Breeding Australian pelican, *Pelecanus conspicillatus*, in the Coorong, South Australia 2010-11

Government of South Australia
Department of Environment and Natural Resources

Government of South Australia

www.environment.sa.gov.au

Cover Page. Australian pelican in breeding plumage, C. Manning 2010 ©

Breeding Australian pelican *Pelecanus conspicillatus*, in the Coorong, South Australia 2010-11

Department of Environment and Natural Resources

Coorong and Lower Lakes District

PO BOX 314

Goolwa

South Australia 5214

Final report for the

Department of Environment and Natural Resources

Department of Environment and Natural Resources (DENR) (2011) Breeding Australian pelican *Pelecanus conspicillatus*, in the Coorong, South Australia 2010-11. Department of Environment and Natural Resources, Adelaide.

Acknowledgements

The DENR Coorong and Lower Lakes District continue to learn a great deal from those who have worked with us over the years and gratefully acknowledge their time and input to improve our understanding of Australian pelicans in the Coorong National Park.

We would like to express our continued thanks to Dr. Greg Johnston for his enthusiasm and guidance. Our thanks to David Connell and Maxwell Waterman for sharing their knowledge of historical banding activities in the Coorong, with a special reference to the Australian pelican. We also acknowledge waterbird data provided by Professor David Paton of the University of Adelaide. In reviewing draft report we thank Steve Bourne and once again Dr. Greg Johnston.

Summary

Australian pelicans (*Pelecanus conspicilatus*) were studied in colonies in the Coorong National Park, South Australia.

In the Coorong, adults regurgitated food consisted mainly of fish in particular *Cyprinus carpio carpio* (European carp), *Perca fluviatilis* (red fin) other food items included *Cherax destructor* (freshwater yabbie). Breeding Australian pelicans were observed on Teal, North Pelican, Pelican and Seagull Island, all of which are islands located in the Coorong South Lagoon. In colonies for which hatching success was monitored (n = 5), only three colonies provided measurable and viable data on survivorship throughout all stages of development. Overall, Australian pelicans showed moderate levels of pre-fledging mortality. Mortality occurred for the most part after eggs had hatched and chicks were confined to the nest.

The hatching success was >80%, suggesting a high level hatching success. Following successful hatching, the mortality of downies ranged between 8 and 54%. While mortality occurred for the most part after eggs had hatched and chicks were confined to the nest, chick survivorship remains greater than chick survivorship observed in other studies (DENR, 2010; Johnston (unpub. data). Fledging birds showed much lower mortality. Overall, the fledging success between colonies was >80%. Australian pelicans wing-tagged at the Outer Harbour rookery near Port Adelaide in South Australia were recorded breeding on islands in the Coorong South Lagoon.

Since inception of the monitoring program in 2009 several advances to understanding the breeding status of Australian pelicans in the Coorong have been made. Distinguishing between successfully hatched chicks, downies and fledged birds has improved our knowledge of pre-fledging mortality, and in the second year of monitoring shown that mortality occurred for the most part after eggs had hatched and chicks were confined to the nest. Overall, pre-fledging mortality appears lower in the Coorong rookery compared to pre-fledging mortality noted at other Australian pelican rookeries

Protection of the Pelican Islands and Coorong Australian pelican colonies is important because the breeding islands are historical breeding sites away from human disturbance and at present mammalian predators.

Keywords: Coorong National Park, Australian pelican, survivorship.

Table of Contents

1.0 Introduction

In Australia, about 70% of water is for irrigated agriculture, and the majority of this is in the Murray-Darling Basin Crabb, 1997 (cited in Kingsford et al., 1999 p.231). In the Murray-Darling Basin, regulation of rivers and diversion for irrigation has caused considerable impacts on river hydrology and wetland ecosystems, in particular to the Coorong and Lake Alexandrina and Lake Albert Wetland of International Significance (Brooks et al., 2009; Paton et al., 2009; Paton, 2010). In the Coorong, Lower Lakes and Murray Mouth (CLLMM) area water resources development combined with periods of drought, in particular 2002-10, resulted in the siltation of the Murray Mouth channel and the hypersalinisation of the Coorong South Lagoon, where salinity excess peaked at four times that of seawater (Brooks et al., 2009). Consequently, changes to the flow regime of the River Murray resulted in significant changes to the ecological character of the region since its listing as a RAMSAR wetland in 1985 (Phillips and Muller 2006).

For example, in 1985, the total abundance for Australian pelican in the Coorong South Lagoon was 6,045 (Paton et al., 2009). In the month of January between 2000 and 2002, Paton (2005) noted a total abundance of >4,000 Australian pelican in the Coorong, 50-75% of which were counted in the Coorong South Lagoon, where traditional breeding islands are located. For the same month <3,000 Australian pelicans were recorded between 2003 and 2005, of which only 20-40% of the birds were in the Coorong South Lagoon (Paton, 2005). Between 2000 and 2007, annual counts of Australian pelicans in January demonstrate a range of 394 to 2,600 individuals in Coorong South Lagoon, a reduction of almost 80% in abundance relative to the species abundance in 1985 (Paton et al., 2009). Between 2008 and 2009, the total abundance of Australian pelican recorded in the Coorong South Lagoon in the month of January was below 330, with a total abundance of 1166 Australian pelicans for the Coorong South and North Lagoon and Estuary area (DENR, 2010). The latter figure was the lowest total abundance recorded for Australian pelicans in the Coorong since observations began in 2000. , In January 2010, the total abundance of Australian pelican in the Coorong South Lagoon was 1828 (DENR, 2010), an increase of over 380% of the birds noted in 2008 and 2009. Despite this short-term increase in the number of Australian pelicans, their number in the Coorong at this time was 30% of the number reported in 1985.

In mid 2010 conditions in the Murray-Darling Basin improved. Flows increased at the South Australia-Victoria border to 32 GL per day[1]. By September 2010, the barrages that separate Lake Alexandrina and the Coorong opened. At this time, there was a significant salinity difference between salinity levels in Lake Alexandrina (freshwater) and the Coorong North Lagoon (marine). Consequently, freshwater fish species were 'stunned' at the open barrages, the transition point between a freshwater and predominately marine environment. European carp are particularly sensitive to salinity above 15‰ (Geddes, 1979).

Long dry periods ('busts') are punctuated by higher flows of high productivity ('boom' periods) (Waterman and Read, 1992; Kingsford et al., 1999). Kingsford et al., (1999) notes that when food resources reach sufficient abundance and waterbirds gain enough weight, they will breed, however in response to water flows piscivorous birds such as the Australian pelican may bred later compared to other birds as it may take some time for fish populations to reach a high enough level for these species to breed. A drawback of such a delay is that there may not be sufficient time to complete the breeding. Australian pelicans abandoned their colony in flooded arid areas of Australia after eggs were laid because the water flow was no longer sufficient (Kingsford and Porter, 1993).

Pelecanidae are among the largest flying birds in the world (Crivelli, 1984) but information on their breeding ecology remains poor (Schaller, 1964; Vestjens, 1977; Knop 1979; Collier et al., n.d; DENR, 2010) and in particular the breeding ecology of the Australian pelican *(Pelecanus conspicilatus)* (Temminck, 1824) (Kingsford and Norman, 2002).

The Australian pelican is one of eight species of pelican (Crivelli, 1984) and is found in Australia and New Guinea (Marchant and Higgins, 1990; DENR, 2010). Most studies of Australian pelicans have

[1] 1 GL (gigalitre equates to 1000 ML (megalitres)

described breeding populations from inland regions (MacGillivray, 1923; Vestjens, 1977; Waterman and Read, 1992) where rookeries of up to 100,000 birds are reported to have bred in response to flood water (Waterman and Read, 1992; Kingsford et al., 1999) but Australian pelican rookeries generally breed in coastal areas with some rookeries often returning each year to bred (Arnold, 1927; Condon, 1941; Chapman, 1963; Eckert, 1965a and b; Chapman et al., 1974; Kluske, 1996; Paton, 2005; Paton, 2010; DENR, 2010; Johnston, unpublished data).

Australian pelicans are reported to mainly eat fish, but will eat a variety of aquatic animals including crustaceans and invertebrates (Eckert 1965b; Vestjens, 1977; Smith and Munro, 2008; DENR 2010). DENR (2010) reported that European carp was the prominent regurgitated food item and rarely crustacean.

Chapman et al., (1974) noted that between 3,000 and 4,000 Australian pelicans breed on islands in the Coorong South Lagoon, South Australia. DENR (2010) found that 2085 Australian pelicans in the Coorong South Lagoon were breeding, a reduction of 50-70% compare to Chapman et al., (1974). In the Coorong, the Australian pelican generally breeds between June and March (Chapman, 1963; DENR, 2010) however this period of egg laying differs to other observations (Vestjens, 1977, Marchant and Higgins, 1990; Pizzey and Knight, 2007; Johnston (2010, *pers. comm.*, 9 July). Pizzey and Knight (2007) report that the most common breeding season for Australian pelicans is August-November while observations of other Australian pelican rockeries note egg-laying takes place in all months of the year, but mostly between June and October (G Johnston 2010, *pers. comm*., 9 July).

Pelecanidae clutch size, hatching success, fledging success and overall reproductive success have been lowered as a result of human (Schrieber and Risebrough 1972; Anderson and Keith 1980; Boellstorff et al., 1988) and aircraft (Bunnel et al., 1981) disturbance. Even in areas far from the site of actual disturbance, low hatching success for the ground nesting Australian pelican appears to be normal (Vestjens, 1977; DENR, 2010; Johnston (unpub. data). Cash and Evans (1984) found low hatching success in clutches of American white pelicans *(Pelecanus erythrorhynchos)* in particular the second hatched chick, which survived in <20% of successful nests. An optimal hatch success for Australian pelicans has been reported to occur in colonies containing about 80 nests or approximately 160 eggs Johnston (unpub. data). In a single colony containing about 250 nests, DENR (2010) found that 12% of 508 eggs (or 61 eggs) successfully hatched. Following successful hatching, studies have shown fluctuating mortality rates. Johnston (unpub. data) found almost 70% during the ten day long nestling period. In contrast, DENR (2010) found recently hatched chick mortality in a single colony was 14.1%. Vestjens (1977) found that 49 of 68 chicks hatched or 72% successfully made it to crèche stage, of which 38 of that 49 or 77.6% that made it to the crèche stage successfully fledge. DENR (2010) were unable to confidently conclude the fledging success due to gaps in the data however in a single colony 52 nearly fledge juveniles were later noted suggesting that up to 85% of the chicks that successfully hatched, potentially fledged. Low hatching success in clutches of other ground nesting waterbirds has also been reported for banded dotterels (*Charadrius bicinctus)*, black stilts *(Himantopus novaezelandiae*) and black-fronted terns (*Sterna albostriata)* (Sanders and Maloney, 2002).

The current report outlines the second year of monitoring aimed to provide information on the breeding status of Australian pelicans in the Coorong. The program specifically aims to document (1) the size of the Australian pelican breeding population in the Coorong, (2) their breeding seasonality, and (3) their breeding success. Survivorship rates are compared to DENR (2010).

2.0 Materials and Methods

2.1. Study Area

The Coorong is comprised of two contiguous long, narrow wetlands of approximately 110 km in total length. The two lagoons, referred to as the *North* and *South Lagoon* are joined by a narrow channel at Parnka Point, which restricts but does not exclude water exchange between the two lagoons. The

lagoons have a maximum depth of 3 m (Paton et al., 2009) and during summer the southern most 11-13 km becomes dry (Paton 2010).

In the Coorong South Lagoon, there are at least 40 islands plus numerous low lying reefs or limestone rock outcrops between Parnka Point and Lake Cantara. Of these islands, six limestone islands consisting of Teal, North Pelican, Halfway, Pelican, Mellor Island and South Reef are collectively referred to as the *Pelican Islands*. The height of these islands above high water varies between 0.3m to 6.0m, and the majority of the islands are <1 ha acre. During summer, water depth around the Pelican Islands may reduce to <1 m. Vegetation on the Pelican Islands consists of sparse annuals and small perennial plants. Native *Rhagodia candolleana ssp. candolleana* (seaberry saltbush) and *Tetragonia implexicoma* (bower spinach) are present on these islands, in particular North Pelican Island. Introduced *Lycium ferocissimum* (African boxthorn), *Mesembryanthemum cristallinumis* (common ice plant), and *Malva* species (mallows) are also common (Chapman, 1963; Seaman, 2005; DENR, 2010) and account for up 56.5% of the species diversity on individual islands (DENR, 2010).

2.2. Logistics

Depending on the time of year and water level, access to the islands in the Coorong South Lagoon including the Pelican Islands is by small flat bottom vessel or canoe, and intermittently by foot. Each mode of transport is determined by external factors e.g. water level, meteorological conditions and resource availability.

2.3. Bird Counts

The Pelican Islands were visited by the DENR Coorong and Lower Lakes District (the District) staff each month between July 2010 and June 2011 when the air temperature was between 18°C and 25°C with little to no wind and no heavy rain. Additional areas of the Park including other islands in the Coorong South Lagoon and the Lower Lakes area were opportunistically searched for colonies of breeding Australian pelicans but the District staff maintained vigilance on daily basis as duties were carried out.

A *colony* was defined as a group of birds that nest and/or roost in close proximity at a particular location. On each island, complete counts of adults in each colony and within 150 m of the shoreline were made. This provided a total abundance of adult Australian pelicans using the Pelican Islands. Birds were observed with binoculars and/or a spotting scope (Swarovski 80 x 65). The aid of a hand-held tally counter and the use of *block counting* were used (see DENR 2010). The circumference of each island was also walked along the shoreline to ensure all birds were counted. Any birds present were counted and added to either the total count of adult birds on the island and/or allocated to a particular colony if this were possible e.g. <10 m from the perimeter of a recognised colony. Still photography using a Canon Power Shot SX20 IS was also used to further aid counts and cross-check field notes.

For the purpose of monitoring breeding success, the number of juveniles (fledged birds), live downies (crèche young), live and dead chicks (pinkies), unhatched eggs and active nests (see definitions below) were recorded monthly for at least one colony at each rookery, referred *0001*. Later within the breeding season, another colony within the largest rookery was also monitored more closely, and for the purpose of this report referred to as *0002*.

Anderson's 1988 study (cited in Carney and Sydeman 1999, p.76) recommended an approach distance for minimizing visitor's disturbance to Pelecanidae between 100 and 600m however, Rodgers and Smith (1995) found that brown pelicans (*Pelecanus occidentalis)* could be approached to <100m on foot, and < 75m in a boat. For the purpose of monitoring breeding success birds were disturbed for a maximum of 12-mins. Not all colonies were monitored however, in which case the number of adults, juveniles, live downies, live and dead chicks, unhatched eggs and active nests were counted with binoculars. Due to the size of individual islands these observations were from a distance of >50m.

2.4.1 Adults

Adults were defined as those birds that showed black and white plumage. If courting, the central ridge of the bill is pink, three-quarters of the length of the mandible at the edge is slate blue, the front parts and the hook are yellow-orange. The skin around the eye is yellow-orange. If incubating, the colours of the bill and gular pouch are faded (Vestjens 1977).

2.4.2 Juveniles

Juveniles were defined as birds where the plumage was brown in areas which are black in adults. Wing converts are shorter than adults. The bill and gular pouch are flesh colour, the head is white, grey or brown, and the naked skin around the eye was flesh in colour (Vestjens 1977). These birds were nearly fledged birds.

2.4.3 Downies

Downies were defined as those birds covered with short grey-white down and about the size of a domestic fowl bird that eventually group with other downies, so forming a crèche.

2.4.4 Chicks

Chicks were defined as naked, pink in colour and open-eyed and termed pinkies, Hatching success was calculated by either (1) subtracting the number of unhatched eggs from the total production of eggs in a colony or (2) the number of chicks known to hatch as a proportion of the total production off eggs within a group.

2.4.4 Unhatched Eggs

Eggs are pure white with the average dimensions of 90 x 59 mm (Vestjens 1977). As the average clutch size of the Australian pelican is two (Vestjens 1977), the proportion of eggs is calculated by counting the number of active nests within a colony and multiplied by two.

2.4.5 Active Nests

Active nest were defined as scrapes or material added to a scrape in which eggs, chicks or sitting adults were observed in. By counting the number of motionless sitting adults (assumed to be incubating) and systematically searching on foot and counting, the total number of active nests in a colony was counted.

The nestling period is 10 days, while the period during which young join a crèche between leaving the nest and fledging at 12 weeks of age is 94 days (Vestjens 1977). The number of nests recorded in a colony was used as an index of colony size. Holm et al., (2003) used nest counts as the best available measure of population size i.e. total abundance however to minimise disturbance this method was only applied to individual colonies rather than the entire rookeries.

2.4 Africa Boxthorn Control

Following a flora assessment on North Pelican Island (DENR 2010) and Teal Island (N Bastian 2011, *pers. comms.*, 7 October) the cover and density of African boxthorn (*Lycium ferocissimum)* was deemed by DENR as a potential threat to nesting habitat availability. Non-native flora however may provide important protective habitat for small native birds and other native fauna at risk of predation by foxes and feral cats (Race 2007), therefore individual plants were checked by District staff prior to control activities. Strategically working between islands and breeding events, the control of Africa boxthorn using glyphosate and low intensity fire (for individual plants >3m) were used. Individual plants <3m were cut and/or drilled and swabbed with glyphosate and the structures left in-situ thus continued to provide shelter for birds from adverse weather. On North Pelican Island, *Isolepis nodosa* (knobby club rush), *Myopurum insulare* (common boobialla), *Rhagodia candolleana ssp. candolleana* (seaberry saltbush) and *Carpobrotus rossii* (native pigface) were re-introduced.

3.0 Results

3.1 Breeding Sites

Within the Pelican Islands, breeding Australian pelicans were observed on Teal, North Pelican and Pelican Island. Breeding Australian pelicans were also observed on Seagull Island <1km south of the Pelican Islands (Table 1). These islands vary in size, the largest of which, North Pelican Island (NPI) is located between Teal and Halfway Island, immediately adjacent to Jacks Point on the mainland. The island is approximately 6 hectares (300m by 200m), with an average height of 4m (Plate 1). The smallest island was Pelican Island (PI). This island is approximately 0.15 hectares (50m by 30m), with an average height of 3m. An active rookery also established on Seagull Island, approximately 1 hectare (50m by 200m), with an average height of 3m (Plate 2). Normally during summer water depth between the mainland and the Pelican Islands may reduce to <1m however water levels remained >1.5m.

Table 1. Known Australian pelican breeding sites in the Coorong, 2010-11.

Site	Zone	Easting	Northing
Teal Island (TI)	54	0370184	6010986
North Pelican Island (NPI)	54	0370257	6010201
Pelican Island (PI)	54	0371659	6007511
Seagull Island (SI)	54	0372897	6005660

Datum in WGS84.

3.2 Abundance of Australian Pelican

Between July and June 2010-11, the Pelican Islands were visited monthly. In February 2011, an Australian pelican colony was observed congregating on Seagull Island and consequently, between March and May 2011 Seagull Island was visited monthly. Individual colonies established on Teal, Pelican and Seagull Island. A total of eight colonies established on North Pelican Island.

In July 2010, the total abundance of Australian pelicans occupying the Pelican Islands was 491 ± 10% (Figure 1), when four colonies in breeding plumage congregated on North Pelican Island (NPI) only. Between August and September 2010 the magnitude of adults rapidly increased.

In September 2010, the total abundance of adult Australian pelicans on NPI peaked to 2939 ± 10% (Figure 1). Compared to the peak total abundance in the 2009-10 breeding season, which peaked in December 2010, this is an increase of 71% and occurred three months earlier (Figure 1). In October 2010, Australian pelicans had begun to congregate on Teal Island (TI). Two additional colonies had also established on NPI and the total abundance of adult Australian pelicans occupying the Pelican Islands was 2351 ± 10%.

By January 2011, the total abundance of adult Australian pelicans occupying the Pelican Islands had reduced to 1402 ± 10%, of which 92.6% (or 1299) were on NPI (Figure 1). Single colonies were also established on TI and Pelican Island (PI). In January 2011, Paton (unpublished data) reported 7260 Australian pelicans in the Coorong, Lower Lakes and Murray Mouth (CLLMM) region (Figure 1), Between February and May 2011, the total abundance of adults ranged from 1091 to 364 ± 10% (Figure 1), the average total abundance of adults for this period being 716. During the same period, a single colony also established on Seagull Island (SI).

Between April and May 2011, the total abundance of adults was <400 (Figure 1). In June 2011, breeding had completed on TI, PI and SI although birds continued to roost on TI. The total abundance of adults however was 935 of which 92.4% (or 864) were on NPI, and the majority of these congregating birds were in breeding plumage.

Over the course of the breeding period, several wing-tagged Australian pelican from the rookery at Outer Harbour at Port Adelaide were observed including birds No. 643, 644, 681 and 803 (Table 2).

Table 2. Observed wing-tagged Australian pelicans from the rookery at Outer Harbour.

Wing-Tag No	Date Observed	Date Tagged	Age (years and months)
643	15 July 2010	24 August 2006	4.10
644	15 July 2010	9 March 2004	4.5
681	10 February 2011	12 October 2006	4.4
803	31 March 2011	6 November 2008	2.4

Plate 1. North Pelican Island (NPI), Coorong South Lagoon April 2011.

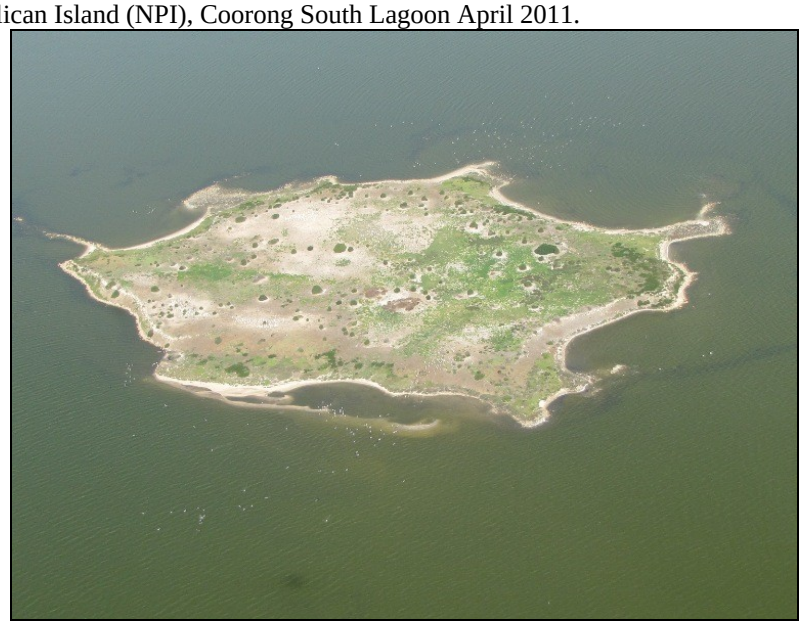
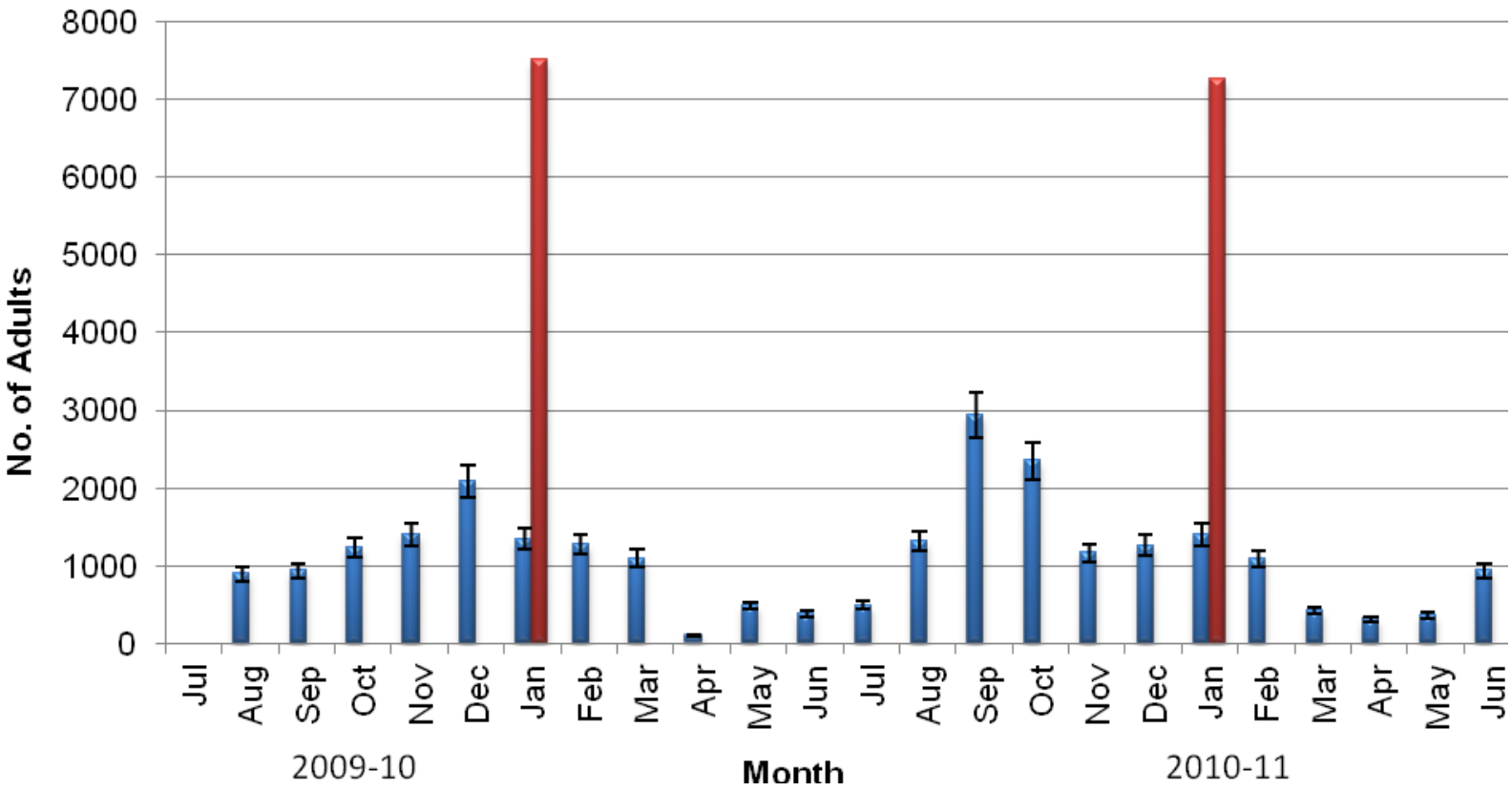


Photo: C. Manning 2011©.

Plate 2. Seagull Island (SI), Coorong South Lagoon April 2011.

Photo: C. Manning 2011©

Figure 1. Total number of adult Australian pelicans in the Coorong, Lower Lakes and Murray Mouth (CLLMM) region in January 2010 and 2011 (red) (Paton unpublished data) and total number of adult Australian pelicans occupying islands in the Coorong South Lagoon (blue) 2009-11 ±10% error.



3.3 Hatching Success and Survivorship

3.3.1 North Pelican Island Rookery

Two colonies were monitored for hatching success and survivorship on NPI. Colony *NPI0001* bred between August and November 2010 and *NPI0002* bred between December and February 2010-11. In August 2010, colony *NPI0001* had 264 breeding pairs. A total of 528 eggs were laid, of which 90% (or 476 eggs) successfully hatched (Figure 2). Of the 476 successfully hatched eggs, 221 chicks successfully survived to the downie stage and formed into a series of crèches. This is a chick survivorship of 42%. Of the 221 chicks, 184 fledged; a fledged survivorship of 35%. This means there was an overall 65% mortality in colony *NPI0001*. In December 2010, colony *NPI0002* was made up of 56 breeding pairs. A total of 112 eggs were laid, of which 28% (or 31 eggs) successfully hatched (Figure 3). During the following visit, a crèche of 45 downies were recorded, giving a survivorship of 40% (Figure 3). During a subsequent visit 2 juveniles were recorded, or <2% of the downies appeared to have successfully survived fledged (Figure 3).

Figure 2. Survivorship curve for single colony North Pelican Island, colony *NPI0001* 2010-11, ± 10%.

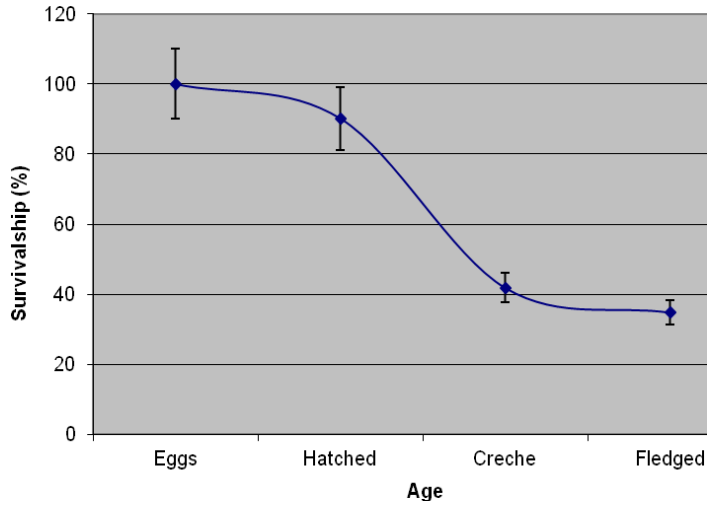
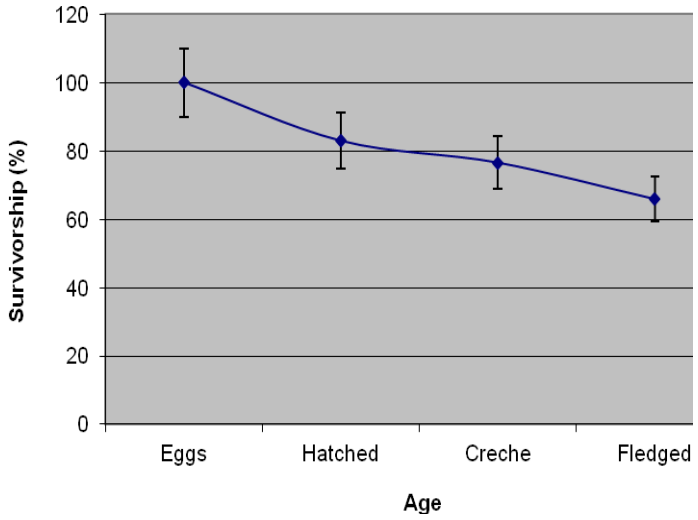


Figure 3. Survivorship curve for single colony North Pelican Island, colony *NPI0002* 2010-11, ± 10%.

3.3.2 Pelican Island Rookery

A single colony of 47 breeding pairs established on Pelican Island (PI), referred as *PI0001*. A total of 94 eggs were laid, of which 83% (or 78 eggs) successfully hatched (Figure 4). Of the 78 successfully hatched eggs, 72 chicks successfully survived to the downie stage and formed crèches. This is a chick survivorship of 77%. Of the 72 chicks, 62 fledged; a fledged survivorship of 66% which means there was an overall 34% mortality.

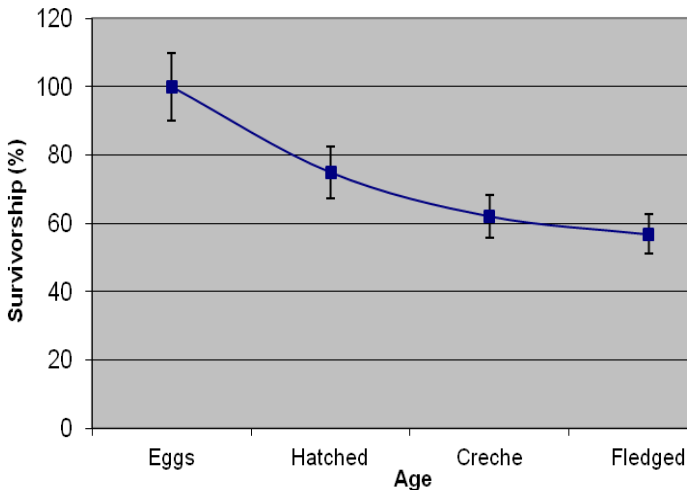
Figure 4. Survivorship curve for single colony on Pelican Island 2010-11, ± 10%.



3.3.3 Seagull Island Rookery

A single colony of 152 breeding pairs established on Seagull Island (SI), referred as *SI0001*. A total of 304 eggs were laid, of which 75% (or 228 eggs) successfully hatched (Figure 5). Of the 228 successfully hatched eggs, 189 chicks successfully survived to the downie stage and formed into a series of crèches ranging from 16 to 34 young. This is a chick survivorship of 62%. Of the 189 chicks, 173 fledged; a fledged survivorship of 57%. Overall, there was 43% mortality.

Figure 5. Survivorship curve for single colony Seagull Island 2010-11, ± 10%.



3.3.4 Teal Island Rookery

A single colony established on Teal Island (TI), referred as *TI0001*. A total of 52 eggs were laid, of which 56% (or 29 eggs) successfully hatched. This means 44% of the eggs were unhatched. Of the 29 successfully hatched eggs, 66% (or 19 chicks) successfully survived to the downie stage. During the following visit, 78 fledged birds were recorded resulting in a fledged survivorship of 150% (Figure 6).

Figure 6. Survivorship curve for single colony Teal Island 2010-11, ± 10%.

3.4 Food

On several occasions adults were observed collecting *Cyprinus carpio carpio* (European carp) *Nematalosa erebi* (bony bream) and *Perca fluviatilis* (red fin). At times, up to 200-300 Australian pelicans were observed feeding at the open barrages, particularly between September and October 2010. These food items along with *Cherax destructor* (freshwater yabbie) and other unidentified crustacean were noted in regurgitated food. The most abundant food items however were the European carp and red fin.

3.5 Predation

Native *Corvus coronoides* (Australian raven) and *Larus novae-hollandiae* (silver gull) were noted at each visit, but in particular following egg hatching. Generally, <12 of each species was recorded, except on Teal Island, where a silver gull colony of <50 breeding pairs had established. Silver gulls were nearly always observed at ground level and at the margins of nesting areas, feeding on eggs that had evidently rolled out of nests and cracked, and/or scavenging on regurgitated food. In contrast, the Australian rravens were seen to perch on the tops of Africa boxthorn or posts, before taking opportunity to feed on eggs or attack pinkies left alone (Plate 3). Following the control of African boxthorn however the number of Australian ravens appeared to reduce. No other evidence of predation e.g. red fox (*Vulpes vulpes*) was noted.

3.6 Human Disturbance

The Pelican Islands and Seagull Island are isolated islands in the Coorong South Lagoon. In 2010-11 the islands were surrounded by water to a maximum depth of 1.5m. Public access to islands within the Coorong is strictly prohibited. Only the District staff and accompanying volunteers were encountered on the islands throughout the breeding season. Visits to the breeding site were minimised to once per month, and detailed counts within individual colonies lasted no more than 12 minutes. When approached by humans, nesting birds took to the air, and after each visit birds were observed to return to their nests within 10-12 minutes. While undertaking Africa boxthorn control,

birds did not appear to be distressed while bushes were cut and swabbed with glyphosate as long as these activities were undertaken >30m from breeding colonies. Low intensity fire for individual plants >3m were undertaken >75m from any birds, which became more alert compared to cut and swab activities but still remained on the island.

Plate 3. Australian ravens observed to perch on the tops of Africa boxthorn or posts, before taking opportunity to feed on eggs or attack pinkies left alone, North Pelican Island, Coorong South Lagoon January 2011.

Photo: C. Manning 2011©.

3.7 Africa Boxthorn Control

A total of 4 individual plants >3m were controlled using low intensity fire. The control of Africa boxthorn achieved 95% and 85% effective on Teal and North Pelican Island respectively (N. Bastian *pers. comms.*, 7 October). On NPI, areas were revegetated using local provenance indigenous plants including *Isolepis nodosa* (knobby club rush), common boobialla (*Myoporum insulare*), *Rhagodia candolleana ssp. candolleana* (seaberry saltbush) and *Carpobrotus rossii* (native pigface) to improve habitat and provide ongoing shelter for Australian pelicans against adverse weather.

4.0 Discussion

During 2010-11, breeding Australian pelicans were observed on Teal, North Pelican, Pelican and Seagull Island located in the Coorong South Lagoon. In 2009-10, Australian pelicans only bred on North Pelican Island although resting adult birds were noted on Teal Island during the breeding period (DENR 2010).

Australian pelicans are reported to mainly eat fish, but will eat a variety of aquatic animals including crustaceans and invertebrates (Eckert 1965b; Vestjens, 1977; Smith and Munro, 2008, DENR 2010). DENR (2010) reported that European carp was the prominent regurgitated food item and rarely crustacean. While adult Australian pelicans were observed collecting and feeding on introduced species European carp, other freshwater species including *Perca fluviatilis* (red fin) and native *Nematalosa erebi* (bony bream) were also prey items. These food items along with *Cherax destructor* (freshwater yabbie) and other unidentified crustacean were noted in regurgitated food often in a partly digested state.

The diversity of diet observed in this study compared to that observed by DENR (2010) may reflex the higher flows from flooding in Victoria and New South Wales and heavy rainfall across in the Murray Darling Basin over the course of 2010-11. In August 2010, flows increased at the South Australia-Victoria Border and peak at 32,000 ML (megalitres) per day. By September 2010, the barrages that separate Lake Alexandrina and the Coorong opened. At this time, there was a

significant salinity difference between salinity levels in Lake Alexandrina (freshwater) and the Coorong North Lagoon (marine). Freshwater fish such as the European carp are particularly sensitive to salinity above 15‰ (Geddes, 1979; Whiterod and Walker, 2006) and thus were 'stunned' at the open barrages, the transition point between a freshwater and marine environment. This appeared to have provided an easily available abundance of non-commercial food source for breeding Australian pelicans as well as other Pelecaniformes such as black-faced cormorant *(Phalacrocorax fuscescens*) and little black cormorant *(Phalacrocorax sulcirostris)*. Flows improved to an average 61,500 ML per day between December 2010 and January 2011, although the timing of the flow remained sensitive to upstream river operations (DfW, 2010). By mid April 2011, when the majority of barrage gates (402 out of 593) were open, flows at the South Australia-Victoria Border were 45,000 to 50,000 ML/day (DfW, 2011). Throughout this period, anecdotal evidence indicated that native fish and other aquatic animal life e.g. yabbies, which breed up quickly in response to flooding, were making a comeback in the revitalised waterways of the Murray-Darling River system.

4.2 Bird Counts

4.2.1 Total Abundance of Adult Australian pelican

Across south-eastern Australia, waterbird populations are in decline (Porter et al., 2006; Nebel et al., 2008), and probably reflects conditions in the Murray-Darling Basin (Paton et al., 2009). The magnitude and scale of this change reflects a general trend around the globe, where more than half of all waterbird populations with known trends are declining (Wetlands International, 2006). For example, between 2000 and 2002, Paton (2005) noted a total abundance of >4,000 Australian pelican in the Coorong, yet for the same month <3,000 Australian pelican were recorded between 2003 and 2005 (Paton, 2005). Between 2008 and 2009, the total abundance of Australian pelican recorded the Coorong was 1166 Rogers (2010, *pers. comm.*, 24 May). The latter figure was the lowest total abundance recorded for Australian pelican in the Coorong since observations began in 2000.

In Figure 1, the total number of adult Australian pelicans occupying the Pelican Islands peaked at 2939 ± 10% in September 2011. In 2009-10, the total number of adult Australian pelicans occupying the Pelican Islands peaked at 2085 ± 10% in December 2010 (DENR, 2010). This is an increase of 71% and occurred three months earlier. This earlier peak in abundance appears to co-inside with the increase of inflows and availability prey items e.g. European carp at the open barrages.

By January 2011, the total number of adult Australian pelicans occupying the Pelican Islands had reduced to 1402 ± 10% (Figure 1). Complete counts of all waterbirds including Australian pelicans have been completed in the Coorong, Lower Lakes and Murray Mouth (CLLMM) region annually since 2000 (Paton, 2010). In January 2009 (before the recent flood event) 5425 Australian pelicans were reported in the CLLMM region (Paton, unpublished data). In January 2010 and 2011, 7509 and 7260 Australian pelicans respectively were reported in the CLLMM region (Paton, unpublished data). This latter figure implies that 19.3% of the total number of adult Australian pelican in the CLLMM region occupied the Pelican Islands. While over 80% of adult Australian pelicans were reported elsewhere within the CLLMM region.

Between April and May 2011 the total abundance of adults was <400 (Figure 1) however by June 2011, the total abundance of adults had increase to 935 and the majority of these congregating birds were in breeding plumage, suggesting the commencement of the 2011-12 breeding season. In the Coorong, egg laying appears to be confined to a period between June and March (Chapman 1963; DENR 2010).

Throughout the 2010-11 breeding season, a total of four wing-tagged adults from the Outer Harbour rookery at Port Adelaide were observed breeding in the Coorong. Of these wing tagged birds, bird 681 was also observed in the 2009-10 breeding season on North Pelican Island on 27 February 2010 (DENR 2010). Bird 644 was also observed on North Pelican Island, however it was later found dead near the Hindmarsh Island bridge, after apparently flown into the over head powerlines Robinson

(2011, *pers. comm.*, 30 August). The presence of these birds breeding on the Coorong demonstrates dispersal between breeding colonies.

4.2.2 Hatching Success and Survivorship

In colonies for which hatching success was monitored (n = 5), 3 colonies provide measurable and viable data on survivorship throughout all stages of development i.e. from point of lay to fledging, these were colonies *NPI0001, PI0001* and *SE0001.* In contrast, survivorship at individual stages of development could only be attained from colonies *NPI0002* and *TI0001.* For example, *NPI0002* and *TI0001* show a hatching success rate of 28% (or 31 eggs) and 56% (or 29 eggs) respectively. In colony *NPI0002* however 45 downies were recorded, giving a survivorship of 40% (Figure 3) i.e. more downies than the total number of successfully hatched chicks recorded. In colony *TI0001,* 37% of successfully hatched chicks survived to the downie stage, however 78 fledglings were recorded, giving a survivorship of 150% (Figure 6) i.e. more fledglings than the total number of downies recorded. These anomalous observations suggest that the time lapse between one monthly observation and the next could be too coarse, as the apparent increase in the number of downies and fledglings within the colonies may reflect the mobile nature of older downies and fledglings from other nearby colonies that had joined *NPI0002* and *TI0001.* Similar observations have been noted at the Outer Harbour rookery at Port Adelaide Johnston (2010, *pers. comm.*, 9 July).

Overall, Australian pelicans from colonies *NPI0001, PI0001* and *SE0001* show moderate levels of pre-fledging mortality. Mortality occurred for the most part after eggs had hatched and chicks were confined to the nest. Studies of survivorship in colonies of Australian pelicans have shown that almost 40% of 1626 eggs (or 650 eggs) from a sixteen colonies successfully hatched in 2003, a high proportion of which had been the result of egg rolls from the nest (Johnston (2010, *pers. comm.*, 9 July). This suggests mortality among eggs was about 60% (or 976 eggs). In a single colony, DENR (2010) found that of 12% of 508 eggs (or 61 eggs) successfully hatched, which suggest mortality among eggs was 88.2%. In contrast, the survivorship of eggs in colonies *NPI0001, PI0001* and *SE0001* in this study have shown that 84.4% of 926 eggs (or 782 eggs) successfully hatched, suggesting an overall egg mortality of 15.6%. Indeed, the hatching success in each colony was 90%, 83% and 75% respectively, suggesting higher level hatching success compared to the Outer Harbour rookery at Port Adelaide and DENR (2010).

The optimal hatch success has been reported to occur in colonies containing about 80 nests or approximately 160 eggs Johnston (unpub. data). In this study, colonies *NPI0001, PI0001* and *SE0001* contained 264, 47 and 152 nests or approximately 528, 94, 304 eggs respectively, which to some extent supports Johnston's observations, although the greatest hatching success was noted in *NPI0001* that contained 264 nests or approximately 528 eggs.

Following successful hatching, Australian pelicans have shown extraordinarily high mortality, almost 70% during the ten day long nestling period Johnston (unpub. data). Figures 2, 4 and 5 show that 42%, 77% and 62% of total egg production within colonies *NPI0001, PI0001* and *SE0001* respectively survived to the downie stage and formed crèches, suggesting overall a greater survivorship of young birds in the Coorong compared to the Outer Harbour rookery at Port Adelaide.

The fledging success in colonies *NPI0001, PI0001* and *SE0001* was between 35, 57 and 66% respectively, suggesting overall mortality was 65, 34 and 43% respectively. Interestingly, fledging success was slightly greater in colonies *PI0001* and *SE0001* compared to that of *NPI0001.* This may reflex that colonies *PI0001* and *SE0001* were single colonies on island locations compared to *NPI0001* that was one of eight colonies established and therefore young might have been at greater risk from cannibalism (Smith and Munro 2008) and/or competition for food from siblings and other young downies, although no observations of cannibalism were recorded.

Overall, lower mortality of fledged birds compared the Outer Harbour rookery at Port Adelaide, may reflect greater food availability and diversity concomitant with greater water flows into the Coorong during 2010-2011.

4.3 Predation

Predation has been a contributing factor in failed success of nesting waterbirds (Brunton 1997; Dowding and Murphy 2001). Native *Corvus coronoides* (Australian Ravens) and *Larus novae-hollandiae* (Silver gulls) were observed at Teal, North Pelican, Pelican and Seagull Island. Generally these native birds were feeding on eggs and/or scavenging on regurgitated food, the Australian Ravens however also attacked pinkies left alone. Similar observations have been reported by Chapman (1963) Eckert (1965b) and DENR (2010). Interestingly, following the control of African Boxthorn the number of Australian Ravens, previously noted to perch on the tops of Africa Boxthorn or posts appeared to reduce although no systematic monitoring was undertaken. No other evidence of predation e.g. *Vulpes vulpes* (Red fox) was noted. At low tide, predation by the Red fox has been reported to account for 11.2 % of colony loss over a 9-year period to the Australian pelican rookery at Outer Harbour at Port Adelaide (Johnston, unpub. data). Predation or disturbance by Red foxes at Outer Harbour was identified by the disappearance of marked eggs between visits and empty nests that were surrounded by tracks. Marked eggs were occasionally found away from these colonies, with one end broken-open and their contents completely removed. Red foxes were reported to enter colonies and scare incubating adult Australian pelicans away from nests, which resulted in birds from one colony abandoning active nests (Johnston, unpub. data). Predation by the Red fox can be devastating on breeding waterbirds (REF). Red foxes can swim, if they have too (Fergus, n.d.) however evidence of Red foxes at Australian pelican rookeries in the Coorong have not been reported recently or historically, even during the recent drought period in South Australia when water levels at the Pelican Island remain at least >0.5m.

4.4 Human Disturbance

Human disturbance has been a contributing factor in failed success of nesting waterbirds (Anderson and Keith, 1980; Carney and Sydeman, 1999), and historically for Australian pelicans in the Coorong (Anonymous, 1911; Barrett, 1911; Chapman, 1963; Chapman et al., 1974). Since monitoring begun in 2009-10, access to the islands was only by District staff and volunteers. Nonetheless, to minimise human disturbance visits to the islands remain monthly.

4.5 Africa Boxthorn Control

Although no systematic monitoring of Africa Boxthorn on North Pelican and Teal Island, anecdotal evidence suggested that their covered had increased over the last decided and reduced the availability of nesting areas (DENR 2010). To some degree however African Boxthorn also appeared to provide some shelter for breeding Australian pelicans. It was therefore vital for a staged removal by working strategically between islands and breeding events. This was especially important as the control period of Africa Boxthorn, in part, coincides with the breeding period of Australian pelicans in the Coorong (DENR 2010).

African boxthorn is a stubborn weed, and control methods including mechanical removal and herbicide application were suitable for seedlings and/or individuals <3m. This method however was only effective if the plants were actively growing, generally limiting this control type to autumn and spring. Prescribed burning has been successfully used as a tool for the control of invasive weeds (Pollak and Kan, 1996; Ditomaso et al 2006), although not generally Africa Boxthorn. Individual plants >3m however presented significant challenges for herbicide application. By prescribed burning the main structures were significantly reduced allowing for a follow up herbicide application. Where individuals were greater than >2m, Common Boobialla (*Myoporum insulare*) was planted in-situ. Follow-up monitoring and treatments will be essential to avoid re-infestation and ensure survivorship of revegetation works.

While undertaking Africa Boxthorn control, birds did not appear to be disturbed during cut and swab activities as long as these activities were undertaken >40m. At times of using low intensity fire for individual plants >3m birds became more alert however did not leave the island. To aid minimal disturbance when using fire to control flora near to breeding sites and/or active colonies, individual

plants were burnt and controlled separately over the course of the breeding season. This staggered and staged method of works appeared to work well in terms of minimising disturbance.

5.0 Conclusion

The establishment of systematic monitoring of pelicans nesting on the Coorong in 2009 has resulted in several advances to understanding the breeding status of Australian pelicans in the Coorong. Distinguishing between successfully hatched chicks, downies and fledged birds has improved our knowledge of pre-fledging mortality, and in the second year of monitoring shown that mortality occurred for the most part after eggs had hatched and chicks were confined to the nest. Overall, pre-fledging survivorship was higher during the 2010-2011 season compared to 2009-10 season (DENR, 2010) and likely reflex's an increase of natural freshwater in flows across the Murray-Darling Basin.

Anomalous observations however suggest that the time lapse between one monthly observation and the next could be too coarse, as downies and juveniles from different breeding colonies converged, making accurate assessment of survivorship post nestling stage difficult as chicks become mobile. To help refine the data it would be advantageous to carry out fortnightly observations.

In addition, while advancements to weed control were made in particular to African boxthorn, this introduced species is a stubborn weed, and long-term control is likely to involve the integration of a number of methods, including mechanical removal, herbicide application, low intensity fire (>3m plants), replacement of appropriate native plants, and ongoing monitoring.

The Australian pelican needs an assured, adequate food supply and an undisturbed nesting area for at least three-months in order to breed successfully. This is the time from the establishment of a nest site to growth of the young bird to near adult size. Thus, the ability of Australian pelicans, and other waterbird populations, to remain stable in the Coorong is dependent on adequate and suitably timed freshwater inflows from the Murray-Darling Basin (Jenson et al., 2000; Paton 2010). To recover and maintain the ecological and cultural integrity of the Coorong and Lakes Alexandrina and Albert that forms the estuary of the Murray-Darling Basin, will require appropriate integrated management of water resources at Basin and local level that recognises the conservation values of downstream ecosystems.

References

Arnold, M., (1927) A trip to the Coorong. *Emu*. 26(3): 207-211.

Anderson, D., and Keith, J., (1980) The human influence on seabird nesting success: conservation implications. *Biological Conservation*. 18(1): 65-80.

Barrett, C., (1911) The Coorong Islands. Emu 1192): 127-128.

Boellstorff., D., Anderson, W., Ohlendorf, H., and O'Neill, E., (1988)Reproductive effects on nest-marking studies in an American White Pelican colony. *Colonial Waterbirds*. 11:215-219.

Brookes, J.D., Lamontagne, S., Aldridge, K.T., Benger. S., Bissett, A., Bucater, L., Cheshire, A.C., Cook, P.L.M., Deegan, B.M., Dittmann, S., Fairweather, P.G., Fernandes, M.B., Ford, P.W., Geddes, M.C., Gillanders, B.M. , Grigg, N.J., Haese, R.R., Krull, E., Langley, R.A., Lester, R.E., Loo, M., Munro, A.R., Noell, C.J. , Nayar, S., Paton, D.C., Revill, A.T., Rogers, D.J., Rolston, A., Sharma. S.K., Short, D.A., Tanner, J.E. , Webster, I.T., Wellman, N.R. and Ye, Q., (2009) *Water for a Healthy Country: An ecosystem assessment framework to guide management of the Coorong*. Final Report of the CLLAMMecology Research Cluster. CSIRO: Water for a Healthy Country National Research Flagship, Canberra.

Brunton, D., (1997) Impacts of predators: Centre nests are less successful than edge nests in a large nesting colony of Least terns. *The Condor*. 99:372-380.

Bunnel, F., Dunbar, D., Kozam L., Ryder, G., (1981) Effects of disturbance on the productivity and numbers of White Pelicans in British Columbia – observations and models. *Colonial Waterbirds*. 4:2-11.

Carney, K., and Sydeman, W., (1999) A review of human disturbance effects on nesting colonial waterbirds. *Waterbirds*. 22(1): 68-79.

Cash, K., and Evans, R., (1984) Brood reduction in the American white pelicans *(Pelecanus erythrorhynchos). Behavioural Ecology and Sociology*. 18:413-318

Chapman, F., (1963) The Pelican in South Australia with special reference to the Coorong Islands. *The South Australian Ornithologist*. 6-13.

Chapman, F., Delroy, L., and Noye, B., (1974) Aquatic birds of the Coorong. In Noye, B., (1974) *The Coorong*. The University of Adelaide.

Collier, N., Brown, A., and Hester, M., (n.d.) Report on searches for seabird breeding colonies in the Lesser Antilles. Available from: http://www.epicislands.org/Update%20on%20Seabirds%20of%20the%20Lesser%20Antilles.pdf [Accessed 06 July 2011].

Condon, H., (1941) Young pelicans. *Ibid*. 41: 92-93.

Crivelli, A., (1984) Status of the Pelecanidae. *Biological Conservation*. 30: 147-156.

Department of Environment and Natural Resources (DENR) (2010) Breeding Australian pelican, *Pelecanus conspicillatus*, in the Coorong National Park, South Australia 2009-2010. Department of Environment and Natural Resources, Adelaide.

Department for Water (DfW) (2010) River Murray flow advice update 31 December 2010. Available from http://www.waterforgood.sa.gov.au/wp-content/uploads/2010/12/flows-advisory-9-31-dec-2010.pdf [Accessed 31 October 2011].

Department for Water (DfW) (2011) River Murray flow advice update 1 April 2011. Available from http://www.waterforgood.sa.gov.au/wp-content/uploads/2011/04/flows_advisory_1_april_20111.pdf [Accessed 31 October 2011].

Ditomaso, J., Brooks, M., Allen, E., Minnich, R, Rice, P., and Kyser, G., (2006) Control of invasive weeds with prescribed burning. *Weed Technology*. 20(20): 535-548.

Dowding, J., and Murphy, E., (2001) The impact of predations by introduced mammals on endemic shorebirds in New eland: a conservation perspective. *Biological Conservation*. 99(1): 47-64.

Eckert, J., (1965a) Pelican breeding in Lake Alexandrina. *Emu*. 64(2): 146-147.

Eckert, J., (1965b) Pelicans breeding near Milang. *The South Australian Ornithologist*. 24: 36-37.

Fergus, C., (n.d.) Red and Gray Foxes. Available from http://www.nysenvirothon.net/foxes_1_.pdf [Accessed 17 November 2011]

Geddes, M., (1979) Salinity tolerance and osmotic behaviour of European carp (Cyprinus Carpio L.) from the River Murray, Australia. Transcript of the Royal Society of South Australia. 103(7): 185-189.

Holm, G. O., T. J. Heiss, D. Justic, L. McNease, R. G. Linscombe & A. S. Nesbitt (2003) Population recovery of the Eastern Brown Pelican following its extirpation in Louisiana. *Wilson Bulletin*, 115, 431.

Jenson, A., Good, M., Tucker, P., and Long, M., (2000) River Murray barrages – environmental flows. An evaluation of environmental flow needs in the lower Lakes and Coorong. Canberra, ACT, Murray-Darling Basin Commission.

Johnston, G., (unpublished data) What drives the change in reproductive seasonality in a coastal Australian pelican rookery? Spatial and temporal aspects of colonial nesting in Australian pelicans (*Pelecanus conspicillatus*).

Kingsford, R., and Porter, J., (1993) Waterbirds of Lake Eyre, Australia. *Biological Conservation*. 65:141-151.

Kingsford, R., Curtin, A., and Porter, J., (1999) Water flows on Cooper Creek in arid Australia determine 'boom' and 'bust' period for waterbirds. *Biological Conservation*. 88:231-248.

Kingsford, R., and Norman, F., (2002) Australian waterbirds – products of the continuant's ecology. *Emu*. 102: 42-69.

Kluske, K., (1996) *Coorong National Park Notes*. South Australian Department for Environment and Heritage, Adelaide.

Marchant, S., and Higgins, P., (1990) *Handbook of Australian, New Zealand and Antarctica Birds. Vol. 1 Ratities to Ducks*. Oxford University Press, Melbourne.

MacGillivray, W., (1923) The nesting of the Australian pelican (*Pelicanus conspicillatus*). *Emu.* 22, 162.

Nebel, S., Porter, J., and Kingsford, R., (2008) Long term trends of shorebird populations in eastern Australia and impacts of freshwater extraction. *Biological Conservation*. 141:971-980.

Paton, D., (2005) Monitoring of biotic systems in the Coorong region 2004-2005. Project report for Earthwatch Australia and for the Department for Environment and Heritage.

Paton, D., and Rogers, D., (2009) Conditioning monitoring of indicator bird species in the Lower Lakes, Coorong and Murray Mouth Icon site: Coorong and Murray Mouth Estuary 2009. South Australian Murray-Darling Basin Natural Resource Management Board.

Paton, D., Rogers, D., Hill, B., Bailey, C., and Ziembicki, M., (2009) Temporal changes to spatially stratified waterbird communities of the Coorong, South Australia: implications for the management of heterogenous wetlands. *Animal Conservation*. 12:408-417.

Paton, D., (2010) *At the End of the River: The Coorong and Lower Lakes*. ATF Press.

Phillips, W., and Muller, K., (2006) *Ecological Character of the Coorong, Lakes Alexandrina and Albert Wetland of International Importance*. South Australian Department for Environment and Heritage.

Pizzey, G., and Knight, F., (2007) *The field guide to the birds of Australia*. 8th edition. Harper Collins publishers.

Pollak, O., and Kan, T., (1996) The use of prescribed fire to control invasive exotic weeds at Jepson Prairie Preserve. Pages 241-249 *in:* C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, CA. 1998.

Porter, J., Kingsford, R., and Hunter , S., (2006) *Aerial Surveys of Wetland Birds in Eastern Australia October 2003-2005*. Department of Environment and Conservation, NSW. Occasional Paper No. 37.

Race, D., (2007) *Review of the Murray Catchment Management Authority Trail Project: Control of African Boxthorn within remnant vegetation*. A report to the Murray Catchment Management Authority. Institute for Land, Water and Society, Charles Sturt University, NSW South Wales.

Rodgers, J., and Smith, H., (1995) Set-back distances to protect nesting bird colonies from human disturbance in Florida. *Conservation Biology*. 9:89-99.

Sanders, M., and Maloney, R., (2002) Causes of mortality at nests of ground-nesting birds in the Upper Waitaki Basin, South Island, New Zealand: a 5-year video study. *Conservation Biology* 106(2): 225-236.

Schaller, G.B., (1964) Breeding behavior of the white pelican at Yellowstone Lake, Wyoming. *Condor*. 66, 3.

Schrieber, R., and Risebrough, R., (1972) Studies of the Brown Pelican. *Wilson Bulletin*. 84:119-135.

Seaman, R., (2005) *Coorong Health Check Report 2004-2005*. Conservation Programs South East Regional Conservation. South Australian Department for Environment and Heritage.

Smith, A., and Munro, U., (2008) Cannibalism in the Australian pelican *Pelecanus conspicillatus*, and Australian white ibis *Threskiornis molucca*. *Waterbirds*. 31(4): 632-635.

Vestjens, W., (1977) Breeding behaviour and ecology of the Australian Pelican, *Pelecanus conspicillatus*, in New South Wales. *Australian Wildlife Research*. 4: 37-58.

Waterman, M., and Read, J., (1992) Breeding success of the Australian Pelican (*Pelecanus conspicillatus*) on Lake Eyre South in 1990. *Corella*. 16, 123.

Wetlands International (2006). *Waterbird Population Estimates*, fourth ed. Wetlands International, Wageningen, The Netherlands.

White, S.A., (1918) A visit to the breeding grounds of swan and pelican on the Coorong. *The South Australian Ornithologist*. 3:198-200.

Whiterod, N., and Walker, K., (2006) Will rising salinity in the Murray-darling Basin affect common carp (Cyprinus carpio L.)? *Marine and Freshwater Research*. 57:817-823.

Personal Communications

Bastian, N., 2011. *Discussion on weed control in the Coorong*. (Pers. Communication 7 October 2011).

Johnston, G., 2010. *Discussion on Australian pelican rookery, Outer Harbour*. (Pers. Communication 9 July 2010). greg.johnston@flinders.edu.au

Johnston, G., 2011. *Email correspondence on tagged pelicans from Outer Harbour rookery*. (Pers. Communication 4 September 2011). greg.johnston@flinders.edu.au

Robinson, R., 2011. *Email correspondence on tagged pelican 466 from Outer Harbour rookery*. (Pers. Communication 30 August 2011). renarobin@picknol.com.au