus erratum and corrigenda *South Australian Ornithologist* 38: 40.

Dennis, T. E. 2007a. Distribution and status of the Osprey *Pandion haliaetus* in South Australia. *Emu – Austral Ornithology* 107: 294-299.

Dennis T. E. 2007b. Reproductive activity in the Osprey *Pandion haliaetus* population on Kangaroo Island, South Australia. *Emu – Austral Ornithology* 107: 300-307.

Dennis, T. E. and Baxter, C. I. 2006. The status of the White-bellied Sea Eagle and Osprey on Kangaroo Island in 2005. *South Australian Ornithologist* 35: 47-51.

Dennis, T. E. 2004. Conservation status of the White-bellied Sea-Eagle, Osprey and Peregrine

Falcon on western Eyre Peninsula and adjacent offshore islands in South Australia. *South Australian Ornithologist* 34: 222-228.

Department of the Environment and Energy (DEE) 2017. *Pandion cristatus* – Eastern Osprey. In *Species Profile and Threats (SPRAT) Database*, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/sprat (accessed 10th Jan 2018).

Grove, R. A., Henny, C. J. and Kaiser, J. L. 2009. Osprey: worldwide sentinel species for assessing and monitoring environmental contamination in rivers, lakes, reservoirs and estuaries. *Journal of Toxicology and Environmental Health, Part B* 12: 25-44.

Henny, C. J., Anderson, D. W., Vera, A. and Cartron, J-L. E. 2008. Region-wide trends of nesting Ospreys in north-western Mexico: a three-decade perspective. *Journal of Raptor Research* 42: 229-242.

Horton, P., Blaylock, B. and Black, A. 2013. In *Census of South Australian Vertebrates, Section 3: Birds Taxonomy.* Department of Environment, Water and Natural Resources, Adelaide.

Johnstone, R. E. and Storr, G. M. 1998. *Handbook of Western Australian Birds. Volume 1: Non-passerines (Emu to Dollarbird).* Western Australian Museum, Perth, Western Australia.

King, A. 1995. *The effects of carp on aquatic ecosystems: a literature review.* Unpublished report, Environment Protection Authority – Murray Region, New South Wales.

Levenson, H., and Koplin, J. R. 1984. Effects of human activity on productivity of nesting Osprey. *Journal of Wildlife Management* 48: 1374–1377.

Marchant, S. and Higgins, P. J. (eds) 1993. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2, Raptors to lapwings.* Oxford University Press, Melbourne.

Monti, F., Duriez, O., Amal, V., Dominici, J-M., Sforzi, A., Fusani, L., Gremillet. D. and Montgelard, C. 2015. Being cosmopolitan: evolutionary history and phylogeography of a specialized raptor, the Osprey *Pandion haliaetus*. *Evolutionary Biology* 15: 255–270.

Newton, I. 1979. *Population Ecology of Raptors.* Poyser, Berkhamsted, U.K.

Palma, L., Ferreira, J., Cangarato, R. and Vaz Pinto, P. 2004. Current status of the Osprey in the Cape Verde Islands. *Journal of Raptor Research* 38: 141-147.

Olsen, P. (1998). Australia's raptors: diurnal birds of prey and owls. *Birdlife Australia Conservation Statement No. 2*. Supplement to *Wingspan* 8(3).

Poole, A.F. 1989. *Ospreys: a natural and unnatural history*. Cambridge University Press, Cambridge, U.K..

Poole, A.F. 1994. Family Pandionidae (Osprey). Pages 42—51 in J. del Hoyo, A. Elliot, and J. Sargatal (eds.). *Handbook of the birds of the world. Volume 2, New World vultures to guineafowl.* Lynx Edicions, Barcelona, Spain.

Poole, A. F. 2009. Osprey (*Pandion haliaetus*), *Neotropical Birds Online* (T.S. Schulenberg, ed.). Cornell Lab. of Ornithology, Ithaca. Available online at: (http://neotropical.birds.cornell.edu/portal/species/lifehistory?p_p_spp=119196)

Prevost, Y.A. 1983. Osprey distribution and subspecies taxonomy. Pages 157—174 in D.M. Bird (ed.), *Biology and management of Bald Eagles and Ospreys*. Harpell Press, Ste Anne de Bellevue, Quebec, Canada.

Richardson, C. T. and Miller, C. K. 1997. Recommendations for protecting raptors from human disturbance: a review. *Wildlife Society Bulletin* 25: 634-638.

Robinson, J. 1980. *South Australian Ornithological Association Newsletter* No. 96: 9.

Robinson, A. C., Canty, P. D., Mooney, P. A. and Rudduck, P. M. 1996. *South Australia's Offshore Islands*. Australian Heritage Commission. AGPS, Melbourne.

Romin, L. A., and Muck, J. A. 2002. *Guidelines for raptor protection from human and land use disturbances*. U.S. Fish and Wildlife Service, Utah Field Office: Salt Lake City, Utah.

Scott, T. D., Glover, C. J. M. and Southcott, R. V. 1980. *The Marine and Freshwater Fishes of South Australia.* Second edition. Government Printer, South Australia.

Siverio, M. and Rodriguez, B. 2005. Population status, reproduction and conservation of Osprey *Pandion haliaetus* in La Gomera and El Hierro, Canary Islands (2003–2004). *Airo* 15: 85-90.

Thibault, J-C., Bretagnolle, V. and Domonici, J-M. 1995. Recovery of a resident population of Osprey on Corsica. *Journal of Raptor Research* 29: 204-207.

**Sharie A. Detmar**
**Flagstaff Hill, South Australia**
**sharie_detmar@hotmail.com**

**Terry E. Dennis**
**Barossa Valley, South Australia**

# A review of White-bellied Sea Eagle distribution and population stability over time in South Australia

**T. E. DENNIS AND S. A. DETMAR**

***Abstract***

*Systematic surveys over three breeding seasons commencing in May 2015 confirmed a total of 73 occupied White-bellied Sea Eagle territories across all coastal, offshore island and inland river habitats in South Australia. This outcome is consistent with surveys in 2008–10 when 72 territories were found. However, when the number of occupied territories based in mainland habitats (*n *= 14) is compared with survey data from 2010, a decline of 7% has occurred over the intervening period. When compared with survey results from the mid-1990s, a significantly greater level of decline of 22% is revealed to have occurred on the South Australian mainland in recent decades.*

*Island-based territories now comprise 81% (*n *= 59 of 73) of the overall breeding population with the majority of these found off western Eyre Peninsula (*n *= 26; i.e. 36% of the remaining population) and on Kangaroo Island (*n *= 19; i.e. 26% of the remaining population). While this study has again highlighted the significance of island habitats for the long-term conservation of the remnant White-bellied Sea Eagle population in South Australia, it has also confirmed the species' long-term population decline and continuing absence from parts of its historical breeding range, particularly in upper Spencer Gulf, the South East region, and on the River Murray floodplain.*

*Studies of White-bellied Sea Eagle productivity outcomes on Kangaroo Island and in northern New South Wales confirmed anthropogenic causal linkages to low fecundity levels, high rates of nest failure, and disturbance-related displacement of pairs to sub-optimal habitats. We contend that these factors are implicated in the number of abandoned mainland territories found in this and earlier studies in South Australia's open coastal landscapes.*

*From the evidence available indicating the species' former distribution, we estimated the scale and distribution of the 19th century sea eagle population, which suggests a probable historical decrease of around 41% in the overall number of occupied territories across all habitats in South Australia and a startling 73% decline on the mainland.*

*To arrest further decline, we contend that strategic species and habitat conservation measures are required, that include seasonally applied breeding refuge protection zones, to ensure maximum reproductive outcomes are achieved among the remaining White-bellied Sea Eagle population in South Australia.*

## INTRODUCTION

Many populations of large eagle species around the world are in decline (Newton 1991), including the White-bellied Sea Eagle, *Haliaeetus leucogaster,* in Australia (Shephard *et al.* 2005b; Debus 2017). Studies in the eastern states have provided evidence of declines being linked to habitat disturbance from landscape-scale habitat modification and increasing levels of human activity in coastal and inland river environments. Disturbance at critical phases of the breeding cycle is known to result in nest failures and displacement of pairs to sub-optimal habitats (Bilney and Emison 1983; Clunie 2004; Thurstans 2009; Debus *et al.* 2014).

In South Australia, surveys completed in 1994 and 2003 confirmed a small and somewhat isolated White-bellied Sea Eagle breeding population with evidence of substantial declines having occurred in mainland coastal areas and on the River Murray floodplain (Dennis and Lashmar 1996; Dennis 2004). In recognition of this trend the White-bellied Sea Eagle was formally re-scheduled as an Endangered species in South Australia in 2008 (*National Parks and Wildlife Act 1972*).

Comprehensive state-wide surveys, completed in 2010, further confirmed the species' diminished status over former mainland coastal and inland river habitats. These surveys also found the majority (79%) of the remaining breeding population was confined to offshore islands, including Kangaroo Island (Dennis *et al.* 2011a).

A long-term study of White-bellied Sea Eagle productivity from territories in varied habitats on Kangaroo Island identified a negative relationship between human activities and nest productivity outcomes. Analysis of data from eleven breeding seasons revealed that territories in modified landscapes and in close proximity to human activities were significantly less productive than those in more isolated locations. That is, disturbed territories became active (produced eggs) less often, fledged fewer young and experienced higher rates of nest failure than those in more remote locations (Dennis, McIntosh and Shaughnessy 2011b). A comparable study in northern New South Wales reported similar adverse outcomes, i.e. nest failures and abandonment (Debus *et al.* 2014). When these findings are considered together, serious concerns arise for long-term White-bellied Sea Eagle conservation in South Australia.

In recognition of the evidence for a much diminished White-bellied Sea Eagle population and that the anthropogenic causal linkages identified with these declines were apparently continuing unabated, we revisited the recommendations made following previous surveys, which included population vigilance through regular monitoring (Dennis *et al.* 2011a). As a result, we commenced planning for another series of state-wide surveys in early 2015, using the regional population model from previous surveys as a baseline to measure current population stability or trend. Consequently, in May 2015 a multi-year re-survey project was commenced with two primary aims:

- to comprehensively re-assess the status and distribution of the White-bellied Sea Eagle population in each coastal region of South Australia, including offshore island and inland river habitats; and

- to identify habitat threats or threatening processes likely to further adversely impact remaining breeding refuge habitat quality.

## METHODS

Raptor population studies entail an assessment of the number of territorial or breeding pairs found in an area of suitable habitat over multiple years, and habitat elements essential for breeding to occur including the availability of both prey resources and potential nesting sites (Newton 1979, 1991). These precepts underscored the scope and ethos of earlier White-bellied Sea Eagle population assessment surveys (Dennis and Lashmar 1996; Dennis 2004), the comprehensive coastal raptor population surveys of 2008–10 (Dennis *et al.* 2011a) and the population re-assessment project reported here.

Typical of large eagle species, the White-bellied Sea Eagle is known to form long-term pair bonds and to use selected nesting locations over long time periods, with favoured nest sites used by successive generations (Wiersma and Richardson 2009; Dennis, Fitzpatrick and Brittain 2012; Debus *et al.* 2014). Therefore, in this project relative territorial stability was assumed, enabling targeted surveys in previously determined territory locations and prospecting efforts to be concentrated in areas near vacant territories or where abandoned nest sites were known to occur.

**Survey scope and planning**
Strategic surveys were conducted over three breeding seasons between May 2015 and January 2018 in coastal and inland areas with known and potential sea eagle breeding habitat, i.e. between the Bunda Cliffs in the Great Australian Bight and Rivoli Bay in the South East region, islands off Yorke and Eyre Peninsula, and the Riverland region of South Australia.

**Permits and project approvals**
Annual Scientific Permits No(s) M26377 1-3, Marine Park Permit No(s) MR00048 1-3, and Wildlife Ethics Committee Approvals No(s) 4/2015 and 16/2017 were obtained from the South Australian Department for Environment and Water (DEW) and the associated Permit Conditions were followed throughout.

**Minimising disturbance**
All large eagle species, and *Haliaeetus* spp. in particular, are recognised as acutely sensitive to disturbance during critical phases of the breeding season, when there is an elevated risk of nest desertion and site abandonment (Clunie 2004; Threatened Species Section 2006; US Fish and Wildlife Service 2007; Dennis, McIntosh and Shaughnessy 2011b; Debus *et al.* 2014). Therefore, the long-established disturbance avoidance protocols (based on temporal and spatial approach constraints) applied in earlier coastal raptor survey and research projects were again observed (see Dennis *et al.* 2011a).

**Ground surveys**
Some breeding habitats on the mainland required cautious ground survey where vehicle access to survey sites was not possible or ethical. These were conducted by extended foot traverse on remote coastlines, e.g. the coastline between Tyringa and Venus Bay on western Eyre Peninsula, with safety back-up transportation logistics and communication arrangements routinely implemented.

To avoid sensitive phases of the breeding season cycle, ground surveys were mostly confined to late-September and October, when pairs in active territories were well settled into established patterns of nest provisioning foraging forays and nest protection. Depending on terrain limitations, observations were made at distances of 700 – 1000 m from nest sites using tripod mounted high-resolution binoculars and/or spotting scope. Because of familiarity with terrain features from previous surveys, some territories could be surveyed at lesser distance without causing disturbance, e.g. from an approach and concealment within vegetation cover, or by the use of full camouflage (Ghillie suit) clothing.

In territories where eagles were not seen at the nest or nearby in the core territory, the nest was closely examined for evidence of recent activity and images were taken of the nest platform for subsequent forensic scrutiny. Known alternative nest sites were similarly checked and where necessary, further prospecting searches were carried out to determine if a new site had been established. Some near-shore islands could be visually surveyed using a spotting-scope from the nearest mainland vantage point.

In accord with Scientific Permit conditions, access to Reserves (e.g. National Parks, Conservation Parks and Wilderness Protection Areas) required prior advice to regional DEW staff, and local knowledge was used to ensure access permission was obtained to private property when required.

**Vessel-based surveys**
Appropriately timed sea-based surveys were used wherever possible, being by far the most time efficient and least intrusive survey method for sea eagle breeding habitats. These are most effective during the otherwise sensitive breeding season onset phase in May and June, when pairs spend long periods at the nest engrossed in courtship bonding behaviours and nest repair activity, regardless of whether egg-laying follows.

Because sea eagle nest placements (in South Australia) are typically adjacent to and overlooking the sea (or wetland), pairs are at least partly pre-conditioned to the presence and movement of boats. Although the level of habituation varies between pairs and the remoteness of the location, most sea eagles, while remaining watchful, largely ignore an approaching or slowly passing vessel at distances >200 m.

A canoe or motorised dinghy was used for prospecting surveys in some tidal creeks in mangrove forest areas, and for lagoons and subsidiary creeks in the upper-Murray Bookmark-Chowilla floodplain complex.

**Data processing and storage**
A standardised survey datasheet was developed and used for each survey site throughout the project. All location data and observation notes were subsequently transcribed from these to an electronic spreadsheet. Images of surrounding terrain characteristics, and of the nest structure in particular, were routinely obtained at all sites and subsequently collated and archived in site-specific electronic files and cross-referenced in the project database.

**Threats**
Actual and potential threats at occupied and abandoned territories with potential for re-occupation were recorded on the survey datasheet. Likely threats to breeding refuge (core territory) quality included: the level of disturbance from recreational pursuits occurring within, or near, the core territory; landscape-scale habitat degradation, such as vegetation clearance or damage from fire or overgrazing; change of land-use, e.g. from open range grazing to land division; proximity to dwellings and other buildings, tourism developments, roads, tracks or walking trails; known recreational, scientific or commercial use of drones over the core territory; and proximity to land-based or marine industry activity likely to cause disturbance or affect the availability of prey.

Horizontal distances between nest sites and physical features associated with disturbance in the landscape were measured using mapping programs including ArcMap, NatureMaps and Google Earth.

**Community contact and participation**
With a view to develop greater community awareness concerning threatened coastal raptor conservation in South Australia, considerable effort was made to liaise with and involve regional National Park and Natural Resource Management staff and, through them, their respective community networks. In addition, to update local knowledge, contact was routinely made with key community members in coastal regions, including: Birds SA members; others involved with the volunteer network established during 2008–10 surveys; the executive and members of the Abalone Industry Association of South Australia; and coastal land owners where access permission was required.

**Historical decline**
Based on evidence derived from early South Australian Museum oology and avian skin collection records, historical and more recent literature accounts, and long-abandoned nest location data from earlier surveys, previous studies concluded that substantial declines had occurred over much of the sea eagle's former range in South Australia (Dennis and Lashmar 1996; Dennis *et al*. 2011a). Here we review those findings and provide a subjective re-assessment of the probable scale and distribution of the 19th

century White-bellied Sea Eagle population. We then calculate the likely level of regional and overall decline by comparison with recent survey data. In this process, we have endeavoured to model the former population by:

- deduction from the number and location of the many long-abandoned nest structure remnants identified in recent surveys in areas where sea eagles are no longer breeding; and
- the addition of a number of locations where we contend there would have been a high probability of more than one territory in the 19th century.

In determining the latter, we have based our reasoning on:

- the apparent availability of the fundamental habitat elements required to support breeding, i.e. adequate prey resources and the availability of suitable nesting habitat (*vide* Newton 1991); and
- contemporary examples of territory 'clusters' linked to these habitat elements identified in recent surveys; e.g. on St Peter Island (3439 ha) 4 territories had primary nest sites spaced an average of 2.4 km apart; and on the north coast of Kangaroo Island, where 10 territories occur, primary nest sites averaged 9 km apart (4 of these were 4.5 km apart).

**Terminology**
Key terms used throughout are defined as follows:

*Occupied territory:* where an adult pair is observed together during the breeding season in the vicinity of the nest(s) with nest repair or territory defence behaviours observed.

*Active nest or territory:* where incubation behaviour is observed, or where young are recorded.

*Successful nest or territory*: where young are fledged.

*Failed nest or territory:* where eggs fail to hatch, or where eggs or young are lost.

*Abandoned territory*: one found unoccupied over two or more consecutive seasons and where nest structures have fallen into disrepair.

*Vacant territory*: where no birds were seen nearby for one season and the nest structure was intact but no evidence of recent repair or occupation was apparent.

*Primary nest*: the most frequently used nest within a territory.

*Alternative nest*: one of sometimes several nest structures within a territory.

*Core territory:* the defended area around a primary nest site.

*Guard-roosts:* strategic nest defence vantage points within the core territory.

## RESULTS

**Population demographics and trend**
All known and potential White-bellied Sea Eagle breeding habitats on the River Murray floodplain and across the coastal regions of South Australia, including offshore islands, were systematically surveyed over three breeding seasons between May 2015 and January 2018. A total of 73 occupied territories were identified (located mainly in the west of the state and on Kangaroo Island), which is similar to the survey results from 2008–10 when 72 occupied territories were found (Table 1 and Figure 1).

Although the geographic spread of territories appears relatively constant, there has been a further decline of 7% in the number of coastal mainland-based territories since 2010. Just 14 occupied territories (or 19%) remain sparsely

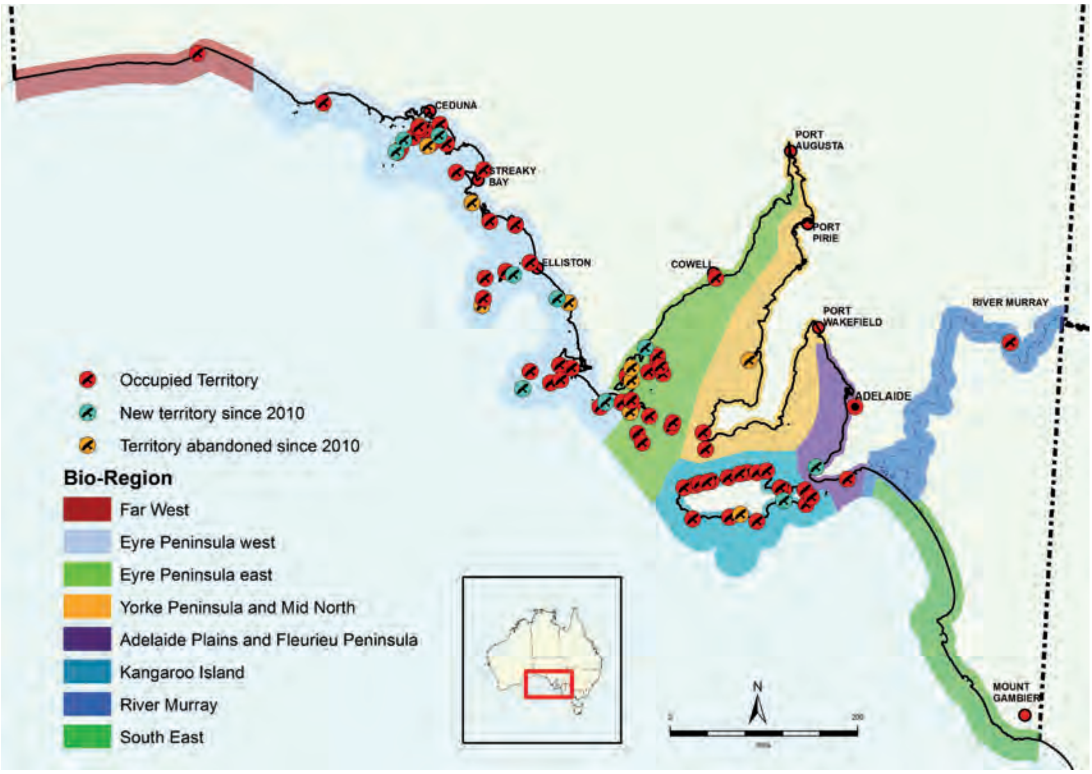


**Figure 1. Map of the South Australian coast showing the current distribution of White-bellied Sea Eagle territories, including new territories since 2010 and territories that have been abandoned since 2010.**

distributed over the ~5500 km of coastline in South Australia, with a single remaining territory on the River Murray floodplain. When these data are compared with the mainland breeding population ($n$ = 18) reported in the mid-1990s (Dennis and Lashmar 1996), the level of decline in mainland coastal and inland river habitat over the intervening period of ~25 years is significantly greater, at 22%.

Since the last surveys were completed in 2010 three* mainland territories on Eyre Peninsula have been abandoned (*two shown in Table 1, as one new mainland territory was found in Eyre Peninsula west). Two of these were in National Park Reserves with high levels of exposure to recreational disturbance. The third was in a remote location bounded by grazing land where the nest was found occupied by Wedge-tailed Eagles, *Aquila audax*.

Island-based sea eagle territories now comprise 81% ($n$ = 59 of 73) of the overall breeding population, with the majority of these off the western coastline of Eyre Peninsula ($n$ = 26); and on Kangaroo Island ($n$ = 19) with 36% and 26% respectively, of the current population; with island territories found similarly distributed as in previous surveys (Table 1 and Figure 1).

**Nest sites**

Consistent with previous surveys, most nest placements in coastal areas were either on cliff-face ledges (Figure 2), in shallow cave overhangs, or on rock outcrops on steeply sloping terrain. Five nests were in low (<6 m) coastal trees: one of these was in a tidally flooded Grey Mangrove, *Avicennia marina,* forest in Spencer Gulf. On offshore islands some nests were at or near ground level on the rocky plateau-edge, or on top of low vegetation (Figure 3). One abandoned Osprey, *Pandion haliaetus cristatus,* nest site (in use from early 1970s to

**Table 1. The number of occupied White-bellied Sea Eagle territories identified for each coastal bio-region* in South Australia (see map in Figure 1), from surveys over three breeding seasons (2015–17) compared with data from earlier (2008–10) surveys (Dennis *et al.* 2011a).**

| Coastal bio-region | General locality and no. of occupied terr. identified in 2015-17 (2008-10) | No. of terr. 2008-10 | No. of terr. 2015-17 | Trend |
|---|---|---|---|---|
| Far West (Wilson Bluff to Wahgunyah CP**) | Bunda Cliffs 1 (1); Head of Bight to Wahgunyah CP 0 (0) | 1 | 1 | 0.0% |
| Eyre Peninsula west (western boundary Wahgunyah CP to Cape Catastrophe) | Mainland 7 (8); Nuyts Archipelago 12 (10); Investigator Group 5 (4); Whidbey Group 4 (4); other islands 5 (4) | 30 | 33 | +10.0% |
| Eyre Peninsula east (Cape Catastrophe to Two Hummocks Point in upper Spencer Gulf) | Mainland 3 (4); Thorny Passage islands 1 (2); Sir Joseph Banks Group 5 (5); Gambier Group 2 (2); other islands 4 (4) | 17 | 15 | -11.8% |
| Yorke Peninsula and Mid North | Mainland 0 (0); islands 2 (3) | 3 | 2 | -33.3% |
| Adelaide Plains and Fleurieu Peninsula | Fleurieu Peninsula 2 (1) | 1 | 2 | +50.0% |
| Kangaroo Island | Kangaroo Island 19 (19) | 19 | 19 | 0.0% |
| Murray Basin | Murray River floodplain and wetlands 1 (1) | 1 | 1 | 0.0% |
| South East | Historical and vagrant records only | – | – | – |
| Cooper Basin | Historical and vagrant records only | – | – | – |
| | **Total** | **72** | **73** | **1.4% increase** |

* broadly based on Natural Resource Management Board regions and Birds SA regional boundaries (*vide* Blaylock *et al.* 2017).
** CP = Conservation Park

2010) was found occupied by sea eagles on Kangaroo Island in 2017.

**Vessel-based surveys**

Around 20 sea-based surveys were undertaken: they included the use of commercial charter vessels to survey some remote offshore island groups. However, several surveys were made possible through the generosity of project volunteers, support from regional State Emergency Service crews (adjunct to sea-rescue training exercises), and from DEW resources. These surveys covered much of the State's otherwise inaccessible coastline and islands, including: from Streaky Bay to Venus Bay; from Coffin Bay around the entire Coffin Bay Peninsula; southern Eyre Peninsula from Port Lincoln to around the Jessieu Peninsula; southern Yorke Peninsula from Cape Spencer to Point Margaret; and the entire Fleurieu Peninsula from Wirrina to West Island. Offshore islands (except those considered too small and isolated to support a sea eagle territory), included: the Nuyts Archipelago, the Gambier, Sir Joseph Banks, Whidbey and Investigator island Groups; Neptune and Thorny Passage islands; and the entire northern, eastern and most of the southern coastline of Kangaroo Island.

## DISCUSSION

The White-bellied Sea Eagle population in

**Figure 2. A typical White-bellied Sea Eagle nest site on Eyre Peninsula in South Australia's open coastal landscapes and vulnerable to disturbance.** **Image Sharie Detmar**

**Figure 3. Sea eagles are attracted to islands with abundant prey (such as Cape Barren Geese and shearwater colonies) and no terrestrial predators. In the absence of cliffs or vegetation other than low chenopod shrubland, they will adapt and place nest sites in whatever terrain features are available.** **Image Sharie Detmar**

Australia has been estimated at >5000 pairs (Debus 2017). The majority of these are located in warm-temperate and tropical coastal regions in the north of the continent where there are substantial rivers and broad freshwater or estuarine wetland habitats, often with tall forests adjacent providing nesting sites (Corbett and Hertog 2011; O'Donnell and Debus 2012; DEE 2018). These archetypal habitats are almost completely absent in South Australia, where a remnant population of 70 – 80 pairs is found sparsely distributed in semi-arid open coastal landscapes with mainly low sclerophyllous and chenopod shrubland vegetation cover, or in similar habitats on islands, and with only a single remaining territory on an inland waterway (Dennis *et al.* 2011a).

Across their range in Australia, sea eagle prey consists mainly of fish, reptiles and a variety of birds (Olsen, Fuentes and Rose 2006; Debus 2008; Corbett and Hertog 2011). Their current distribution in South Australia is linked to the availability of these prey on offshore islands, where pelagic and coastal seabird rookeries occur, as well as flocks of Cape Barren Geese, *Cereopsis novaehollandiae* (see Robinson *et al.* 1996).

While this study has again highlighted the significance of island habitats to the long-term conservation of the White-bellied Sea Eagle in South Australia, it has also confirmed the species' continuing inexplicable absence from parts of its historical breeding range, i.e. in upper Spencer Gulf, the South East region and on the River Murray floodplain in particular (Dennis and Lashmar 1996; Dennis *et al.* 2011a). This evidence of decline is discussed further in the following regional summaries and re-examined in an expanded context in Table 2.

**Far West region**

Despite the remoteness of this region only one occupied sea eagle territory was again confirmed over the ~300 km of coastline between the Western Australian border and the western boundary of Wahgunyah Conservation Park (CP). However, abandoned nest structures attributed to this species were found at the Head of Bight and further west on the Bunda Cliffs in 1994 (see Dennis and Lashmar 1996).

**Eyre Peninsula west region**

A total of 33 occupied territories were identified in this region. Seven of these were sparsely distributed in mainland habitats (over ~1000 km of coastline) between the western boundary of Wahgunyah CP and Cape Catastrophe in Lincoln National Park on the southern tip of Eyre Peninsula, whereas 26 territories were found on islands (Table 1 and Figure 1).

Twelve territories were in the Nuyts Archipelago, with four of these concentrated on St Peter Island (3439 ha), the largest island in the group, where attended nests in 2015 and 2016 had a mean separation of just 2.4 km. Goat Island (303 ha) lies just 2 km distant, providing an extended foraging range for these territories, as a large Short-tailed Shearwater, *Ardenna tenuirostris,* breeding colony (estimated at 94 000 birds by Robinson *et al.* 1996) occurs there, and is active each year coincident with the sea eagle breeding season.

Two mainland territories in this region which were occupied in 2010, were found to have become abandoned over the period between surveys. One of these was in Cape Blanche CP, where ironically, both the primary and alternative nest sites appear to have experienced increased disturbance from uncontrolled recreational access following the land tenure change from private farmland to Conservation Park in 2012. The other on the Kiana Cliffs was found occupied by Wedge-tailed Eagles in 2016. However, overall these were counteracted by five new or re-occupied former territories, only one of which was on the mainland. In three territories, primary nest sites were re-located within the core territory since 2010, one of these being on the mainland.

**Eyre Peninsula east region**
Fifteen occupied sea eagle territories were found in this region between Cape Catastrophe and Two Hummocks Point in upper Spencer Gulf (Table 1 and Figure 1). Only three of these were situated in mainland habitats (over ~650 km of coastline), two of which had primary nest sites in trees <6 m in height. One was in a mature mallee (*Eucalyptus* sp.) in a remote section of the Memory Cove Wilderness Protection Area, where, despite its remoteness, this nest narrowly escaped a fuel reduction burn in the Autumn of 2016 (Figure 4). The other was in the extensive mangrove and tidal creek complex in Franklin Harbor, near where first reported in 1967 (*South Australian Ornithologist* 26: 32). The remainder were spread among the region's many islands, from the remote Neptune Islands in the south to the Sir Joseph Banks Group in Spencer Gulf where there were five occupied territories, the same number as were found in 2010.

Three territories were found abandoned in this region over the period between surveys: one was on Cape Donington in Lincoln National Park, where a walking trail had been established <150 m distant; one was on Rabbit Island and the third was on Williams Island. (From behavioural observations in 2016 the latter now appears to be part of the Cape Catastrophe territory). In four territories, primary nest sites were found re-located within the core territory since 2010. Two of these were on the mainland, both in the Memory Cove Wilderness Protection Area. One had moved to a more remote existing alternative site (possibly due to disturbance from bushwalkers, i.e. campground <2 km distant), the other was re-built nearby after the original tree nest had collapsed.

**Yorke Peninsula and Mid North region**
Whereas there were three occupied territories in this region in 2010, only two were confirmed in 2017, both in island habitats. The former territory on Wardang Island was found occupied by Wedge-tailed Eagles in the period between surveys (K. Treloar pers. comm.). As was the case during the 2008–10 surveys, there were periodic sightings of single adult sea eagles in the region but no territories were found in upper Spencer Gulf, on the mainland of Yorke Peninsula, or in upper-Gulf St Vincent. This disappointing absence is despite historical breeding records from mangrove forest areas in northern Spencer Gulf (*vide* South Australian Museum oology collection records – Yatala Harbor 1899, Reg. No. 29665; and 'near Port Augusta' 1901, Reg. No. B16180) previously reported by Dennis *et al.* (2011a).

**Adelaide Plains and Fleurieu Peninsula region**
Two occupied sea eagle territories were confirmed on the mainland in this region, both on the Fleurieu Peninsula (Table 1 and Figure 1). One of these in southern Gulf St Vincent only became established in 2017, in the same general area where remnants of a long-abandoned nest structure were found on cliffs during 2008–10 surveys (see Dennis *et al.* 2011a).

Frequent reports continue of mainly sub-adult sea eagles in the Torrens Island, Barker Inlet and St Kilda areas in Gulf St Vincent, and more rarely of two adults together (P. Graaf and M. Price *in litt*.). Although territorial activity was not confirmed in this area over the survey period, the locality has potential for re-occupation as breeding habitat. Dennis and Lashmar (1996) reported an active territory in the Buckland Park area of the Gawler River delta in the mid-1990s. However, intensive horticultural industry activity and associated buildings now occur <200 m from the former nest location and surveys along the river channel and floodplain, including around Buckland Lake in 2010 and 2015, failed to locate evidence of alternative sites.

**Kangaroo Island region**
Kangaroo Island retains significant sea eagle habitat, with 19 occupied territories (26% of the total breeding population) identified from mainly boat-based surveys in 2015 and 2016. Although there were some minor shifts in primary nest locations over the period between surveys, the

**Figure 4. An example of a controlled burn in a National Park on Eyre Peninsula that narrowly missed damaging a sea eagle tree nest in 2016.** **Image Sharie Detmar**

population there appears stable with the same number of territories found in 2010. There was an unexplained abandonment of the Nobby Island territory, which is inaccessible and therefore largely protected from human disturbance. This loss was counterbalanced by the re-occupation of an abandoned territory in Pennington Bay. However, this site is likely to be under increasing pressure from human disturbance, as a new golf course and resort development has been approved within close proximity to the nest.

Three primary nests were in trees with the remainder found on the Island's spectacular cliffs. Twelve territories are on the Island's more sheltered north coast, several of which are spaced <10 km apart. As in previous surveys, no territories were found on the exposed high-energy western coastline (see Dennis and Baxter 2006; Dennis *et al.* 2011a).

Kangaroo Island, in particular, has been under increasing pressure in recent years for tourist developments in largely undeveloped areas of the coast, often in close proximity to sea eagle breeding territories. The risk potential for disturbance will increase at these sites from the increased human activity that these types of development inevitably incur.

**South East region**

No occupied sea eagle territories were found in the South East region and only occasional vagrant records have been reported from coastal areas and some inland wetlands (e.g. Bool Lagoon) over the last decade. In the early 1990s there were frequent observations of two adult sea eagles at Baudin Rocks in Guichen Bay and a nest structure was reported to occur on the highest point of the middle islet (I. Falkenberg pers. comm.), but could not be found in 2010 (Dennis *et al.* 2011a). No sea eagles were recorded there during shore-based surveys in 2015 or 2016. An early historical record for the region is the account of a "white-tailed eagle" and nest on Penguin Island in Rivoli Bay by members of the

Governor Grey Expedition in May 1844 (Cleland 1946; Dennis *et al.* 2011a).

**Inland Rivers**

Despite much search effort involving ground transects and exploration of subsidiary creeks and wetlands by canoe and small motorised dinghy, plus vigilance by regional DEW staff and local volunteers, only one occupied sea eagle territory was again confirmed over the entire South Australian River Murray floodplain complex during the survey period. Periodic reports of adult sea eagles continued (N. Kroemer pers. comm.) for the area of the former territory (occupied until March 2010) north of Renmark below Lock 6. However, these were most likely transient birds, as the territory was again found occupied by Wedge-tailed Eagles in both the 2015 and 2016 breeding seasons.

There are many historical White-bellied Sea Eagle breeding records from the River Murray floodplain in South Australia. These were previously reported by Dennis *et al.* (2011a) and are repeated here for completeness with some additions. They include: on Portee Station south of Blanchetown *ca*.1870 (Birds SA *Historical Series;* No 40, F. W. Andrews); near Morgan in 1965 (*South Australian Ornithologist* 24: 102) and 1968 (*South Australian Ornithologist* 25: 224); at Lake Merreti in 1966 (*South Australian Ornithologist* 25: 32); at Spectacle Lakes in the 1950s (P. Schramm pers. comm.); and near Nynes Island between 1968 and 1976 (D. Haslam pers. comm.).

Dennis and Lashmar (1996) reported an active sea eagle nest in the far northeast of the State, at Embarka Swamp on the northwest anabranch of Cooper Creek in the early 1990s. Whereas this was likely an ephemeral event, sightings of both adult and sub-adult sea eagles continue to be periodically reported from Cooper Creek and associated wetlands. Since 2010 these include: single adult sightings recorded during ornithological surveys in the autumn and winter of 2012 at Narie Waterhole on the main channel downstream from Innaminka; at Coongie and Minkie Waterholes on the northwest anabranch (Reid and Gillen 2013); and again in the latter area in early November and late December 2015, reported by DEW feral animal control staff (E. Dahl *in litt*.).

**Important sub-adult and transient sea eagle foraging habitat locations**

Sub-adult sea eagles and, less frequently, solitary adults, were recorded or reported by others from many areas away from known breeding habitats. These include:

- the lower lakes and River Murray delta, including the upper Coorong region;
- the upper River Murray floodplain complex in the Bookmark Biosphere Reserve and Chowilla area, particularly when coincident with periodic controlled flood simulation events;
- Gulf St Vincent, particularly from Outer Harbor to the Light River outflow, and over the tidal creeks near Port Clinton and Price;
- upper Spencer Gulf, from Port Broughton to Port Davis;
- Coffin Bay and Boston Bay on southern Eyre Peninsula; and
- Venus Bay, Baird Bay, Denial Bay and nearby Tourville Bay on western Eyre Peninsula.

These areas are considered vitally important foraging locations for sub-adult and non-paired/transient eagles, as each has abundant prey and is clear of potential spatial conflicts with territorial adults known to occur during the breeding season.

**Population isolation?**

East of the single remaining White-bellied Sea Eagle territory in the South Australian Riverland, the nearest breeding habitats are on the Murray-Darling catchment in south-western New South

Wales, including near Tarina ~110 km distant; on Moorna Station near the feeder channel to Lake Victoria ~150 km distant (R. Brinsley pers. comm.); and ephemeral habitat at Menindee Lakes ~320 km distant (Cooper, McAllan and Curtis 2014).

Away from the Murray, the nearest territories to the most southerly mainland territory in South Australia are in western Victoria at Lake Taylor east of Horsham ~400 km distant (I. Morgan pers. comm.); Lake Condah north-east of Portland ~450 km distant; and offshore, on New Year Island in Bass Straight ~700 km distant.

To the west, the nearest known breeding territory is on the western end of the Baxter Cliffs in the Great Australian Bight near Point Culver in Western Australia (Storr 1987; Johnstone and Storr 1998; R. Johnstone *in litt*.). This is ~450 km west of the nearest territory on the Bunda Cliffs in South Australia. However, recent Birdlife Australia survey data from Kanidal Beach near Twilight Cove (on the eastern end of the Baxter Cliffs) contains frequent sea eagle sightings. Single birds have been recorded there during the breeding season for all years except one between 2006 and 2017; and of two adults together during the breeding seasons of 2009, 2013, 2015 and 2016 (A. de Rebeira *in litt*. – Eyre Bird Observatory). Nevertheless, further specific surveys are required at this remote location to assess the likelihood of a previously unknown territory at or near Twilight Cove (~270 km distant), or conversely to determine if sightings there are of sub-adults or transients on a coastal flyway.

**Population mobility and genetic exchange**

From DNA evidence, high levels of genetic exchange occur among regional White-bellied Sea Eagle populations across Australia (Shephard, Catterall and Hughes 2005a). Immature sea eagles are known to disperse widely and the Australian Bird and Bat Banding Scheme database contains examples of movements between states (Marchant and Higgins 1993; Dennis *et al.* 2011a). The River Murray and tributaries present almost continuous foraging opportunity across the continent, and therefore is a probable flyway connecting otherwise widely spaced populations and a conduit for genetic exchange. However, satellite tracking of sea eagles is required to better understand the species' dispersal patterns in Australia.

**Population decline**

The likely 19th century White-bellied Sea Eagle breeding population in South Australia is conservatively estimated to have been at least 124 pairs (Table 2). When this estimate is compared with the extant population determined in recent surveys ($n$ = 73), it represents a likely level of overall decline of around 40% (Table 2). However, even more significant is the level of likely decline in mainland habitats, i.e. from a probable 52 occupied territories to 14 confirmed in recent surveys, a startling decline of around 73%!

The steep declines apparent on Eyre Peninsula and along the River Murray are likely to have occurred coincident with landscape-scale development in these regions last century.

In response to lesser population declines in Victoria (Bilney and Emison 1983) and Tasmania, specific White-bellied Sea Eagle habitat conservation strategies have been developed, i.e. in Victoria, the *Flora and Fauna Guarantee Action Statement #60* (Clunie 2004), and in Tasmania, the *Threatened Tasmanian Eagle Recovery Plan 2006–2010* (Threatened Species Section 2006). These provide a model by which to progress the development of conservation strategies for the White-bellied Sea Eagle in South Australia.

**Habitat threats**

Whereas habitat destruction represents the most significant threat to the White-bellied Sea Eagle in Australia (Clunie 2004; Threatened Species Section 2006), declines are related in no small part to anthropogenic encroachment, in all its forms, during critical phases of the breeding

**Table 2. A subjective assessment of the likely White-bellied Sea Eagle population in South Australia in the 19th century, constructed from: historical records and published accounts; the likely number of former territories in localities with abundant prey (based on a theoretical 'carrying capacity' factor, represented by an *); and the number of isolated long-abandoned territories identified in recent surveys. The population trend for each region is calculated from a comparison with recent survey data.**

| Coastal bio-region | Known abandoned and probable former territory locations | No. terr. 2015-17 | No. aband. (current) | Decline (%) |
|---|---|---|---|---|
| **Mainland** | | | | |
| Far West (Wilson Bluff to Wahgunyah CP) | Wilson Bluff | 1 | 1 (2) | -50.0% |
| Eyre Peninsula west (western boundary Wahgunyah CP to Cape Catastrophe) | Cape Adieu; Clare Bay; Point Bell; Tourville Bay*; Streaky Bay; Point Westall; Cape Blanche; Baird Bay*; Venus Bay*; Lochs Well; Kianna; Coffin Bay*** | 7 | 14 (21) | -66.7% |
| Eyre Peninsula east (Cape Catastrophe to Two Hummocks Point) | Cape Donington; Point Bolingbroke; Sheep Hill; Lucky Bay | 3 | 4 (7) | -57.1% |
| Yorke Peninsula and Mid North | Yatala Harbour; Chinaman Creek; Germein Bay; Port Broughton; Point Margaret; Port Clinton | 0 | 6 (6) | -100.0% |
| Adelaide Plains and Fleurieu Peninsula | Barker Inlet; Gawler River delta; Blowhole Creek; Deep Creek Cove | 2 | 4 (6) | -66.7% |
| Murray Basin | Murray River estuary; Finnis River estuary; Portee Creek; Morgan; Spectacle Lakes; Mundic Creek; Horseshoe Lagoon; Lake Merreti; Chowilla Is. | 1 | 9 (10) | -90.0% |
| | **Mainland totals** | **14** | **38 (52)** | **73.1% decline** |
| **Islands** | | | | |
| Eyre Peninsula west | Masillon Is.*; Franklin Is.; Dorothee Is. | 26 | 3 (29) | -10.3% |
| Eyre Peninsula east | Williams Is.; Thistle Is.*; Rabbit Is.; Wedge Is.* | 12 | 4 (16) | -25.0% |
| Yorke Peninsula and Mid North | Wardang Is. | 2 | 1 (3) | -33.3% |
| Kangaroo Island | Charlies Gulch; Cape Bouger; Nobby Island | 19 | 3 (22) | -13.6% |
| South East | Baudin Rocks; Penguin Island | 0 | 2 (2) | -100.0% |
| | **Island totals** | **59** | **13 (72)** | **18.0% decline** |
| | **Combined totals** | **73** | **51 (124)** | **41.1% decline** |

cycle (Dennis, McIntosh and Shaughnessy 2011b; Debus *et al.* 2014).

Studies to determine primary causes of nest failure among the closely related Bald Eagle, *H. leucocephalus*, populations in North America found that pedestrian incursions near nest sites during breeding provoked the strongest and most prolonged reaction, particularly at remote sites (Grubb and King 1991; U.S. Fish and Wildlife Service 2007). In contrast to forested breeding habitats common for the species elsewhere, in South Australia sea eagle nesting sites are mostly limited to treeless offshore islands, or on a cliff-face in open coastal terrain with low heath vegetation cover. In these landscapes nest sites have little or no visual screening and are therefore particularly vulnerable to disturbance from human activity and approach. As this predominantly occurs above nest level and at long distance from the nest or the strategic nest-guard roost site, it typically triggers an earlier and stronger reaction causing both eagles to loft and rise above the perceived threat, leaving the nest exposed for as long as the 'threat' remains (Romin and Muck 2002; Dennis, Detmar and Patterson 2015).

In recent decades change of land-use in coastal areas of South Australia has emerged as a threat to the refuge quality of sea eagle habitat, through land division of agricultural properties into smaller holdings with part-time or permanently occupied housing, exponentially increasing the level of human activity and associated impacts in coastal landscapes. A study of productivity outcomes associated with human disturbance factors in sea eagle habitat on Kangaroo Island found that pairs in disturbed territories produced eggs less often, had higher nest failure rates and fledged significantly fewer young compared with pairs in more isolated locations (Dennis, McIntosh and Shaughnessy 2011b). Similar outcomes were found in a study of sea eagles exposed to disturbance during the breeding season in northern New South Wales, with nests being abandoned and pairs displaced to sub-optimal nesting habitat (Debus *et al.* 2014).

Other threats identified to habitat refuge quality from disturbance coincident with a breeding season include fauna research and monitoring programs on islands, low-altitude aircraft operation and similarly, the rapid increase in the use of drones for recreational, scientific and commercial purposes. Land management activities, such as fuel reduction burns (Figure 4), pest plant and pest animal control activities, also pose a threat, the latter resulting in risk-exposure to secondary poisoning from toxin- (e.g. Pindone) affected pest species as prey or as carrion (McLeod and Saunders 2013). Also, the resurgence of exploration interest in potential gas and oil deposits in the Great Australian Bight has elevated the risk of environmental contamination in the remaining significant sea eagle habitat in the west of the state.

## CONCLUSIONS

Collectively, these habitat-degrading processes and threats appear to have compromised White-bellied Sea Eagle population sustainability in South Australia. To address this negative trend a species management plan is required, that includes specific protection and management for remaining breeding refuge habitat in South Australia to minimise disturbance and to maximise productivity.

In the short term, initial population stabilisation measures should include: the development of site-specific management prescriptions for vulnerable territories; state-wide implementation of the recommended 2000 m radius breeding season refuge zone concept centred on known nesting sites (Dennis, Fitzpatrick and Brittain 2012); and subsequently, the implementation of a population monitoring program to measure stability and productivity outcomes in key habitats.

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## REFERENCES

Bilney, R. J. and Emison, W. B. 1983. Breeding of the White-bellied Sea-Eagle in the Gippsland Lakes region of Victoria, Australia. *Australian Bird Watcher* 10: 61–68.

Blaylock, B., Black, A., Carpenter, G. and Horton, P. 2017. *A Field List of the Birds of South Australia*. Fifth edition. The South Australian Ornithological Association Inc., Adelaide.

Clunie, P. 2004. *Flora and Fauna Guarantee Action Statement #60, White-bellied Sea-Eagle*. Department of Sustainability and Environment, Victoria.

Cleland, J. B. 1946. References to South Australian Birds by George French Angas in 1847. *South Australian Ornithologist* 17: 84-86.

Cooper, R. M., McAllan, I. A. W. and Curtis, B. R. 2014. *An Atlas of the Birds of New South Wales & the Australian Capital Territory, Volume 1: Emu to Plains-wanderer.* NSW Bird Atlassers Inc., Sydney.

Corbett, L. and Hertog, T. 2011. Diet and breeding of White-bellied Sea-Eagles *Haliaeetus leucogaster* in the Northern Territory, Australia. *Corella* 35: 41–48.

Debus, S. J. S. 2017. *Australasian Eagles and Eagle–like Birds.* CSIRO Publishing, Clayton South, Vic.

Debus, S. J. S., Baker, G., Owner, D. and Nottidge, B. 2014. Responses of White-bellied Sea-Eagles *Haliaeetus leucogaster* to encroaching human activities at nest sites. *Corella* 38: 53–62.

Debus S. J. S. 2008. Biology and diet of White-bellied Sea-Eagles *Haliaeetus leucogaster* breeding in northern inland New South Wales. *Australian Field Ornithology* 25: 165–193.

Dennis, T. E., Detmar, S. A. and Paterson, C. 2015. *The White-bellied Sea Eagle as a key indicator* *species by which to measure the health and stability of coastal biodiversity in South Australia.* Unpublished Discussion Paper available online at http://www.naturalresources.sa.gov.au/kangarooisland/coast-and-marine/coastal-birds/Coastal_raptors

Dennis, T. E., Fitzpatrick, G. J. and Brittain, R. W. 2012. Phases and duration of the White-bellied Sea Eagle *Haliaeetus leucogaster* breeding season in South Australia and the implications for habitat management. *Corella* 36: 63–68.

Dennis, T. E., Detmar, S. A., Brooks, A. V. and Dennis, H. M. 2011a. Distribution and status of White-bellied Sea Eagle, *Haliaeetus leucogaster,* and Eastern Osprey, *Pandion cristatus,* populations in South Australia. *South Australian Ornithologist* 37: 1–16; with erratum and corrigenda *South Australian Ornithologist* 38: 40.

Dennis, T. E., McIntosh, R. R. and Shaughnessy, P. D. 2011b. Effects of human disturbance on productivity of White-bellied Sea Eagles *Haliaeetus leucogaster. Emu – Austral Ornithology* 111: 179–185.

Dennis, T. E. and Baxter, C. I. 2006. The status of the White-bellied Sea Eagle and Osprey on Kangaroo Island in 2005. *South Australian Ornithologist* 35: 47-51.

Dennis, T. E. 2004. Conservation status of the White-bellied Sea Eagle, Osprey and Peregrine Falcon on western Eyre Peninsula and adjacent offshore islands in South Australia. *South Australian Ornithologist* 34: 222-228.

Dennis, T. E. and Lashmar, A. F. C. 1996. Distribution and abundance of White-bellied Sea-Eagles in South Australia. *Corella* 20: 93-102.

Department of the Environment and Energy (DEE) 2018. *Haliaeetus leucogaster* in *Species Profile and Threats Database*, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Wed, 10 Jan 2018.

Grubb, T. G, and King, R. M. 1991. Assessing human disturbance of breeding Bald Eagles with classification tree models. *Journal of Wildlife Management* 55: 500–511.

Johnstone, R. E. and Storr, G. M. 1998. *Handbook of Western Australian Birds. Volume 1: Non-passerines (Emu to Dollarbird)*. Western Australian Museum, Perth, Western Australia.

Marchant, S. and Higgins, P. J. (eds) 1993. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2, Raptors to lapwings.* Oxford University Press, Melbourne.

McLeod, L. and Saunders, G. 2013. *Pesticides used in the management of vertebrate pests in Australia: a review.* p.140-144. NSW Department of Primary Industries.

Newton, I. 1979. *Population Ecology of Raptors.* Poyser, Berkhamsted, U.K.

Newton, I. 1991. Population limitations in birds of prey: a comparative approach. In: *Bird Population Studies: Relevance to Conservation and Management* (eds. C. M. Perrins, J. D. Lebreton and G. J. Hirons) pp. 3–21. Oxford University Press. Oxford, U.K.

O'Donnell, W. B. and Debus S. J. S. 2012. Nest-sites and foraging of the White-bellied Sea-Eagle *Haliaeetus leucogaster* on the subtropical eastern Australian coast. *Australian Field Ornithology* 29: 149–159.

Olsen, J., Fuentes, E. and Rose, E. B. 2006. Trophic relationships between neighbouring White-bellied Sea-Eagles *(Haliaeetus leucogaster)* and Wedge-tailed Eagles *(Aquila audax)* breeding on rivers and dams near Canberra. *Emu – Austral Ornithology* 106: 193-201.

Reid, J. R. W. and Gillen, J. S. 2013. *Riparian bird assemblages of Cooper Creek, South Australia.* Report to SA Arid Lands Natural Resources Management Board, Port Augusta, South Australia.

Robinson, A. C., Canty, P. D., Mooney, P. A. and Rudduck, P. M. 1996. *South Australia's Offshore Islands.* Australian Heritage Commission. AGPS, Melbourne.

Richardson, C. T. and Miller, C. K. 1997. Recommendations for protecting raptors from human disturbance: a review. *Wildlife Society Bulletin* 25: 634-638.

Romin, L. A., and Muck, J. A. 2002. *Guidelines for raptor protection from human and land use disturbances*. U.S. Fish and Wildlife Service, Utah Field Office, Salt Lake City, Utah.

Shephard, J. M., Catterall, C. P. and Hughes, J. M. 2005a. Long-term variation in the distribution of the White-bellied Sea-Eagle *(Haliaeetus leucogaster)* across Australia. *Austral Ecology* 30: 131–145.

Shephard, J. M., Hughes, J. M., Catterall, C. P. and Olsen, P. D. 2005b. Conservation status of the White-bellied Sea-Eagle *Haliaeetus leucogaster* in Australia determined using mtDNA control region sequence data. *Conservation Genetics* 6: 413–429.

Storr, G. M. 1987. *Birds of the Eucla Division of Western Australia.* Supplement No. 27, Western Australian Museum, Perth.

Threatened Species Section 2006. *Threatened Tasmanian Eagles Recovery Plan 2006-2010*. Department of Primary Industries and Water, Hobart.

Thurstans, S. D. 2009. A survey of White-bellied Sea-Eagle *Haliaeetus leucogaster* nests in Tasmania in 2003. *Corella* 33: 66–70.

U.S. Fish and Wildlife Service 2007. *National Bald Eagle Management Guidelines*. Division of Migratory Bird Management: Arlington, Virginia.

Wiersma J. M. and Richardson A. 2009. Foraging of White-bellied Sea-Eagle *Haliaeetus leucogaster* in relation to marine fish farms in Tasmania. *Corella* 33: 71–79.

**Terry E. Dennis**
**Barossa Valley, South Australia**
**osprey842@gmail.com**

**Sharie A. Detmar**
**Flagstaff Hill, South Australia**

# Bird Note

## Gravid White-chinned Petrels, *Procellaria aequinoctialis*, off Port MacDonnell, South Australia

**COLIN ROGERS**

### INTRODUCTION

The White-chinned Petrel, *Procellaria aequinoctialis*, has a circumpolar distribution in the Southern Ocean and is known to breed on sub-Antarctic islands in the Indian and Atlantic oceans and in the south-western Pacific on the Auckland, Campbell and Antipodes Islands off New Zealand.

The breeding season extends from October to May but there is little data on the pre-laying exodus during which time egg development occurs (Marchant and Higgins, 1990, pp. 557-566). In this note, I report on at least two gravid female White-chinned Petrels obviously carrying the large single egg typical of the species.

Pelagic trips off Port MacDonnell during the Austral summer regularly report White-chinned Petrel along the continental shelf indicating that the area is a regular foraging area for the species together with other species that also breed on islands off New Zealand, such as Campbell Albatross, *Thalassarche impavida*, and Grey-faced Petrel, *Pterodroma gouldi*.

### RECORDS

On a pelagic trip from Port MacDonnell to the continental shelf on 10 December 2017, at least 60 White-chinned Petrels were observed close to the boat at the continental shelf near 38º 27'S 140º 37'E, water depth 1200 m (Hull 2018). Their occurrence in numbers was not unusual for a summer pelagic but on this occasion, I noticed that some birds were carrying eggs of a size suggesting egg laying was imminent. Figures 1 and 2 illustrate examples of gravid female White-chinned Petrels.

### DISCUSSION

The identification of gravid female White-chinned Petrels in Figures 1 and 2 follows Shirihai *et al.* (2014) who photographed a gravid female Mascarene Petrel, *Pseudobulweria aterrima*, off Réunion Island showing a bulge similar to that on the birds in Figures 1 and 2. Perpiñán (2014) rejected that interpretation and argued that gravid female petrels cannot be determined by visual inspection.

However, examination of Perpiñán's arguments reveals that they apply mainly to parrots who lay several small eggs compared to petrels who lay one large egg. Furthermore, Paul Scofield has recorded gravid Sooty Shearwaters, *Puffinus griceus*, arriving at New Zealand breeding sites in late November showing egg bulges like those illustrated in Figures 1 and 2 and in the burrows, he "... could palpate the egg inside them and these individuals laid hours later" (Paul Scofield pers. comm.).

Consequently, Perpiñán's argument that gravid female petrels cannot be determined

**Figure 1. White-chinned Petrel showing an obvious egg 'bulge'. Images Colin Rogers**

**Figure 2. Gravid White-chinned Petrel showing an obvious egg 'bulge'. This bird has no obvious white chin, a feature that is typical of many New Zealand birds that are regularly recorded off Port MacDonnell in summer. Images Colin Rogers**

by visual inspection should be rejected. The birds photographed off Port MacDonnell and illustrated in Figures 1 and 2 as well as other factors reported in this note support the conclusion by Shirihai *et al.* (2014) that the female Mascarene Petrel photographed off Reunion was indeed gravid. It also implies that gravid female *Procellariiformes* that lay a single large egg can be detected by visual inspection and digital photography, at least just prior to egg laying.

All *Procellariiformes* lay a single large egg and between copulation and egg laying the female spends time at sea acquiring the nutrients needed to grow the egg. At the same time males are putting on weight in preparation for the first incubation period that may last several weeks. The birds illustrated in Figures 1 and 2 must be close to egg-laying given their egg 'bulge' is clearly visible. In the case of White-chinned Petrel, the pre-egg laying exodus from the breeding islands lasts an average of 17 days and for birds breeding in the south Atlantic and Indian Oceans eggs are usually laid between mid-October and mid-November (Agreement on the Conservation of Albatrosses and Petrels, 2009). White-chinned Petrels breeding on islands off New Zealand lay their eggs in late November through December and chicks hatch from late January through February (New Zealand Birds Online).

Most White-chinned Petrels breeding on islands off New Zealand have the white chin confined to the interramal area which is hard to see as per the birds in Figure 2. Birds from the Indian and Atlantic Oceans, westward from Australia, show progressively whiter chins.

Although birds from breeding islands in the southern Indian and Atlantic oceans cannot be ruled out, the plumage features mentioned above suggest the birds recorded off Port MacDonnell are from the New Zealand population breeding on the Auckland and Campbell Islands, some 2450 to 2700 km from the continental shelf off SE Australia.

The failure to notice any gravid female White-chinned Petrels on previous summer trips is probably explained by the fact that very few trips are organised for December when the egg bulge is most likely to be seen.

## CONCLUSION

This record of several gravid female White-chinned Petrels off Port MacDonnell, South Australia, supports the claim by Shirihai *et al.* (2014) that gravid female petrels can be identified by visual inspection, contra Perpiñán (2014).

The record of gravid White-chinned Petrels off Port MacDonnell on 10 December is also consistent with the timing of egg-laying and other features of the New Zealand breeding population. It therefore provides some evidence of the range of female White-chinned Petrels on the pre-egg-laying exodus from their breeding areas on New Zealand islands.

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## REFERENCES

Agreement on the Conservation of Albatrosses and Petrels. 2009. ACAP Species assessment: White-chinned Petrel *Procellaria aequinoctialis*. Downloaded from http://www.acap.aq on 14 September 2009.

Hull, S. 2017. *Pelagic Seabird Trip 93, Summary Report*.

Marchant, S. and Higgins, P. J. 1990. *Handbook of Australian, New Zealand and Antarctic Birds, Volume 1A, Ratites to petrels*. Oxford University Press, Melbourne.

New Zealand Birds Online. http://nzbirdsonline.org.nz/species/white-chinned-petrel

Perpiñán, D. 2014. Gravid female birds cannot be determined by visual inspection. *Bulletin of British Ornithologists Club* 135: 92-94.

Shirihai, H., Pym, T., San Román, M. and Bretagnolle, V. 2014. The Critically Endangered Mascarene Petrel *Pseudobulweria aterrima*: identification and behaviour at sea, historical discovery of breeding sites, and breeding ecology on Réunion, Indian Ocean. *Bulletin of British Ornithologists Club* 134: 194–223.

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**Colin Rogers**
**6 Flavel Avenue**
**Woodforde, South Australia 5072**

# Bird Note

## A second record of White-rumped Sandpiper, *Calidris fuscicollis,* for South Australia, with some comments on identification

**COLIN ROGERS AND PETER KOCH**

### INTRODUCTION

The White-rumped Sandpiper, *Calidris fuscicollis,* breeds in the Canadian Arctic and most spend the austral summer in southern South America. There is some vagrancy, however, and prior to the sighting reported in this note there had been seven records of White-rumped Sandpiper for Australia accepted by BirdLife Australia Rarities Committee (BARC). One of those, BARC Case no. 124, was from South Australia, on 15 January 1988 at Dry Creek Saltfields, Adelaide by Cox and Lees (1990).

On 16 March 2018, at approximately 2 pm, we were seated and using our telescopes to count shorebirds at an ephemeral swamp on private property on the margins of Lake Alexandrina when we noticed a wader intermediate in size between Red-necked Stint, *Calidris ruficollis,* and Sharp-tailed Sandpiper, *Calidris acuminata,* feeding no more than 30 feet away. Based on Colin Rogers' experience with the species in South America, a careful inspection quickly revealed that it was a White-rumped Sandpiper. We took a series of photographs, some of which are reproduced here.

### THE RECORD

Examination of the bird, illustrated in Figure 1, indicates a rather dull individual, probably a first-year bird, showing a hint of rufous on the crown, ear coverts and scapulars. Streaking on breast and flanks on a pale wash is relatively dense and typical for White-rumped Sandpiper. Some chevrons were also present on the lower breast and flanks. Only a very faint hint of red at the base of the lower mandible is detectable in some of the photographs but was not noticed in the field under the low light conditions ahead of approaching rain squalls.

A detailed description of White-rumped Sandpiper in breeding and non-breeding plumage is given by Menkhorst *et al*. (2017, p. 162) although a bird in its first summer plumage, as in Figure 1, is not illustrated. Figure 2 illustrates a more sharply patterned bird consistent with adult breeding plumage.

A useful size comparison with Red-necked Stint is illustrated in Figure 3. White-rumped Sandpiper is larger than Red-necked Stint, but smaller than Sharp-tailed and Curlew Sandpiper, *Calidris ferruginea*, and in Australia has usually been found in mixed flocks of those three species. White-rumped Sandpiper has a longer and finer tipped black bill than Red-necked Stint and usually shows a reddish tinge on the lower mandible (just visible in Figures 1 and 2).

Possible confusion species in Australia might be Sharp-tailed Sandpiper that should, however, be readily excluded by leg and bill colour as well as

**Figure 1. White-rumped Sandpiper near Lake Alexandrina, 16 March 2018. Image Colin Rogers**

**Figure 2. White-rumped Sandpiper in adult fresh breeding plumage, Ushuaia, 23 March 2018. Image Colin Rogers**

**Figure 3. Size comparison between White-rumped Sandpiper (left) and Red-necked Stints. Image Colin Rogers**

plumage, shape and the diagnostic white rump (Figure 4).

Another American vagrant that could be confused with White-rumped Sandpiper is the superficially similar Baird's Sandpiper, *Calidris bairdi*, of which there are at least four records for Australia accepted by BARC: Case Nos: 74, 99, 182 and 185. There are two records for South Australia. The first South Australian record was a bird at Buckland Park Lake, SA on 17 December 1986 seen by Bob Snell (1988) and accepted as BARC Case No. 182. The second record was a bird seen by David and Sue Harper on 5 December 1992 in Dry Creek Saltfields, and subsequently seen over the next few days but no report was submitted to BARC. For comparison, an illustration of Baird's Sandpiper taken in South America is presented in Figure 5.

Baird's and White-rumped Sandpiper have similar shape and structure, in particular, long wings giving an elongated rear end to the bird, but Baird's generally has browner non-breeding plumage and lacks the distinct streaking and chevrons on the flanks usual on White-rumped Sandpiper. Nevertheless, the two species are superficially similar, and some care is required to separate them in the field.

If seen, the obvious diagnostic feature is the white rump on White-rumped Sandpiper, revealed in Plate 4. By comparison, Baird's Sandpiper has a dark central rump stripe similar to that on Red-necked Stint and Sharp-tailed Sandpiper. Curlew

**Figure 4. White-rumped Sandpiper revealing the white rump after which it is named. Image Peter Koch**

Sandpipers also have a white rump but in non-breeding plumage are easily distinguished by their much longer legs and long black downcurved bill.

Finally, those interested in calls should listen for the mouse-like squeak of the White-rumped Sandpiper, made as it flew away when the flock of stints took off. That call is unlike any made by other *Calidris* sandpipers that regularly visit Australia.

The record was submitted to BARC as case 991 and accepted 18 June 2018.

**Figure 5. Baird's Sandpiper, Tierra del Fuego, Chile, January 2009. Image Colin Rogers**

## REFERENCES


Cox, J. B. and Lees, A. F. 1990. A sighting of the White-rumped Sandpiper in South Australia. *South Australian Ornithologist* 31: 18-19.

Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P., and Franklin, K. 2017. *The Australian bird guide*. CSIRO, Clayton Victoria.

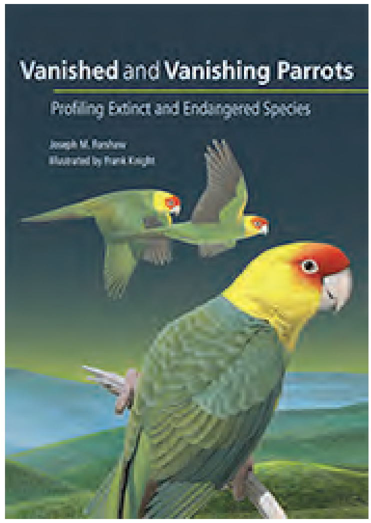
Snell, R.G.T. 1988. First record of Baird's Sandpiper in South Australia. *South Australian Ornithologist* 30:118-119.



**Colin Rogers**
**6 Flavel Avenue**
**Woodforde**
**SA 5072**

**Peter Koch**
**102 Mitchell Avenue**
**Murray Bridge**
**SA 5253**

# Book Review




## Vanished and vanishing parrots: profiling extinct and endangered species

**JOSEPH M. FORSHAW, ILLUSTRATED BY FRANK KNIGHT, 2017**

*CSIRO Publishing, Clayton South, Vic. $150*
*Hardcover, 323 pages*

Forshaw and Knight's *Vanished and vanishing parrots: profiling extinct and endangered species* is a work of compelling significance and substance; it is rigorous and wide ranging, engaging and illuminating, beautiful and yet deeply disturbing. Different to the majority of illustrated and illustrative texts that take parrots as their focus, and indeed the comparisons to Forshaw and Cooper's seminal work on the subject, *Australian parrots (*3rd rev. ed. 2002*)* are stark, this work's singular concern is the plight of this most marvellous and varied of species. Seventy-four parrot species are afforded consideration; as the book's title makes clear – each of them is either extinct or endangered. And as much as one may wish it were otherwise, Forshaw's treatment of this array of birds makes clear that there are no quick, clear or easy remedies to the prevailing predicament. Instead, what reading and consideration of *Vanished and vanishing parrots* does make clear is that, just as the range of contexts covered is broad, so too are the concerns and catalysts for decline many and varied. Nonetheless, if any consolation is to be found within the covers of this book, it may well be that a knowledge-base clearly exists, and that it is growing; that research and restoration initiatives are underway – both here and abroad – and are being led by proactive and committed entities, and that with a work such as this – fashioned as it is upon a voluminous array of academic articles and publications – a foundation for hope and a pathway forward has been established.

To hold this book is to feel the weight of time and effort invested in its production. To leaf through the pages, the paper heavy and textured, the printing crisp, the formatting and organisation clear and easy to negotiate, is to know that this is a book that rewards reader investment – not only of time, but also money. Because this is an expensive book. But to own this book is to be richly rewarded, if for no other reason than to be privileged to experience Frank Knight's luminous and exquisite illustrations. They are works of art. Most famous for his association with Graham Pizzey and their *Field guide to the birds of Australia*, herein Knight has been released from the constraints of form and genre. In the field guide, for the most part his rendering of birds and their features lacks for context; an occasional branch, some leaves, perhaps a land feature. In *Vanished and vanishing parrots*, the depiction of context is integral to the depiction of the species. Each is fully realised across the full extent of an A4 page. Sometimes singularly, sometimes in pairs, occasionally in groups, the depicted birds inhabit both place and space.

The manner and means of Knight's depictions allows the reader to view and consider images that are more experiential than diagnostic in their function and purpose. In effect, to see these illustrations is to see these birds being who they are (or were), where they are (or were). Furthermore, throughout, dozens of eighteenth and early nineteenth century illustrations are embedded in the text, be it in support of Knight's speculative rendering of extinct species, or to complement and contrast his presentation of known and assumed features of rarely sighted species. In short, there is considerable value in the illustrations alone; but this is a text with an agenda far more significant than promoting the aesthetic merits of these species.

Following a forward by Noel F. R. Snyder, noted American ornithologist, educator and researcher, and director of the US Wildlife Trust's Parrot programs from 1989 to 1998, in which he discusses disease as causation factor for predation amongst Carolina Parakeet, *Conuropsis carolinensis*, Puerto Rican Parrot, *Amazona vittata*, and Thick-billed Parrot, *Rhynchopsitta pachyrhyncha* populations, the text proper begins. Commencing with an introduction from the author covering the multitudinous forces and factors arrayed against parrot populations, Forshaw also makes a case for the book's central concern – the lack of data for all parrot groups and the corollary problem that this highlights; the lack of in-depth qualitative analyses of the nature and trends in threats to parrot populations.

As Forshaw states, "Parrots are more threatened than other comparable taxonomic groups." But why? And perhaps that's the underpinning function and purpose of this work – to suggest that 'context matters' and that 'there's no one-size-fits-all' solution is a moot point; what is irrefutable is that we know so little about how and why so many birds can warrant a publication titled *Vanished and vanishing parrots*.

Followed by a detailed and wide-ranging account of the Fossil History of Parrots by the Australian Museum's Walter E. Boles, the body of *Vanished and vanishing parrots* is organised into three distinct categories: Australasian distribution (35 birds); Afro-Asian distribution (5 birds), and Neotropical distribution (34 birds). In keeping with its ostensible function and purpose of being a reference work, the text subscribes to a clear and consistent set of organising principles: prior to discussion of each bird, across all three categories, contextualising information and data is provided on the bird or birds' superfamily, family, genus, and where appropriate, their subfamily and/or tribe. Thereafter, each bird is afforded detailed diagnostic treatment under each of the following headings: description; distribution; status; habitats; habits; calls; diet and feeding; breeding, and eggs.

The text for each entry is, for the most part, surprisingly engaging for a text-type of this nature. The superfamily 'framing narrative' for each bird is, clearly, both necessary and useful in order to orientate the reader and situate the bird within a larger schema, but, along with the material presented under the headings Description, Distribution and Eggs, is dry and perfunctory. It is when these matters of particular detail are dealt with that Forshaw's text takes flight.

A reference work this is, but so too is it a text inflected with the passion and insights of not only an eminently qualified and learned individual, but also that of an author who is both deeply engaged with and concerned by the situation of his subjects. The authorial voice is, in effect, that of Forshaw speaking; it reads as if he is offering a personal account of that which matters, but his judgements and pronouncements are not singular in their making. The References Cited section runs to 19 two-column pages, with 808 texts cited within the book, and when deployed throughout, these works and their concerns are synthesised into Forshaw's account and serve to add texture rather than function as substantive text.

Reading the treatment of each bird is akin to accompanying Forshaw on a fieldtrip as he tells of and talks to both the behaviours and experiences, and contexts and concerns of each bird. This is especially so as Forshaw journeys through members of the Australasian species, and it becomes manifestly clear that here he is negotiating intimately familiar terrain. Suffice to say, treatments of the Afro-Asian and Neotropical distribution birds are erudite and illuminating, and no less rewarding for the effort expended in reading of them, but are rarely privileged to the welcome intrusion of the first-person voice and the anecdotal embellishments that characterise the Australasian section.

When reading about the Golden-shouldered Parrot, *Psephotellus chrysopterygius*, the Swift Parrot, *Lathamus discolor*, the Ground Parrot, *Pezoporus wallicus,* and most especially the Orange-bellied Parrot, *Neophema chrysogaster*, the experience transcends that of being simply educative and morphs into a pleasure more profound, and more rewarding. To this end, and being mindful that the book never positions itself as being anything other than a reference text, and I have every confidence that it will be highly regarded and widely employed as such, I must confess to wishing at times that this book was something other; that in a parallel universe, Forshaw released a complementary book contending only with the Australasian birds, dispensed with conventional organising constraints, and gave free reign to guiding us through what needs to be said and shown about each of these birds, such is the power and potency of his prose.

A caveat to this recommendation of the visceral rewards on offer is carried in the book's title: *Vanished and vanishing parrots*. As engaging and compelling as Forshaw's prose may be, the book remains a sobering and at times confronting reading experience. Turn to the entry for the Paradise Parrot, *Psephotellus pulcherrimus,* and in the margin is a sizeable red tag with the word 'EXTINCT' embedded there; the first words under the heading Status, "It is a tragedy that arguably the most beautiful of Australian parrots has been lost." To his credit, and reflective of his authorial and academic integrity, Forshaw does not descend to the didactic. Nor does he shy away from predation attribution or the apportioning of blame, but does so in a manner that is both dispassionate yet calmly and clearly reasoned. As an example of such, with regard to the Red-fronted Parakeet, *Cyanoramphus novaezelaniae*, Forshaw writes, "I do not share the view that recognition of the Norfolk Island population as a separate species enhances conservation priorities, for that endangered population is deserving of the highest conservation effort irrespective of its taxonomic status."

Be it habitat loss or degradation, competition from introduced species, disease, the live-bird trade, environmental change and its consequent impacts, biological attributes, or anthropogenic and socio-economic factors, Forshaw presents a wide-ranging and balanced treatment of the forces and factors impacting upon parrot populations; his determinations are consistently and comprehensively supported and/or substantiated with varied case-study evidence and interpretive analysis. By no means an 'easy read', when appropriate or necessary, Forshaw's argumentation is presented in a clear and considered fashion; I particularly liked that Forshaw questions and challenges authorities and received orthodoxies – for instance, in regards the listing of the Grey Parrot on CITES Appendix I, he writes, "… it is timely to pose the question – How effective are CITES controls in restricting trade in this, or in any other parrot species?" and then proceeds over a couple of columns to make a sound case, through linked comparisons, for the need for synthesised research studies to provide appropriate and sufficient data to support and substantiate better policy determinations.

Does *Vanished and vanishing parrots* have flaws or weaknesses? If there are any, when reading and thinking on this text, I did not feel at all inclined to consider such. I'm no ornithologist, nor am I an academic – in fact, my experience and knowledge of birds and birding is really quite limited - so I cannot attest to or challenge the veracity of distribution diagrams or nomenclature or any of the other peccadillos that, on occasion, emerge in a review of a book of this type and nature. That said, I did make sure to have a good look at the index and can, with confidence and certainty, proclaim it a success. In fact, there are two indices: first is the index of scientific names, wherein everything is obviously in Latin, which I didn't find so useful; second is the index of English names, wherein everything is obviously, and quite usefully, in English. Not only are the birds listed in English, but they are also cross-referenced – if I want to know more about the White-crested Cockatoo, page numbers are provided under the heading 'Cockatoo', which has White-crested and each of the other twenty Cockatoo-types mentioned in the book alphabetically listed below. Alternatively, White-crested Cockatoo gets its own listing further into the index, with the very same page numbers accompanying.

Again, it needs be said, this is an expensive book, and is likely to remain so. If you inhabit the field of parrot research, or are invested in the pursuit of bird preservation, you most likely already own or have ready access to this text. If it were not for the fact that I am fortunate enough to have been a reviewer of this book, it is unlikely that I would have been able to find $150 to purchase it; nevertheless, I recommend – without reservation – the purchase of *Vanished and vanishing parrots*. It is, truly, worth saving up for. I am grateful to have read it; I am grateful to have been made to think on the issues and concerns that it raises. Most especially, I am grateful to have read not only what Joseph Forshaw has written, but commend to you the experience of reading his writing. And then there are Frank Knight's illustrations: magnificent. This is a valuable, and for this reviewer, a valued book.

**Stephen Ramm**

# Book Review

## Birds in their habitats: journeys with a naturalist

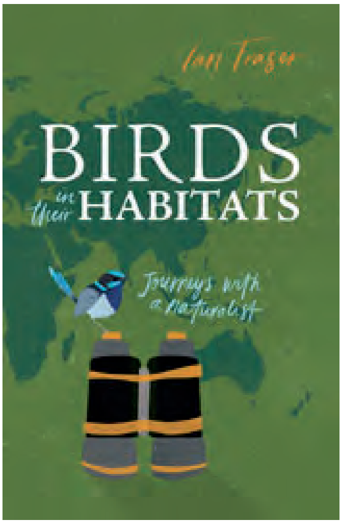
**IAN FRASER, 2018**

*CSIRO Publishing, Clayton South, Vic. $39.95*
*Paperback, 240 pages*

When I first opened the pages of this book, I half expected a type of bird travel log, the kind that's written by a keen birder who wishes to share their birding experiences with others, including where the bird `fits' in their personal sighting list.

These books can be quite interesting, but generally aren't really very exciting, as the triumph of sighting a rare species belongs to the author, not the reader. Some are just plain bragging opportunities! Fraser could have written such a book, simply adding the habitat descriptions in which he finds the birds.
So, what does habitat mean? I had always thought the habitat of an animal is a place where it lives, feeds and breeds, but Fraser's `habitat' is much more than this in *Birds in their habitats*.

This book is written for those who are interested in the environment, ecology and natural history, no matter what level of knowledge. Based upon scientific facts (as supported by lengthy lists of references), the information is presented in a manner easy for all to understand. Fraser's style is easy-going and friendly, and he makes the reader feel included in his journey of discovery. At times his descriptions take on the form of a piece of poetry, and Fraser certainly doesn't shy away from showing his less scientific side. The




book is also a treasure trove of interesting facts with which to impress your fellow bird-loving friends at dinner parties, such as `A bird must eat 1000 seeds a day'.

In order to take the reader on his journey, Fraser divides his chapters according to environments, such as deserts and rainforests. These chapters are further subdivided into sections, and subsections of widely varying topics. For example, we can read about `Waza National Park and its panting birds', and `Paz de las Aves: positive ecotourism news', `Melbourne Cricket Ground: a groggy gull' and then `Can birds smell?' Where known, historical factors are woven into the chapters, providing a description of habitat beginning with evolution of the species and ending with the present day.

A selection of colour plates in the centre of the book punctuates the text with visual colour, illustrating some of the most interesting facts involving birds.

This may not be a book that you devour greedily in one sitting - there are so many interesting facts to absorb. (Unless you already know them all!)

I enjoyed the book best by reading a chapter, then putting the book down in order to allow all the information to soak in properly before moving on to the next fact-filled chapter.

By the time you have finished reading, you will have been entertained, taken to never-heard-of-before places, realized your knowledge of world bird species is really quite scanty, heard of amazing facts to impress your family and friends at parties, learned how ecological systems work, and, above all, been taken along on some really amazing bird-watching expeditions.

Take a bite, sit back and chew slowly before taking another bite of the tasty *Birds in their habitats.*

**Diana Koch**

# Book Review


## Grasswrens: Australian outback identities

**ANDREW BLACK AND PETER GOWER, 2017**

*Axiom, Stepney, South Australia, $45*
*Hardback, 153 pages*
*Numerous photos and maps*

Grasswrens, though not as colourful as their fairywren cousins, are fascinating to many birders. Well-named as 'Australian outback identities' by the book's subtitle, they reside in many out-of-the-way and remote places around this continent. Then if and when you manage to get there, there are no guarantees that you will see them, even if they are in your vicinity.

These cryptic birds seem to be highly practised at avoiding people, running swiftly with tail erect between clumps of vegetation and rarely venturing much above ground level. I learnt from this book that their thigh muscles and pelvic bones are much more developed than their breast (i.e. flight) muscles and bones.

In his foreword, Leo Joseph describes grasswrens as 'enigmatic' and the thrill of seeing them, often a hard-won experience, as 'electric'.

Andrew Black's text introduces grasswrens within their wider family (Australasian Wrens, Maluridae), covering the history of their discovery, naming and understanding of the relationships between species. The nature and behaviours of grasswrens, their habitats and social organisation are also described. Each species has its own chapter, giving details of its discovery, formal description, distribution (including a map), population, habitat, subspecies and hints on where to find it. There are also chapters on voice, nests and eggs, and threats and conservation.

Many grasswren species went unreported for decades in the 20th century and it was only the advent of oil exploration and better outback roads that allowed their rediscovery. Even though it has become easier to travel the outback, grasswrens' habit of moving 50 – 200 m ahead of our intrusive presence makes photography of these small birds difficult, to say the least. It is all the more impressive that the late Peter Gower was able to assemble so many excellent photographs of each species as well as their habitats. In addition, Peter contributed an interesting chapter on the photographer's view.

While not setting out to be a comprehensive monograph on grasswrens, this book contains a wealth of information for any reader who has seen or wants to see these birds. For those who want to investigate further, there is a comprehensive bibliography. And if you want to do none of these things, the photographs will provide much enjoyment. For me, this book is a welcome addition to Australia's bird literature.

**Merilyn Browne**

## ADVICE TO CONTRIBUTORS

**Aims:** The *South Australian Ornithologist* aims to publish material on the birds of Australia, with an emphasis on the birds of South Australia. We publish papers and bird notes that are peer-reviewed, plus annual bird reports, book reviews and obituaries. Submissions should be concise, original, consider previous relevant literature and, except for bird notes and book reviews, begin with an abstract. Book reviews and obituaries are the authors' personal views. Manuscripts (MS) should be exclusively submitted to this journal. Contributors need not be SAOA members.

**Submissions:** We prefer MS that are submitted electronically by e-mail or on a CD, but if necessary accept printed copies. MS should be typed with double-spacing and > 3 cm margins. Type the text unjustified and without end-of-line hyphenation, except in the case of compound words. We accept MS prepared on most word processors; if in doubt also submit a copy in RTF (Rich Text Format). MS should be consistent and simple without special fonts, indents and elaborate formatting. Avoid footnotes and if possible appendices unless they are absolutely necessary.

**Graphics and Photographs:** Both are encouraged and should be submitted electronically as Encapsulated Postscript (EPS) or TIFF files. Figures and Tables should be self-explanatory and designed to fit within the margins of the journal (single page 146 mm, double page 203 mm). Letters, numbers and symbols within the graphic must be clear. Ensure that stippling and/or symbols in figures are legible at the size likely to be used in the published paper. Place captions for the tables and figures *after* the references as they will be formatted separately from the graphic. We also encourage the submission of relevant colour photographs that should be sharp and high quality (preferably DNG, RAW or TIFF) that supplement the MS or are suitable for the cover. If necessary, transparencies or prints can be submitted for scanning and the originals will be returned to the authors. Please credit relevant photographers, artists and cartographers.

**Nomenclature:** When a species is first mentioned give both its English and scientific name, the latter unbracketed and italicised, e.g. Square-tailed Kite, *Lophoictinia isura.* Thereafter only use one, and always the same name. Nomenclature, style and systematic order are based, subject to revision, on *Census of South Australian Vertebrates, Section 3: Birds Taxonomy*, available as a pdf at www.environment.sa.gov.au/Science/Information_data/Census_of_SA_Vertebrates. Scientific plant names, subject to revision, are according to the *Electronic Flora of South Australia/Census of South Australian Plants, Algae and Fungi,* which is available on-line. Note the use of capitals for animals and plants, e.g. six Superb Fairywrens, but an unidentified fairywren; one Fat-tailed Dunnart, but several dunnarts; one Ruby Saltbush).

**References:** List references alphabetically at the end of the paper with the names of the authors and periodicals given in full. Avoid referring to web pages if possible because they constantly change and have poor longevity. Authors are cited in the text thus: Baxter (2010); (Marchant and Higgins 1993); (Blakers, Davies and Reilly 1984; Hornsby 1987); (Roshier *et al.* 2001). Note *et al.* is used where a cited paper has four or more authors, but is not used in the reference list. Authors must reasonably endeavour to locate and cite the primary or original sources of their information. In some cases handbooks, field guides and compendiums (although valuable resources) do not suffice as the primary reference.

The following style should be used for references:

Baxter, C. 2010. Antarctic Terns, *Sterna vittata*, in Australia with an analysis of their possible race and origin. *South Australian Ornithologist* 35: 209-222.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. 2003. *The new atlas of Australian birds.* Birds Australia, Melbourne.

Close, D. 1982. Birds of the Ninety Mile Desert. In *The Ninety Mile Desert of South Australia.* C.R. Harris, A.R. Reeves and D.C. Symon (eds). Nature Conservation Society of South Australia, Adelaide, pp 85-87.

Marchant, S. and Higgins, P.J. (eds). 1990. *Handbook of Australian, New Zealand and Antarctic birds. Volume 1B, Australian Pelican to ducks.* Oxford University Press, Melbourne.

SAOA. 1995. Bird Records. *South Australian Ornithological Association Newsletter* 155: 15.

**Style, measurements and abbreviations:** Style generally follows the *Style manual: for authors, editors and printers*, Sixth edition, Australian Government Publishing Service, Canberra 2002. We encourage the use of the first person for a direct and engaging style. Spelling follows *The Macquarie Dictionary*, Second Edition, the Macquarie Library, Sydney, 1991. Use 's' not 'z' in words such as 'recognise', 'analyse' and 'organisation', and use 'ou' in words like 'colour' and 'behaviour'. Check carefully that all references mentioned in the text are in the References, and *vice versa.* To abbreviate, first use the full wording followed by the abbreviation in brackets, then use the abbreviation only. Numbers under 10 are spelled out and then Arabic numerals are used, e.g. nine whistlers but 10 finches. However, to avoid unnecessary inconsistency and confusion, if a sentence or paragraph contains other numbers larger than 10, all numbers, including those under 10, should be given as Arabic numerals. No sentence should start with an Arabic numeral. Type a space between a numeral and its unit e.g 3 m. For time use the 24-hour clock system, e.g. 0735 – 2050 h. Give dates in the form 1 November 2008, though in tables and figures dates be given as 1/11/08. Geographical references should be in the form: 20 km NE (or north east) of Adelaide; southern areas of South Australia; 35º 24′ S, 138º 39′ E. Other abbreviations are in the form: 8 x 42 binoculars; 2% or two percent; 3 m or three metres; $\bar{x}$ or mean; s.d. or standard deviation; s.e. or standard error; $\chi^2$ or Chi square.

**Population Studies:** Reviews of the birds of an area should include the habitats and climate and a summary of relevant literature. Include a map of the area showing localities mentioned in the text, an insert showing the locality in Australia, and a scale. Extensive data on many species should be given in a table(s) or an annotated list, preferably not as an appendix. Summarise repeated patterns as ranges on each visit (e.g. 3-10 during Aug-Oct 2001-3), using measures of variance if there are sufficient data (e.g. modes, means and standard deviations). If possible report breeding, seasonal movements, population trends, habitat use and other significant observations.

**Referees and editorial assistance:**
The editors will provide some assistance in the preparation of an MS. Submissions without a reasonable attempt to conform to the specifications above will be returned to the author for correction before being refereed. Acceptance of a MS will be subject to the decision of the editors.

Revised September 2018

# Contents



**Front cover image:**
**Sharp-tailed Sandpipers and Red-necked Stint, Dry Creek Saltfields, SA**
**Merilyn Browne**

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