Distribution and status of White-bellied Sea-Eagle, *Haliaeetus leucogaster*, and Eastern Osprey, *Pandion cristatus*, populations in South Australia

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Abstract

Surveys throughout coastal regions and in the Riverland of South Australia over three breeding seasons between May 2008 and October 2010, estimated the population of White-bellied Sea-Eagle, Haliaeetus leucogaster, as 70 to 80 pairs and Eastern Osprey, Pandion cristatus, as 55 to 65 pairs. Compared to former surveys these data suggest a 21.7% decline in the White-bellied Sea-Eagle population and an 18.3% decline for Eastern Osprey over former mainland habitats. Most (79.2%) sea-eagle territories were based on offshore islands including Kangaroo Island, while most (60.3%) osprey territories were on the mainland and near-shore islets or reefs. The majority of territories were in the west of the State and on Kangaroo Island, with three sub-regions identified as retaining significant habitat for both species. These were upper-western Eyre Peninsula, southern Eyre Peninsula and Kangaroo Island (Figs. 4 & 7), which together encompassed 70.8% of the White-bellied Sea-Eagle territories and 62.1% of Eastern Osprey territories. Threats identified for both species included: rural land-use change leading to increased human activity in the coastal landscape and corresponding levels of disturbance at nest sites; poorly conceived tourism developments; ill-timed research projects and pest plant control programs coincident with the breeding season; and inter-species conflicts between White-bellied Sea-Eagles with Wedge-tailed Eagles, Aquila audax, were identified. Collectively, these habitat degrading processes and threats have reduced the wilderness quality and therefore the breeding refugia, particularly for the disturbance-intolerant White-bellied Sea-Eagle.

INTRODUCTION

Top-order predators, such as the White-bellied Sea-Eagle, *Haliaeetus leucogaster*, and Eastern Osprey, *Pandion cristatus*, are recognised indicator species by which to measure wilderness quality and environmental integrity in a rapidly changing world (Newton 1979). In South Australia (SA) both species have small populations with evidence of recent declines linked to increasing human activity in coastal areas (Dennis 2004; Dennis *et al.* 2011 in press). A survey of the sea-eagle population in the mid 1990s found evidence for a decline in the breeding range since European colonisation (Dennis and Lashmar 1996). Similarly, a survey of of the opsrey population in 2005, reported high levels of nest failure in some areas (Dennis 2007a).

These populations are somewhat isolated from those in other regions of Australia, with the most westerly sea-eagle territory in SA >400 km from the nearest known territory in Western Australia (WA) and the most easterly coastal territory (on the Fleurieu Peninsula) >550 km from the nearest known territory in Victoria at Lake Connewarre (Dennis and Lashmar 1996). They are capable of long distance movement, for example a nestling banded at Franklin Harbour on Eyre Peninsula in 1970 was found dead on Fraser Island Queensland the following year (*Aust. Bird Bander* 10: 82), and it is likely that the Murray River system is a conduit for genetic exchange as there are breeding territories thinly distributed along the river in each State (Marchant and Higgins 1993).

Similarly, with ospreys there is also a substantial break in their continental distribution, with the most westerly territory on the Bunda Cliffs >750 km from the nearest known territory near Esperance in WA, and there are no recent or historical breeding records south-east of Kangaroo Island in SA, or from Victoria or Tasmania (Dennis 2007a).

In contrast to the forested habitat available in other States, in SA both species are largely limited to offshore islands or remote coastal cliff sites and associated broken terrain with low heath vegetation cover, and tree nests are rare. This results in most breeding sites having little visual screening and therefore being particularly vulnerable to disturbance from human activity, which invariably occurs above nest level and in line-of-sight at long distance from the nest or guard-roost sites (Olsen 1998, Dennis *et al*. in press).

In 2008 the conservation status of both species was elevated to *Endangered* in SA. Both are listed on the Marine and Migratory Species Schedules of the Federal *Environment Protection and Biodiversity Conservation Act, 1999*.
With support from various sources a series of surveys commenced in 2008 to re-assess what was known of these species in SA. The aim of these surveys was to: i) determine the distribution and status of the White-bellied Sea-Eagle and Eastern Osprey in SA; ii) locate significant habitats; and iii) identify adverse human activities and habitat threats.

METHODS

Raptor populations are determined by surveying the number of territorial or breeding pairs in suitable habitat (Newton 1979). Both the sea-eagle and osprey form long-term pairs and are known to use nesting locations over long time periods, with favoured sites being used by successive generations (Marchant and Higgins 1993; Clunie 2003; Dennis 2007b; Dennis *et al.* in press). Therefore, relative stability was assumed for previously known sites in remote locations enabling survey effort to be targeted in those areas and prospecting surveys to concentrate on potential and previously poorly surveyed sections of coastline.

Survey scope and planning

Prior to on-ground survey, digitised oblique imagery and orthorectified aerial imagery from the Department for Environment and Natural Resources (DENR) were examined for terrain features typical of those used as breeding sites, in order to plan access and survey methods in unfamiliar areas. Between June 2008 and October 2010 strategic coastal surveys were conducted over three breeding seasons between

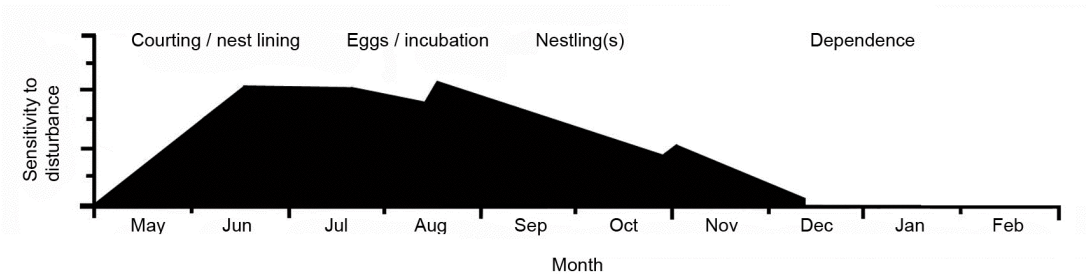

Figure 1. The likely phases of greatest sensitivity and corresponding risk of nest desertion during the White-bellied Sea-Eagle breeding season in South Australia. Note the risk of desertion increases through the courtship phase, is highest from mid-June to mid-September, and declines with increased parental investment thereafter. This figure adapted from estimates developed in Tasmania (Mooney and Holdsworth 1991; Forest Practices Authority 2006).

Wilson Bluff on the WA border (2008) and Rivoli Bay in the South East of SA (2010), in the Riverland between Morgan and the New South Wales Border (2009-10), and in offshore island groups off Yorke and Eyre Peninsulas (2010). In addition, a comprehensive literature search at the South Australian Museum (SAM) and Royal Geographic Society of SA libraries, found historical records of breeding locations for both species.

Minimising disturbance

Due to the sensitivity of sea-eagles to disturbance during the breeding season (Olsen 1998; Clunie 2003; Threatened Species Section 2006; Dennis *et al.* in press), ground surveys were confined to mid-September and October, when pairs were settled into established patterns of foraging forays and nest protection, thus avoiding the risk of desertion during the courtship, pre-egg laying and early incubation phase in May to early September (Figure 1). Depending on terrain limitations, observations were made at distances of at least 750m from sea-eagle nest sites and 250m from osprey sites using high-resolution binoculars (Swarovski 8.5 X 42 and 2 X booster) and/or a tripod mounted spotting scope (Kowa 25, 40 and 60 X 75). However, because of familiarity with terrain and nest locations from previous surveys, some territories could be surveyed at lesser distance without causing disturbance. Similarly, as sea-eagles largely ignore boats that are >150 m away, sea-based surveys were able to be undertaken during the sensitive breeding season onset in May and June, when all pairs spend long periods at the nest engrossed in courtship and nest repair activity, regardless of whether egg laying occurs. In contrast, ospreys are strongly attached to nest sites throughout the year and are generally more tolerant to approach from landward.

Ground surveys

Ground surveys were conducted by a combination of vehicle and foot traverse e.g. in the Far West region in 2008. Extended foot transects were conducted where vehicle access to survey sites was not possible or ethical. Access to DENR Reserves was under Scientific Permit (C25629 1-3), entry to the Yalata Indigenous Protected Area was through the Yalata Community Council, and considerable effort was directed to obtaining permission to access private property.

Due to the remoteness of some sections of coastline volunteer back-up assistance was essential to maintain portable radio contact, mobile or satellite phone watch and to ferry a vehicle between the commencement and end point of foot transects.

Vessel-based surveys

Remote coastlines were surveyed from the sea. These included: 55 km of coast south of Elliston on western Eyre Peninsula; most of Kangaroo Island; Nuyts Archipelago; and the Investigator, Gambier and Sir Joseph Banks Groups of islands.

Near-shore islands (<4 km offshore) were surveyed visually by spotting scope from the nearest headland vantage point, or by circumnavigation by small boat. A canoe or dinghy was used to survey tidal creeks in mangrove forest areas, and for lagoons and subsidiary creeks in the upper-Murray and Bookmark-Chowilla floodplain complex.

Data processing and storage

A standardised data-sheet was used for each site throughout the project. Once identified by ground or vessel-based survey, the location of nest sites was tentatively determined using a range-finder (Leupold RX-IV 8 X 28) to measure an offset distance (accuracy ± 5 m) along a compass bearing from a GPS (Garmin 60CSx) determined waypoint location. At some inactive sites it was possible to obtain location data directly above a cliff nest or directly under a nest tree. All observation data were entered in a field notebook or directly onto survey record data-sheets and subsequently transcribed

into an electronic database. Digital images of the terrain and nest placement setting were obtained in all cases and stored in electronic files, cross-referenced in the project database. The images, together with GPS waypoint data recorded in the field, were subsequently used to pinpoint nest site locations on digitised orthorectified aerial imagery using GPS mapping software (OziExplorer) which provided precise latitude and longitude (and UTM) data. The data, site description notes, historical records and an assessment of likely threats were recorded for each territory and entered into the project database. The database and associated image files are lodged with the DENR Biological Database of SA (BDBSA), where precise nest site location data will be buffered from public access.

Threats

Actual and potential threats in currently occupied and abandoned territories with potential for re-occupation were recorded, including obvious recreation pursuits occurring within the core territory and proximity to buildings, roads, tracks and industrial or other land-use activities. Horizontal distance measurements between nest sites and physical features were obtained from the digitised aerial imagery using the tools available in the mapping software.

Community contact and participation

To develop community awareness, garner local knowledge and cultivate volunteer participation, project flyers and posters were distributed through: regional Natural Resource Management (NRM) networks, DENR offices, indigenous communities, natural history groups, tourist information outlets, and commercial fishing organisations such as the Abalone Divers Association, commercial charter boat operators and fishing tackle shops. This resulted in a network of observers contributing sighting information and enabled delegation of some site surveys. Communication was maintained with volunteers through regular newsletters. A log of volunteer participation was maintained throughout the project. Contact was also established with indigenous community representatives e.g. the Yalata Community Council, the Narrunga community on Yorke Peninsula and the Ngarrindjeri communities in the Riverland through the Indigenous Facilitator attached to the Murray-Darling Basin NRM.

Terminology

Key terminology is defined as follows:

Occupied territory – an adult pair observed together during the breeding season in the vicinity of nest(s) and repairing nest or defending the territory.

Active nest or territory – a site where incubation behaviour suggests eggs are laid or young are recorded.

Successful nest or territory – fledglings are observed.

Failed nest or territory – where eggs fail to hatch, or where all eggs or young are lost.

Core territory – the defended area around a nest site.

Guard-roosts – strategic vantage points within the core territory used as day-roosts by the non-incubating bird.

Primary nest – the most frequently used nest within a territory.

Alternative nest – one of sometimes several nest structures within a territory.

RESULTS AND DISCUSSION

Survey outcomes

The coastal regions, including offshore islands, and the Riverland of SA were surveyed over three breeding seasons between May 2008 and October 2010. A total of 72 White-bellied Sea-Eagle and 58 Eastern Osprey occupied territories were identified, mainly in the west of the State and on Kangaroo Island (Tables 1 and 2; Figures 2-4 & 6- 7). However, the number of pairs of

both species holding territories or attempting to breed varies from year to year, resulting in survey observations being inconclusive in a small number of locations. Therefore, breeding populations are estimated to range from 70-80 White-bellied Sea-Eagle and 55-65 Eastern Osprey pairs annually. The majority of sea-eagle territories were on offshore islands (79.2%, n = 57), including Kangaroo Island, while most osprey territories were on the mainland (60.3%, n = 35) or on near-shore islets or reefs <1 km offshore (Figures 2 and 6).

Significant habitats

From the current high density of territories present, three sub-regions of SA were identified as retaining significant breeding habitat for both the White-bellied Sea-Eagle and Eastern Osprey (Figures 4 and 7). Each sub-region is approximately 12,500 km^2 and includes offshore island habitats. Specifically, the upper-western and southern Eyre Peninsula sub-regions each had 16 occupied sea-eagle territories (22.2%) and 11 osprey territories (19.0%), and the Kangaroo Island sub-region had 19 sea-eagle (26.4%) and 14 osprey territories (24.1%).

WHITE-BELLIED SEA-EAGLE

Sea-eagle prey consists mainly of fish, reptiles and a variety of birds (Marchant and Higgins 1993; Olsen *et al*. 2006), and their current distribution reflects the likely abundance of these prey on offshore islands, including pelagic and other seabird species, as well as Cape Barren Geese, *Cereopsis novaehollandiae* (Robinson *et al*. 1996). While this study has highlighted the conservation significance of island habitats (Figure 2), it has also confirmed the species' decline in parts of its historical breeding range, particularly in the upper-Spencer Gulf, on the River Murray and in the South East region (Dennis and Lashmar 1996). Although more occupied sea-eagle territories were recorded in this survey than the 55

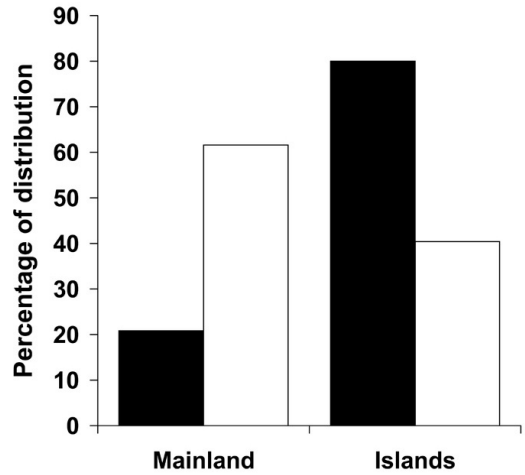

Figure 2. Occurrence of White-bellied Sea-Eagle (black) and Eastern Osprey (white) on mainland and offshore island habitats. With the majority (80%) of the contemporary sea-eagle population, island habitats are crucial to the species' long-term conservation in South Australia.

estimated in a mid-1990s population estimate (Dennis and Lashmar 1996), this may not represent an increase, but rather increased survey effort and coverage. Nevertheless, six previously vacant territories (Dennis and Lashmar1996) were occupied in 2009. These were on the Bunda Cliffs and Point Fowler in the Far West region; Cape Blanche and Hall Bay on Western Eyre Peninsula; and Cape Catastrophe and Boston Island in the Spencer Gulf.

The number of abandoned mainland territories in Table 1 was determined from:
i) historical records, especially in the upper-Spencer Gulf, western Yorke Peninsula, along the River Murray and in the South East;
ii) from derelict nests where there was apparent abundant prey nearby (e.g. seabird rookeries) and space exists for at least one additional territory (e.g. Tourville Bay in the Far West region and Baird Bay, Venus Bay and Coffin Bay on western Eyre Peninsula); or,
iii) where derelict nests were >25 km distant from currently occupied territories (e.g. Cape Adieu and Point Bell in the Far West region, Lochs Well and Coles Point on western Eyre

Table 1: The location and number of occupied White-bellied Sea-Eagle territories identified during the 2008, 2009 and 2010 breeding seasons for each coastal region in South Australia. The estimate of linear population density is the mean distance between 'nearest neighbour' nest sites (excluding island-based territories >10 km offshore) for occupied habitat in each region. The number of abandoned mainland territories identified (in parentheses) represents a likely overall decline of 21.7% (calculated as % abandoned sites/total known sites).

Coastal region	Locality and number of pairs/ occupied territories	Total territories (abandoned)	Habitat density (range)
Far West – Wilson Bluff to Rocky Point	Bunda Cliffs 1, Twin Rocks to Rocky Point 1	2 (3)	127.4 km
Western Eyre Peninsula Rocky Point to Cape Catastrophe	Nuyts Archipelago 9, Rocky Point to Elliston 5, Investigator Group 5, Elliston to Cape Catastrophe 2, Whidbey Group 5, other islands 3	29(6)	28.6 km (2.2 - 67.4 km)
Spencer Gulf – Cape Catastrophe to Cape Spencer	Cape Catastrophe to Cape Spencer 4, Thorny Passage islands 2, Sir Joseph Banks Group 5, Gambier Group 3, other islands 6	20 (4)	57.3 km (6.0 - 155.0 km)
Central Coasts – Cape Spencer to River Murray	Southern Yorke Peninsula 0, Gulf St. Vincent 0, Fleurieu Peninsula 1, Kangaroo Island 19	20 (2)	18.3 km (3.9 - 55.7 km)
South East – Murray River to Vic. border	Historical and vagrant records only	0 (2)	–
Inland rivers and lakes	Murray River 1	1 (3)	–
	Total	72 (20)	**Mean:** 57.9 km

Peninsula and in Gulf St Vincent). Collectively these represent an actual population decline of 21.7% (Table 1).

Sub-adult and non-territorial sea-eagle foraging habitats

In addition to territorial pairs recorded in this survey, solitary adults (and rarely two together) were seen or reported by other observers from most areas, particularly in Gulf St Vincent and the upper-Coorong and Murray River estuary and Lakes region. From the frequency of sightings, the latter region is considered an important foraging area throughout the year for sub-adult sea-eagles; it has abundant prey and importantly, is well clear of potential spatial conflicts with territorial adults. Other locations where sub-adult sea-eagles are regularly recorded include: Tourville Bay and Denial Bay in the Far West region; Baird Bay, Venus Bay, Coffin Bay and Boston Bay on Eyre Peninsula; and in the upper-Murray River floodplain complex e.g. the Bookmark Biosphere Reserve and Chowilla area.

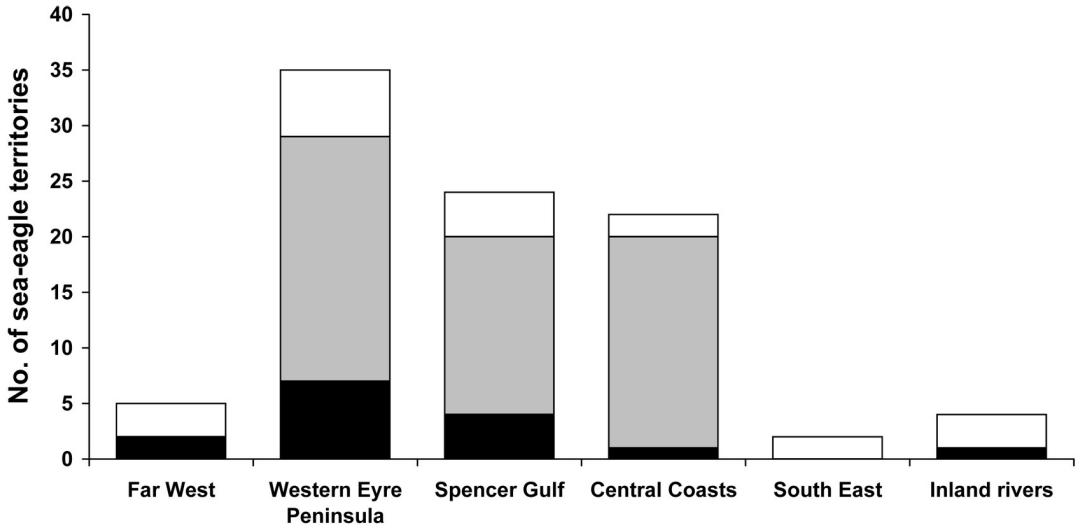

Figure 3: The number of White-bellied Sea-Eagle occupied territories in mainland (black) and offshore island habitats (grey) in South Australia 2008-2010. The number of abandoned territories (white) represents the likely level of mainland population loss for each region.

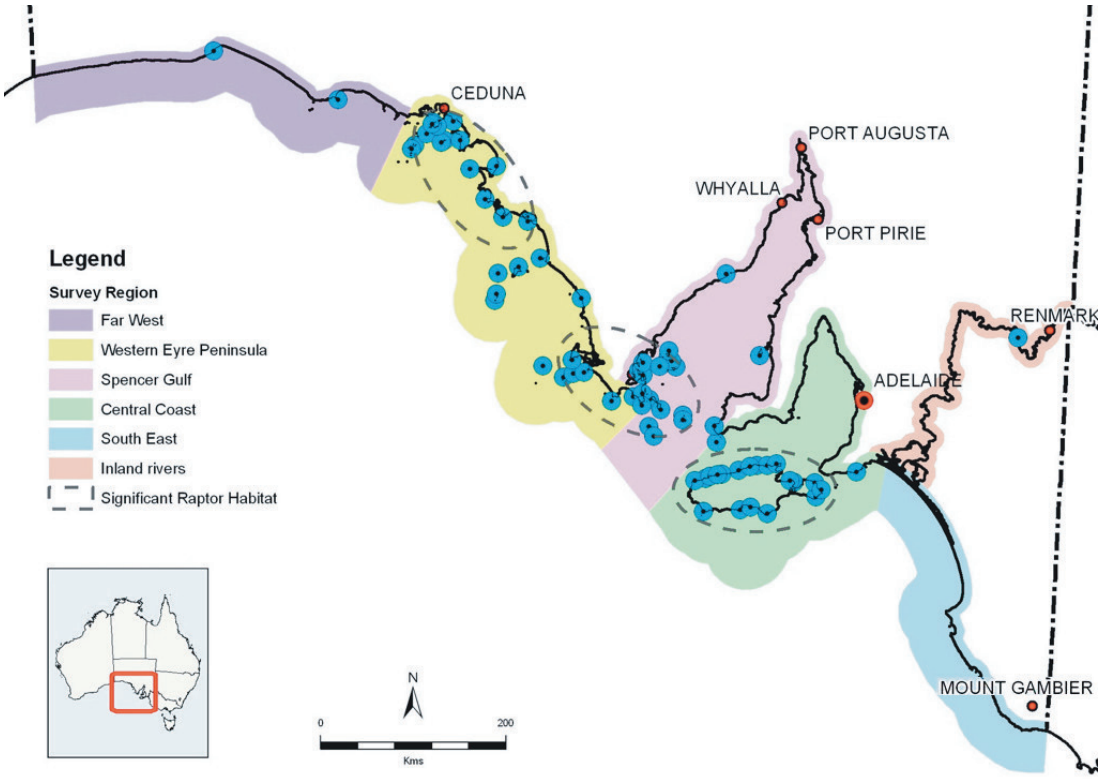

Figure 4: Map of the distribution of White-bellied Sea-Eagle territories in South Australian coastal regions.

Sea-eagle nest sites

Most nests were on cliff-face ledges or in shallow caves, on sheer-sided headlands, or on rock outcrops on steeply sloping coastal terrain. Six were in low (<6 m) coastal trees and some nests on offshore islands were at or near ground level on the plateau-edge or on low bushes.

Far West – Despite the area's remoteness only two occupied territories were found on the ~480 km of coast west of Ceduna. One of these was on the Bunda Cliffs. Three abandoned territories were identified in this region, each on a coastal prominence where high levels of recreational activity and four-wheel-drive (4WD) vehicle use were evident.

Western Eyre Peninsula – Seven occupied territories were found on the mainland, sparsely distributed over ~750 km of coastline, while 22 were on islands (Figure 2). A concentration of occupied territories was found in the Nuyts Archipelago, where eight of nine primary nest sites had a mean separation of 9.7 km (range 2.2 - 18.4 km). Among these, three were on St Peters Island with attended nests having a mean separation of just 4.9 km. However, it is likely that one of these pairs was from nearby (~3 km) Goat Island, which was vacant in 2010.

Spencer Gulf – Just four occupied territories were found over ~860 km of mainland coastline from Thorny Passage to southern Yorke Peninsula. Primary nests in three were in trees, two of which were in Lincoln National Park and the third in mangroves in Franklin Harbour. Despite historical breeding records from mangrove areas in northern Spencer Gulf (e.g. SAM Oology collection records: Yatala Harbour 1899, Reg. No. 29665; and 'near Port Augusta' 1901, Reg. No. B16180), no occupied territories were found there or from mainland Yorke Peninsula.

Several occupied territories were on islands in Thorny Passage and on the Neptune Islands, and were particularly concentrated in the

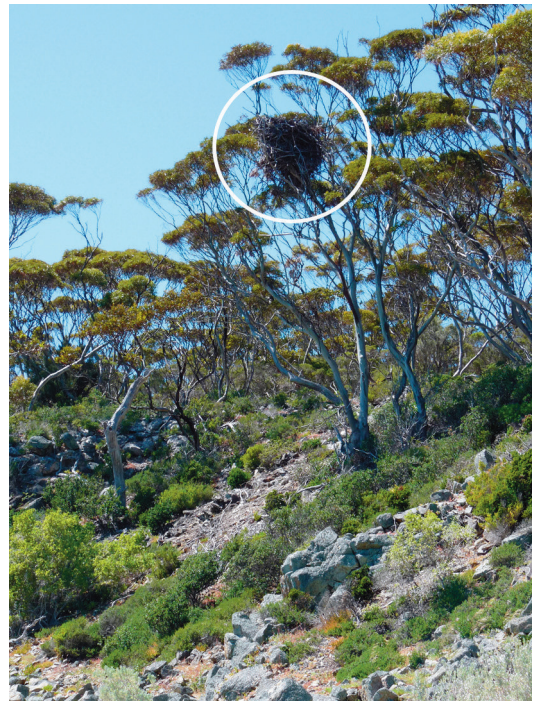

Figure 5. One of the few tree nests (southern Eyre Peninsula).

Sir Joseph Banks Group where attended nest sites (n = 5) were found on most of the larger islands with a mean separation of 10.3 km. Two territories were on islands off Yorke Peninsula, one of which was thought to be a new discovery until the literature search revealed that it had already been found by Dr. AM Morgan and Capt. SA White in 1916 while on an ornithological survey of islands in St. Vincent and Spencer Gulfs (Morgan and White 1916). Following the departure of lighthouse keeper staff from Althorpe Island in 2002, sea-eagles established a territory and breeding was recorded (E. Lawley *pers comm*.). It was presumed that these had moved across from Haystack Island (~6.5 km distant), where a derelict nest structure was recorded in 2010.

Central Coasts – Only one occupied sea-eagle territory was confirmed on the mainland between southern Yorke Peninsula and the River Murray mouth (~480 km), on the Waitpinga Cliffs. Historical breeding records include near

Stenhouse Bay 1901, and near Carrickalinga Head 1938 (RAOU Atlas Scheme database); the latter is likely to be where remnants of a long-abandoned nest structure were found on the cliffs south of the Myponga River estuary during this survey.

Despite frequent reports of adults (and sub-adults) in the St Kilda-Barker Inlet precinct prior to and during the survey period, no evidence of recent breeding activity was found, nor from the mangrove and tidal creek complex near Price at the head of Gulf St Vincent. However, these localities continue to be important foraging areas for transient and sub-adult sea-eagles and breeding may yet occur. 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 activity and associated buildings now occur <200 m from the former nest location. Significant sea-eagle habitat remains on Kangaroo Island, where 19 occupied territories were found in 2010, with primary nest sites having a mean separation of 16.9 km (range 3.9 - 55.7 km). Primary nest sites in 12 of these territories over ~118 km on the comparatively sheltered north coast had a mean separation of 9.8 km (range 3.9 - 23.3 km).

South East – No occupied sea-eagle territories were found in the South East region and only occasional vagrant records have been reported. In the early 1990s there were frequent observations of two adults at Baudin Rocks in Guichen Bay and a nest structure was reported on the middle island (G. Watson *pers comm*.). A single adult was recorded there in January 2009 (R. Anderson *pers comm*.), but none were present during the 2009 breeding season and the reported nest could no longer be found. Among the historical reports for the region is the account of a "white-tailed eagle" and nest "about four foot high" on Penguin Island in Rivoli Bay, seen by members of the Governor Grey Expedition in May 1844 (Angas 1847 (Vol. 1, 2nd Ed.p. 160)). Although generally accepted as a sea-eagle breeding record for the region (e.g. Cleland 1946), what remains intriguing about this account is that Angas recorded the eagle as "hovering round its eyrie", behaviour more typical of osprey and unknown for sea-eagle. There are no recent sightings of either species reported from the Rivoli Bay area.

Inland rivers and lakes – Despite much search effort and vigilance by local volunteers, only one occupied territory was confirmed in the Murray River complex during the survey period. A second sea-eagle territory north of Renmark was occupied by Wedge-tailed Eagles, *Aquila audax*, in 2009 and 2010, with young recorded in the former sea-eagle primary nest in September 2010 (N. Kroemer *in litt*.). It is not known if the sea-eagles were displaced or if they had already relocated prior to the 2009 breeding season in response to a controlled flooding in the Chowilla section of the Bookmark Biosphere Reserve, which resulted in an exceptional concentration of prey species. It is possible the former territory might be re-occupied, or a new territory established elsewhere.

Historical records of sea-eagle breeding sites on the River Murray are many and include: near Morgan 1965, SAO 24: 102 and 1968, SAO 25: 224; Lake Merreti 1966, SAO 25: 32; Spectacle Lakes 1950s (P. Schramm *pers comm*.); Nynes Island 1968-76 (D. Haslam *pers comm*.).
In the northeast of SA, Dennis and Lashmar (1996) reported an active territory from the north-west anabranch of Coopers Creek in 1992. However, this was probably an ephemeral event and only single sub-adults were reported during the survey.

EASTERN OSPREY

In contrast to the White-bellied Sea-Eagle, the Eastern Osprey appears to have adapted more readily to landscape change and human activity in the SA coastal environment. As a

Table 2: The location and number of occupied Eastern Osprey territories identified during the 2008, 2009 and 2010 breeding seasons for each coastal region in South Australia. The estimate of linear population density is the mean distance between 'nearest neighbour' nest sites (excluding island-based territories >10 km offshore) for occupied habitat in each region. The number of abandoned mainland territories (in parentheses) is determined from the number of derelict nest structures >25 km distant from currently occupied territories and represents a likely overall decline of 18.3% (calculated as % abandoned sites/total known sites).

Coastal region	Locality and number of pairs/ occupied territories	Total territories (abandoned)	Habitat density (range)
Far West – Wilson Bluff to Rocky Point	Bunda Cliffs 2, Twin Rocks to Rocky Point 5	7 (1)	59.9 km (20.6 - 163.0)
Western Eyre Peninsula Rocky Point to Cape Catastrophe	Nuyts Archipelago 3, Rocky Point to Elliston 12 Investigator Group 1, Elliston to Cape Catastrophe 11, Whidbey Group 0, other islands 1	28 (4)	19.2 km (2.9 - 64.8km)
Spencer Gulf – Cape Catastrophe to Cape Spencer	Cape Catastrophe to Cape Spencer 3, Thorny Passage islands 0, Sir Joseph Banks Group 0, Thistle Island 2, Gambier Group 1, other islands 2	8 (4)	30.7 km (7.0 - 99.6 km)
Central Coasts – Cape Spencer to River Murray	Southern Yorke Peninsula 0, Gulf St. Vincent 0, Fleurieu Peninsula 1, Kangaroo Island 14, other islands 1	15 (2)	18.9 km (6.8 - 66.2 km)
South East – Murray River to Vic. border	Vagrant records only	0	–
Inland rivers and lakes	Historical and vagrant records only	0 (2)	–
South East – Murray River to Vic. border	Historical and vagrant records only	0 (2)	–
Inland rivers and lakes	Murray River 1	1 (3)	–
	Total	58 (13)	**Mean:** 32.2 km

consequence of this apparent resilience, ospreys have re-occupied primary nest sites in some areas despite displacement to alternative sites following disturbance or increased human activity (Dennis 2004). For example, ospreys have returned after development of cliff-top walkway and tourist lookout at Cape Bauer in 2000, and after site-works and residence construction at Searcy Bay in 2003.

The 58 occupied territories or pairs was similar to the earlier estimate of 52 from surveys in 2003 and 2005 (Dennis 2007a). These were sparsely distributed from the Bunda Cliffs in the west of the state to Kangaroo Island in the east, with the majority on western and southern Eyre Peninsula (Table 2 and Figures 6 & 7).

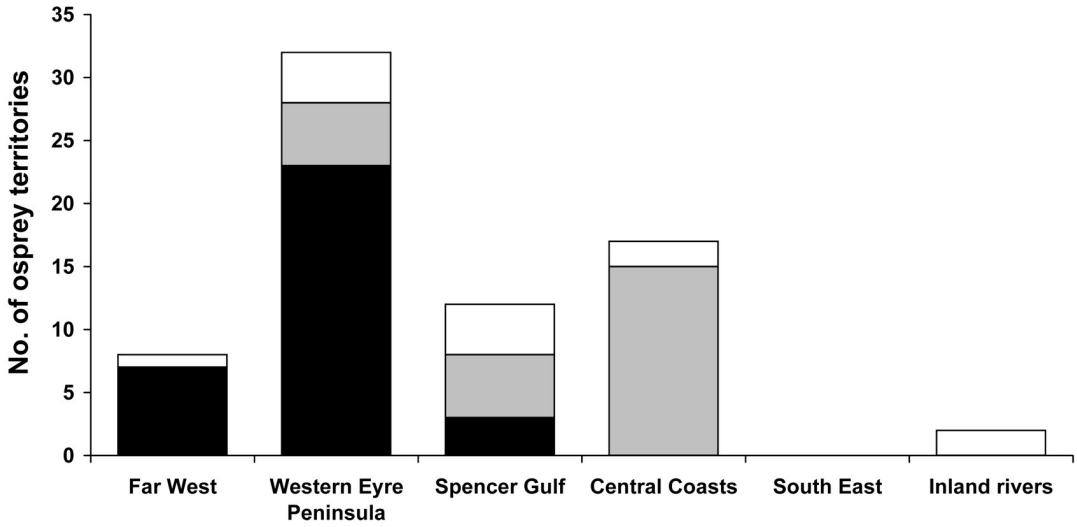

Figure 6. Occurrence of Eastern Osprey on mainland (black) and offshore islands (grey) with abandoned territories (white) for the period 2006-2010.

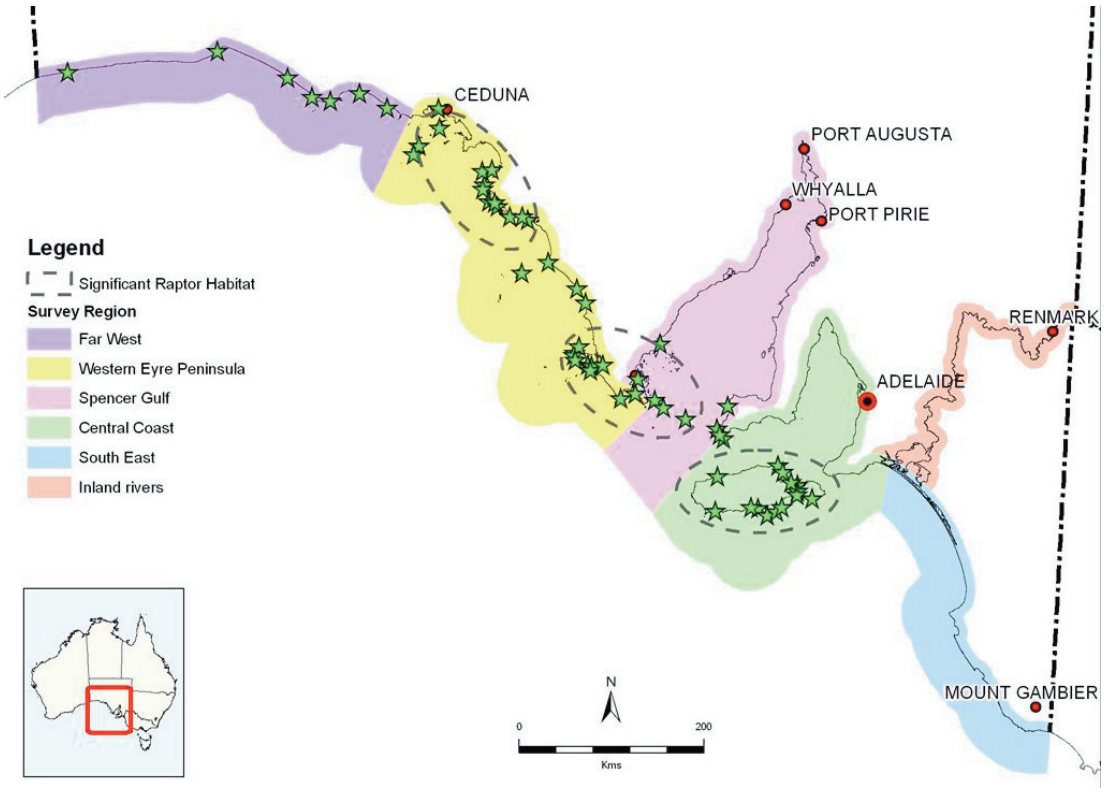

Figure 7. Map of the distribution of Eastern Osprey territories in South Australian coastal regions.

Figure 8. One of the artificial platforms provided by oyster farmers on Eyre Peninsula with both adults and two near-fledged young present, December 2010.

Sub-adult and non-territorial osprey foraging habitats

Single adult osprey were recorded in several areas remote from known breeding territories. These included: Merdayerrah Sands and remote beaches in the Yalata Indigenous Protected Area in the Far West region; several of the extensive shallow bays on Eyre Peninsula; western and eastern Yorke Peninsula and south-eastern Gulf St. Vincent. Osprey are regularly reported from the latter area (e.g. *Bird Records*, Birds SA Newsletters), and in recent years single birds, or two together, are frequently seen in the Onkaparinga and Myponga River estuaries. These have been mainly juvenile or sub-adults, most likely emanating from territories on nearby Kangaroo Island.

Eastern Osprey nest sites

Most nests were on broken sections of coastal cliff and near-shore rock-stacks, but six were on specially constructed artificial platforms, and one was in a tree.

Far West – Seven occupied osprey territories were recorded over ~480 km of coastline in this remote coastal region. Two of these were ~163 km apart on the Bunda Cliffs, between the Head of Bight and Wilson Bluff on the WA border (Figure 7).

Western Eyre Peninsula – The mainland region with the highest density of osprey territories was western Eyre Peninsula. Excluding those based on islands >10 km offshore, 23 primary nests had a mean separation of 19.2 km. Three active nests were on artificial platforms provided by oyster farm operators, motivated by concern for the species in their area. One of these (an upturned lobster pot placed over an oyster lease boundary marker post) has been in continuous use since 1988 and another since 1991, the latter being a wooden tripod structure that has had to be re-built three times after storm-surges (Figure 8).

Spencer Gulf – Only three occupied territories were found on the mainland over ~860 km of coastline in the Spencer Gulf. One has been occupied continuously since the mid-1980s on a specially provided platform situated on an abandoned bulk-loading wharf near Port Lincoln. Several historical breeding records were found for the northern Spencer Gulf. These include records in the South Australian Museum (SAM) Oology collection from nests in mangroves: Mambray Creek 1897, Reg. No. B29670; and Port Germein 1898 -1903, Reg. Nos. B29671, B16374, B10093. In addition, there are records from Port Broughton of a nest on a channel marker (Morgan 1918), and at Murnininnie, where young were banded at a nest in mangroves in 1964 (ABBBS banding record). No occupied territories were found in the northern Spencer Gulf region in this survey.

Central Coasts – No occupied territories were found on the southern Yorke Peninsula

east of Cape Spencer, or elsewhere in Gulf St Vincent. Although breeding does not occur, from the frequency of observations reported from Stansbury to Port Julia, and in the Onkaparinga and Myponga River estuaries, these must be regarded as important foraging areas for transient adult and sub-adult osprey, with potential for breeding territories to be established.

On Kangaroo Island, 14 primary nests were found in 2010, with a mean separation of 18.9 km (Table 2), a similar population density to that of western Eyre Peninsula. Two nests were on specially provided artificial platforms in use since 1990 and 2001, and another, in use since 2007, was on a disused electricity supply pole.

South East – There are occasional vagrant records only from the southeast but there are no historical breeding records (nor from Victoria or Tasmania).

Inland rivers and lakes – Occasional vagrant records only are received from inland rivers and lakes, with the last reliable breeding record for the River Murray region, near Nildottie in 1980 "tree nest … two young fledged" (Robinson 1980).

HABITAT THREATS

Most large eagles use the same nest in consecutive years and are renowned for their sensitivity to disturbance in the breeding season (Newton 1979; Richardson and Miller 1997). Development of coastal land for residential, tourism or industrial purposes increases the level of human activity and, correspondingly, the incidence of disturbance to nesting sea-eagles (Threatened Species Section 2006; Dennis *et al.* in press). In recent decades, change of land-use in coastal areas of SA has emerged as a threat to the refuge quality of sea-eagle habitat. Subdivision of grazing properties into smaller holdings with part-time or permanently occupied housing has exponentially increased 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 *et al.* in press).

Figure 9. A well-used 4WD track follows the cliff-edge in a remote section of Wahgunyah Conservation Park in the Far West region of SA. The track passes directly above and in line-of-sight from a now abandoned White-bellied Sea-Eagle nest site.

In otherwise remote areas, particularly in the west of SA, the 'traditional' practice of gaining access to every beach and coastal feature by 4WD vehicles for recreational pursuits such as fishing and surfing, has resulted in a plethora of vehicle tracks leading to serious erosion and vegetation damage. Many of these tracks closely follow the cliff-edge and are in direct line-of-sight to nests and therefore cause serious disturbance (Figure 9).

Other identified threats to the habitat integrity of both species include ill-timed management activities such as pest plant control programs, or scientific research projects coincident with breeding seasons, or disturbance events such as low altitude aircraft operation. A potential threat is habitat contamination such as an oil spill affecting prey availability. Collectively, these habitat degrading processes and threats have reduced the wilderness quality and therefore the breeding refuge for White-bellied Sea-Eagles on the SA mainland and, to a lesser extent, for the Eastern Osprey.

In some areas inter-species conflict may cause displacement and therefore localised decline. This has occurred in recent years in the upper-Murray region and at a cliff nest site at Kianna on western Eyre Peninsula, where former sea-eagle primary nest sites with a history of long-term occupation were occupied by Wedge-tailed Eagles in 2009-10. Conflict between these species is likely to be spatial, rather than competition for prey (Olsen *et al.* 2006).

The incidence of conflicts between sea-eagle and osprey is common and is likely to stem from varying levels of kleptoparasitism and harassment initiated by sea-eagles (Marchant and Higgins 1993; T. Dennis unpublished data). This may be magnified to intolerable levels on islands, as several osprey nest sites were found deserted on islands during surveys including: St Francis, Waldegrave, Flinders, Reevesby and Althorpe Islands, each of which had an occupied sea-eagle nest site within 3 km.

CONCLUSION

The population of both species have declined in recent decades in SA and are further threatened by apparent continued habitat loss and degradation (Dennis 2007a; Dennis *et al.* 2011 in press). Consequently, it is essential that remaining breeding habitat of the White-bellied Sea-Eagle and Eastern Osprey be specifically protected and managed to minimise disturbance and to maximise productivity. Such measures would include: a) development of specific management prescriptions at vulnerable sites; b) a program of regular monitoring; and c) formal recognition at all levels of Government that land-use planning decisions in coastal areas must include consideration of impacts to threatened (coastal raptor) species habitat. A broad community benefit would be the positive biodiversity outcomes which invariably follow top-order predator habitat conservation (Sergio et al. 2006).

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