Breeding Australian pelican, *Pelecanus conspicillatus*, in the Coorong National Park, South Australia 2009-2010

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Summary

The Coorong and Lakes Alexandrina and Albert in South Australia are globally significant wetland systems, listed in the Ramsar Convention under a number of different criteria, including its importance to waterbird populations. The Australian pelican is highly symbolic of the Coorong and Lakes Wetland of International Importance and of cultural significance to the Ngarrindjeri people. There has long been extensive interest in their status because islands in the Coorong National Park represent a regular historic breeding location in South Australia. Information on breeding ecology of Australian pelicans in the Coorong appears to have been based on single and infrequent visits during any one breeding season.

Monitoring methodologies were established and the nest sites of breeding Australian pelicans were monitored monthly throughout the 2009-10 breeding season to determine a range of breeding success e.g. no. of eggs laid, no. of chicks hatched and no. of successfully fledged thus providing a baseline data set.

Australian pelican were found breeding on North Pelican Island located in the Coorong South Lagoon and in terms of diversity, non-native species made up 56.5% of the vegetation on the island. The total abundance of individual adult Australian pelican peaked to 2085 in December 2009. Eight colonies were initiated on the island, occupying approximately 50% of the island. The breeding period was confined between June and March and the average clutch size was two.

In one colony, 12% of the eggs laid successfully hatched, while hatched chick mortality was 14.1%. The number of nearly fledge juveniles observed in the same colony suggest that up to 85% of the chicks successfully hatched were ~12 weeks old however because of gaps in data (due to extreme weather conditions) this figure should be viewed with caution.

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 to near adult size.

Re-defining and classifying terminology to distinguish between pinkies and juveniles will provided greater understanding of survivorship at different stages of early life from point of lay to hatchling, crèche stage and fledged birds.

Keywords: Coorong National Park, Australian pelican, survivorship, monitoring

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1.1 Introduction

The Coorong and Lakes Alexandrina and Albert are located south-east of Adelaide, South Australia. In 1985 they were designed as a Wetland of International Importance under the Ramsar Convention. Situated at the terminus of the Murray-Darling Basin, it is approximately 140,500 hectares, and comprises one of Australia's largest wetland systems, which is of great importance to breeding and non-breeding waterbird species (Paton et al., 2009). Surface water inflows are mainly from the River Murray into the north of Lake Alexandrina, with other inflows from tributary streams draining the Eastern Mount Lofty Ranges along the northwestern edge of Lake Alexandrina. Rainfall on the lake surfaces and groundwater discharge are also significant inputs (Phillips and Muller 2006). Historically, surface flows of freshwater naturally flowed from the south east of South Australia. In recent years, inflows from the south east into the Coorong's South Lagoon have been re-established, although under regulated conditions. This is via the Upper South East Drainage Scheme. Lake Albert lies to the south east of Lake Alexandrina connected via a narrow channel (Narrung Narrows). Lake Alexandrina is the primary source of inflows to Lake Albert. Freshwater of the River Murray and Lake Alexandrina are separated by a series of five barrages from the more saline waters of the Murray Mouth estuary and Coorong lagoons. As the estuary of Australia's largest river system, the ecological condition of these wetlands are of State and National concern.

Due to escalating demands for water and over-allocation of water resources in the Murray-Darling Basin, combined with severe drought, the magnitude and the timing of River Murray inflows to the region have changed significantly since European settlement. These changes have led to severe impacts upon the Coorong, Lower Lakes and Murray Mouth (CLLMM) (Kingsford et al., 2009). Changes to the flow regime of the River Murray have resulted in significant changes to the ecological character of the region, and although River Murray inflow during March 2010 was 150 GL, which was higher than the 40 GL received in March 2009 the inflows are less than the long-term March average of about 190 GL. Salt carried along the River Murray from upstream is naturally washed out to sea through the Murray Mouth. With less water flowing down the River Murray however, only a very small amount of water has flowed through to the sea since late 2005. This means that water levels remain below sea-level and because the amount of water entering the lakes has not matched evaporative losses in recent years, there has been a build up of salt. One effect of this is that salinity levels have increased throughout the CLLMM region. The salinity of seawater is approximately 35‰ however in recent year's salinity levels throughout the Lower Lakes and Coorong have increased but particularly in the South Lagoon (Paton, 2005) where salinity levels now exceed 150‰ (MDBC 2008). With decreasing inflows, salinity levels have exceed the salinity tolerance of key fish species (Paton, 2005; Wedderburn et al., 2008), resulting in dramatic decline in species diversity and abundance (Paton 2005; Paton et al., 2009; Paton and Rogers, 2009; Wedderburn and Barnes, 2009; Kingsford et al., 2009). Studies have shown that salinity is a driving factor of the Coorong food web (Deegan et al., 2009), and dramatic changes to salinity levels has reduced the number of Small-mouthed Hardyhead *Atherinosoma microstoma* (Gunther, 1861), a known source of food for adult pelicans and their chicks (Paton, 2005).

1.1 Australian pelican in the Coorong National Park

The Australian pelican *Pelecanus conspicilatus* (Temminck, 1824) is one of eight species of pelican, which is found on freshwater, estuarine and marine wetlands and waterways including lakes, swamps, rivers, coastal islands and shores of Australia and New Guinea (Marchant and Higgins 1990). Although this species has occasionally been observed in Fiji, Indonesia and New Zealand Connell (2009, pers. comm. 23 January) these records are of stragglers moving beyond the species normal geographic range. The Australian pelican is currently evaluated as Least Concern on the 2009 IUCN Red List (BirdLife International 2009) however there is evidence for a decline in numbers of Australian pelican over large parts of Australia (Porter et al., 2006).

The lower River Murray including the Coorong and Lakes Alexandrina and Albert Wetland of International Importance are particularly important to Ngarrindjeri people as the area include environments and resources that have been central to their cultural survival for thousands of years (Ngarrindjeri Nation, 2006). Ngarrindjeri people hold cultural and spiritual connections to particular places, to particular species of animals and plants, and all elements of the environment are part of their kinship system. Particular animal and plant species are the *Ngartji* (totem or special friend) of the Ngarrindjeri people, who have special responsibility to care for their *Ngartji*. To care for *Ngartji* is to care for country (Ngarrindjeri Nation, 2006). There are several Ngarrindjeri Creation stories concerning the sacred nature of the waters of the lower River Murray and of *Ngori* (pelican), a *Ngartji* of Ngarrindjeri people Hartman (2010, pers. comm. 3 March). In recent years, the Australian pelican has also become symbolic of the Coorong and Lower Lakes Wetland of International Importance, particularly following the 1976 Australian film, *Storm Boy*, based on the children's book by Colin Thiele about a boy and three rescued Australian pelicans.

There has long been extensive interest in Australian pelicans because islands between Woods Well and Salt Creek in the Coorong National Park (CNP) represent a regular historic Australian pelican breeding location in South Australia (Sturt 1831; Arnold, 1927; Condon, 1941; Chapman, 1963; Eckert, 1965; Chapman et al., 1974; Kluske, 1996; Paton, 1982; Paton, 2005; Paton, 2010). It is for that reason combined with records of bird massacres and other human disturbance (Anonymous 1911; Barrett 1911; Condon, 1941; Chapman 1963) that individual islands including 200m from their shoreline were declared prohibited areas in 1963 (Chapman et al., 1974; Kluske, 1996).

Knowledge of the movements of Australian pelican in the Coorong improved between 1984-2004 when the Coorong National Park Banding Program was implemented, under the auspices of the Australian Bird and Bat Banding Scheme (ABBBS). Bird bands were returned from most Australian States and as far away as the Gulf of Papua New Guinea (Kluske, 1996). In 1985, the total abundance (the total number of individuals of a certain species present in an area) 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 CNP, 50-75% of which were counted in the South Lagoon where traditional breeding islands are located. For the same month <3,000 Australian pelican were recorded between 2003 and 2005, of which only 20-40% of the birds were in the South Lagoon (Paton, 2005). Between 2000 and 2007, annual counts of Australian pelican in January demonstrate a range of 394 to 2,600 individuals in South Lagoon, a reduction of 77.3% 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 South Lagoon in the month of January has been below 330, with a total abundance for the South and North Lagoon and Estuary area as 1166 Rogers (2010, pers. comm. 24 May). The latter figure is the lowest total abundance recorded for Australian pelican in the CNP since observations began in 2000. In January 2010, however the total abundance of Australian pelican in the South Lagoon was 1828 Rogers (2010, pers. comm. 24 May), a 384% increase of the birds noted in 2008 and 2009. Despite this short-term increase in the number of Australian pelican, the number of Australian pelicans on the Coorong in January 2010 was 30% of the number reported in 1985.

Between 3,000 and 4,000 Australian pelicans have been reported to breed on islands in the South Lagoon (Chapman et al., 1974). In the 1962-63 breeding season, Chapman (1963) noted approximately 875 individuals breeding for the month of September whereas something like 3,500 individuals were observed for the same period the following season. In July 1910, forty-two nests were reported on an island adjacent to Jacks Point in the South Lagoon (Barrett, 1911), indicating at least 84 eggs might have been laid. Arnold (1927) noted twenty nests on a low-lying island in the Coorong in the month of October 1924 where the birds were reported to be nesting on bare, sandy ground. In October 1929, 200 nests were reported on the highest point of an island in the South Lagoon (Hanks; 1930; Sutton 1930 (cited Chapman 1963, p. 10) indicative of at least 400 eggs potentially laid. Generally, between 1910 and 1965 the numbers of eggs and chicks vary from 500 to 2000 (Chapman, 1963; Paton, 1982). In a single visit to North Pelican Island Seaman (2005) noted

two nesting areas had been established with a total of 80 nests containing an average of 2 eggs per nest. Overall, the numbers of eggs and chicks reported vary considerably. The 1981-82 season was apparently an exceptional good breeding season Wanke 1982 (cited Paton 1982, p 20), although no counts were made. Interestingly this was a year of above-average rainfall and before one of South Australia's severe drought in 1982-83 (Government of South Australia, 2004). Breeding Australian pelicans have also been reported on Seagull Island, south of the Pelican Islands (Paton, 1982), near the Snake Pit on the Younghusband Peninsula (date unknown) Jenkins (2010, pers. comm. 19 May) and at Reedy Point near Milang on the western shore of Lake Alexandrina where up to 400 nests were recorded (Eckert, 1965; SNC, 2000). There are also reports of breeding Australian pelicans on a sandy island 3km east of the River Bremer mouth (SNC, 2000).

While the abundance of Australian pelicans in the Coorong has been recorded annually since 2000 (Paton 2009), across Australia information on the breeding ecology of Pelecaniformes (Australian pelican and cormorants) is considered poor (Kingsford and Norman, 2002), and even more sparse for the Australian pelicans in the CNP. What is known is based on single and infrequent visits during any one breeding season (Barrett, 1911; Arnold, 1927; Condon, 1941; Chapman, 1963; Seaman, 2005) with no regular monitoring of breeding success having been published, as was noted by Paton (1982: 20).

This report outlines a monitoring program designed to provide information on the breeding status of Australian pelicans in the CNP from August 2009 to June 2010. The program specifically aimed to document (1) the size of the Australian pelican breeding population in the Coorong, (2) their breeding seasonality, and (3) their breeding success. These data will provide a baseline data set, to which future monitoring of breeding pelicans on the Coorong may be compared.

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 *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 South Lagoon, between Woods Well and Salt Creek, six limestone islands consisting of Teal, North Pelican, Halfway, Pelican, Mellor Island and South Reef are located. Collectively these islands are loosely referred to as the *Pelican Islands*. The height of these islands above high water varies between 0.3m to 6.0, and the majority of the islands are <1 ha acre. During summer water depth around the Pelican Islands may reduce to <1 m. Chapman (1963) indicated that vegetation on the Pelican Islands consists of sparse salt tolerant species of annuals and small perennials. Non-native *Lycium ferocissimum* (African Boxthorn), *Mesembryanthemum cristallinumis* (Common Ice Plant), and *Malva* species (Mallows) have also been reported (Chapman, 1963; Seaman, 2005).

2.2. Logistics

Depending on the time of year and water level, access to the Pelican Islands is possible 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. Vegetation

In early autumn, a walk-over field survey combined with a voucher survey of the site identified the diversity of native and non-native flora. One botanist walked over the site looking at which species occurred. All plants were identified to the level practicable in the field. Two vouchers of each

species found were collected, tagged and tag numbers recorded before being formally identified at the State Herbarium of South Australia.

2.4. Bird Counts

Active surveillance (fortnightly) of the Pelican Islands by DENR Coorong and Lower Lakes District staff (DENR CLL District) and/or verbal reports from community volunteer triggered the census period when Australian pelicans were observed returning to the Pelican Islands and adults were seen congregating. Other areas of the Park or the Lower Lakes area were not purposely searched for colonies of breeding Australian pelicans but DENR CLL District staff maintained vigilance on daily basis as Park duties were carried out. Early morning coincide with the parent birds being away from the breeding site in search of food (Vestjens, 1977) and therefore observations were made between 1030 and 1200hrs when it was presumed the parent birds to have returned to the breeding colony. To minimise stress on the birds and reduce opportunistic predation, visits to the islands were made once per month when the air temperature was between 18°C and 25°C with little to no wind or and no heavy rain.

A colony was a group of birds that nest and/or roost in close proximity at a particular location. Complete counts were made of adults in each colony and within 150 m of the shoreline during each visit to the island. As colonies formed they were numbered chronologically e.g. Colony 1, 2, 3 and so on. In addition, the number of juveniles, live and dead chicks (e.g. pinkies and crèche young), unhatched eggs and active nests (see definitions below) were preformed monthly during the same period for the first colony to breed, referred as *Colony 1*. The bird counts were performed on foot by two observers recording abundance of birds from at least 50m from any individual colony at the most favourable visual point on the island. For the purpose of counting live and dead chicks, unhatched eggs and active nests birds in Colony 1 were disturbed for a maximum of 12-mins. From a minimum distance of 50m, birds were observed with binoculars and with a spotting scope (Swarovski 80 x 65). The aid of a hand-held tally counter and the use of *block counting* were used. Block counting involved counting or estimating a *block* of birds within a colony. Each colony was counted in a block size of 10 (Figure 1). The block was used as a model to measure the remainder of the colony. The circumference of the 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 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. In addition, each island was divided into 50 m by 50 m cells and the location of each colony on each island was mapped.

Figure 1. Block Counting. This flock contains an estimated 60-70 bird (i.e. 6 blocks of 10 birds plus several left over). (NB actual size is 66 birds) (Subramanian and Sethuraman, n.d).

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 Chicks

Chicks were defined as naked, pink in colour and open-eyed and termed pinkies, and also those birds covered with short grey-white down and about the size of a domestic fowl bird referred to as downies that eventually group with other downies, so forming a crèche. 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 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.

3.0 Results

3.1 Breeding Sites

Between August 2009 and June 2010, the Pelican Islands were visited monthly and/or observed using binoculars. Infrequently, resting adult birds were noted on Teal Island however the birds were found breeding solely on North Pelican Island (NPI) N 0370257 E 6010201 (Plate 1 and 2). North Pelican Island is located between Teal Island 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. During summer water depth between Jacks Point and NPI reduced to <1m. As the water levels fell, sandbanks became exposed, particularly on the west and north shores of the island. The west half of the island has a raised bare limestone ridge. Although historical records exist of Australian pelicans breeding on Seagull Island (south of the Pelican Islands), the Snake Pit and at on a sandy island east of the River Bremer mouth and at Reedy Point on the western shore of Lake Alexandrina, no Australian pelicans were reported breeding in the vicinity of these locations during the study period. If the birds had been breeding on Seagull Island and at the Snake Pit DENR CLL District staff would have mostly likely noticed during daily Park patrols. The River Bremer mouth area was not investigated, and Reedy Point is privately owned, contact with the landholder was not made.

3.2 Vegetation

In terms of diversity, 56.5% of the vegetation on NPI consists of non-native species, notably *Lycium ferocissimum* (African Boxthorn), *Mesembryanthemum cristallinumis* (Common Ice Plant) and *Malva* species (Mallows) (Table 1). These species are well established and widely spread. *Euphorbia paralias* (Sea Spurge) occupied a narrow band for most part of the island perimeter where it co-exists with *Cakile martime* (Sea rocket) and native *Tecticornia pergranulata* (Blackseed glasswort). Native species accounted for 43.5% of the plants. *Muehleneckia gunnii* (Coastal lignum) was noted to creep over the dead structures of African Boxthorn.

Plate 1. North Pelican Island is adjacent to Jacks Point and between Teal and Halfway Island in the CNP. Image courtesy of DENR Coast and Marine Branch.

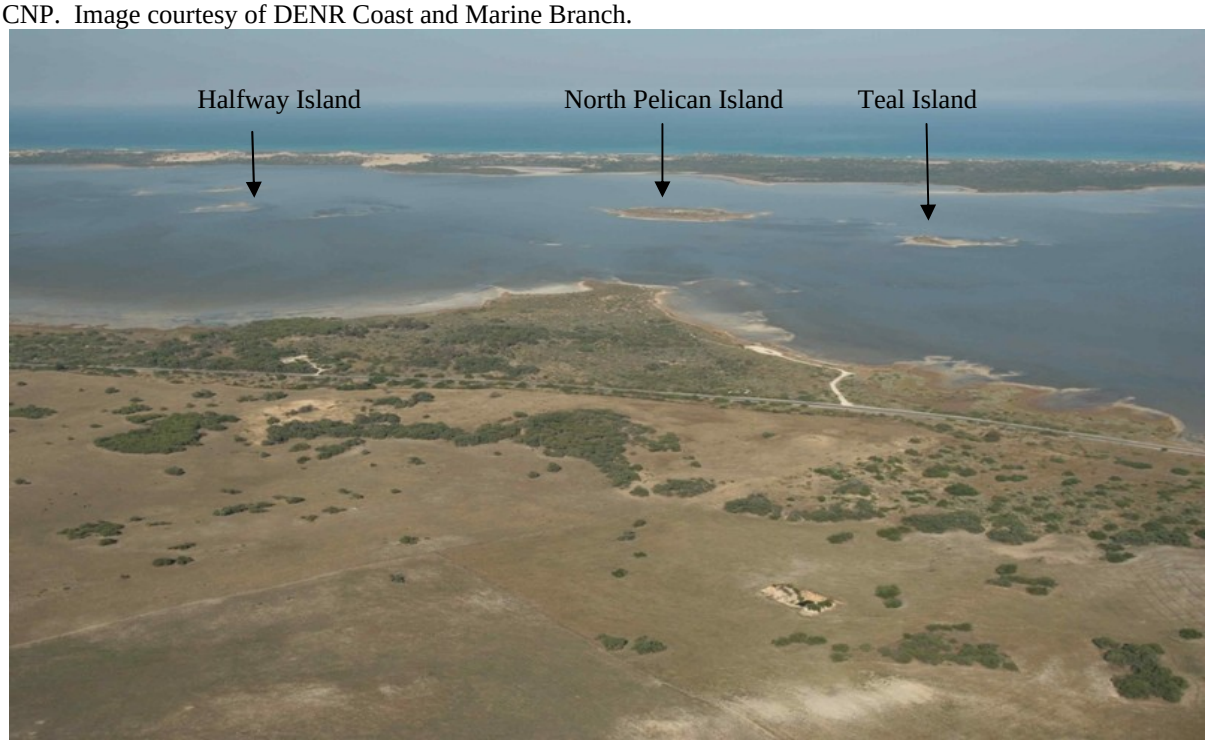


Plate 2. Australian pelicans nest in colonies on North Pelican Island in the South Lagoon, Coorong National Park, November 2009 (Kingsford et al., 2009: 28).

Table 1. A species list for North Pelican Island.

Botanical Name	**Common Name**	**Type**
Rhagodia candolleana ssp. candolleana	Seaberry saltbush	Native
Tetragonia implexicoma	Bower spinach	Native
Muehleneckia gunnii	Coastal lignum	Native
Suaeda australis	Austral seablite	Native
Tecticornia pergranulata	Blackseed glasswort	Native
Atriplex suberecta	Sprawling saltbush	Native
Myoporum insulare	Boobialla	Native
Senecio lautus	Pinnatifolius	Native
Dianella ssp.		Native
Zygophyllum billardierei	Coastal twin leaf	Native
Euphorbia paralias	Sea spurge	Non-Native
Cakile martime	Sea rocket	Non-Native
Sonchus oleraceus	Sowthistle	Non-Native
Mesembryanthemum cristallinumis	Common ice plant	Non-Native
Malva nicaeensis	Bull mallow	Non-Native
Lycium ferocissimum	Africa boxthorn	Non-Native
Urtica urens	Annual nettle	Non-Native
Chenopodium murale	Nettle-leaved goosefoot	Non-Native
Chenopodium glaucum	Oakleaf goosefoot	Non-Native
Solanum nigrum	European black nightshade	Non-Native
Reichardia tingitana	False sowthistle	Non-Native
Hordeum ssp.	Barley grass	Non-Native
Senecio elegans	Purple ragwort	Non-Native

3.3 Bird Counts

Monthly bird counts were conducted on North Pelican Island between August 2009 and June 2010, except for October 2009, when air temperatures exceeded 30ºC combined with 35km/hr northerly winds (BOM, 2009).

Congregations of Australian pelicans were first observed by DENR CLL District staff on North Pelican Island 2 August 2009. A total of seven colonies bred on NPI plus one colony abandoned. The coordinates and extent of each colony with location description is shown in Table 2 and Figure 2.

Table 2. The coordinates of each colony on North Pelican Island 2009-10. (Note: WGS84 Datum).

Colony	Easting	Northing	Site Description
1	0370078	6010217	On exposed, gently sloping limestone outcrop west of the island
2	0370122	6010313	Partly exposed limestone bed, part *Malva* sp., north-centre of island
3	0370116	6010347	Among *Malva* sp., and *Urtica* sp., north west of island
4	0370170	6010337	Among *Malva* sp., and *M. crtstallinum*, north east of island
5	0370161	6010116	Part exposed limestone bed, part *M. Crtstallinum*, south west of island
6	0370183	6010156	Among *Malva* sp., *Urtica* sp., and *M. crtstallinum*, south east of island
7	0370242	6010115	Among *L. ferocissimum*, *M. crtstallinum* & *M. gunnii* in south east
8	0370118	6010279	Almost centre of island, among *Malva* sp., and *Urtica* sp.

Figure 2. The approximate extent of Australian pelican colonies on North Pelican Island 2009-10.

3.3.1 Total Abundance of Adult Australian Pelican

In August 2009, the total abundance of adult Australian pelicans on NPI was 894 (Figure 3), when four colonies (referred as Colony 1-4 respectively) were formed. In September 2009, a fifth colony initiated (Colony 5) and between September and November 2009 the magnitude of breeding adults steadily increased, although the number of colonies did not increase.

In December 2009, a further two colonies formed and the number of colonies peaked to seven (Colony 1-7). The total abundance of adult Australian pelicans in December 2010 was 2085 (Figure 3), the majority of which were actively nesting and collectively occupying approximately 3 hectares of the island (Figure 2).

Between January and March 2010, the total abundance of adults ranged from 1098 and 1341 (Figure 3), the average total abundance of adults for this period being 1240. During this same period, a tagged adult from the Outer Harbour rookery at Port Adelaide was observed in Colony 6 (Plate 3). Between April and June 2010, the total abundance of adults was <500. In April, two colonies remained on the island, which gave the total adult abundance as 110. By the following month of May a new colony (Colony 8) made up of 260 adults formed thus gave the total abundance of adults in May 2010 as 486, an increase of 341%. In June 2010, the area in which Colony 8 had initially gathered was totally abandoned however the total abundance of adults was 381. Total abundance of adults on NPI for each month can be found in Appendix 1.

Figure 3. Total adult abundance of Australian pelicans on North Pelican Island 2009-10.

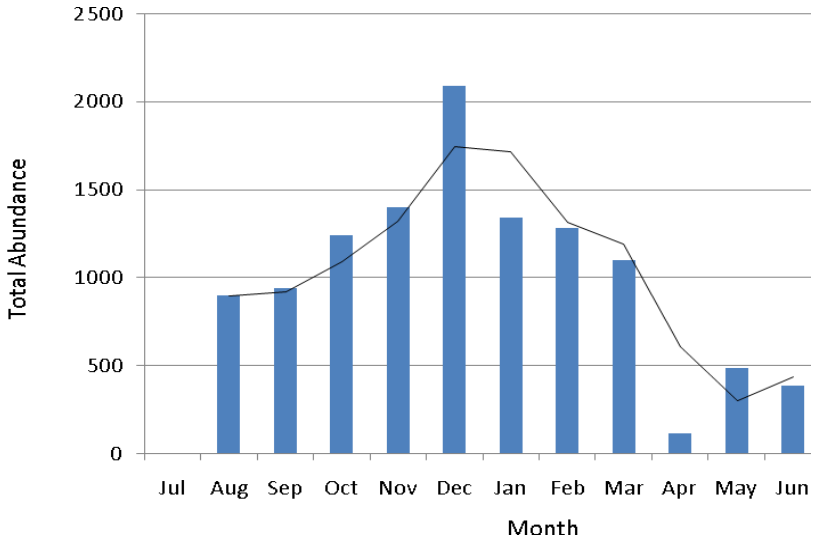


Plate 3. Tagged adult from the Outer Harbour rookery, Port Adealide observed on North Pleican Island, February 2010. Image courtesy of DENR CLL District.

3.3.2 Colony Structure within the Rookery

Nests were not randomly distributed across the island, and all but one nest, located approximately 2ft above ground level on the branches of *Muehleneckia gunnii* (Coast lignum), occurred at ground level in colonies that were spatially and temporally separate. No measurements of the distance between one nest and the next were recorded, but the distance between colonies was notably greater than approximately 10m. The number of nests in a colony can be used as an index of colony size (Johnston, unpublished data). Nests were only counted in Colony 1 and monthly counts of nests indicate that the average size of Colony 1 was 191. Where the number of nests was unknown, and to improve accuracy, the average monthly adult counts for each colony was determined (Figure 4). Applying the number of adult birds to express colony size shows that the average size of colonies ranged from 90- 673, and in this way the average size of Colony 1 is given as 250 ± 10% (Figure 4). Using counts of adults as an index of colony size over estimates the colony size compared to using the number of nests an index of colony size.

Among the colonies, 85% synchronised their activities e.g. gathering, courting, nesting, egg laying etc. In August 2009, four colonies (Colony 1-4) gathered on NPI. At that time, the majority of adult birds in Colony 1 and 3 had established nests, and incubation was the main activity taking place however some individuals at the edge of the nesting areas continued to court, occasionally disturbing incubating birds. At the same time, adult birds in Colony 2 and 4 congregated to the north of the island and were simultaneously courting. Some resting or standing over areas of *Malva* sp., and *M. crtstallinum*, other birds walked repeatedly over these areas. Small groups of birds, between 4 and 6 were observed to perform a display of courtship walking during which a female lead three or more males through flattened areas of *M. crtstallinum.*

In September 2009, eggs hatched in Colony 1 and 3, although a group (< 20) of birds covered with short grey-white down and about the size of a domestic fowl bird had formed a crèche near to where Colony 3 nested, and possibility originated from Colony 3. Colony 2 and 4 were incubating eggs. One additional colony had also formed, Colony 5. Between September and December courting and

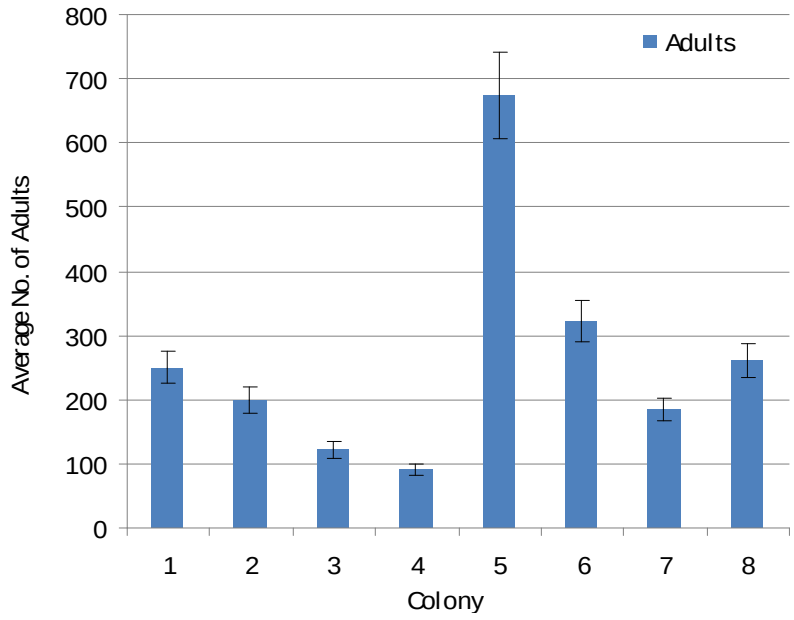
incubation within Colony 5 was unsynchronised. For example, in September adults came together, some resting or standing. Other adults within the colony were courting and observed to perform pouch-ripping; motions of waves appearing over the pouch, and in another part of the colony birds were incubating eggs.

Two additional colonies formed in December 2009 (Colony 6 and 7). The majority of adult birds in Colony 6 and 7 established nests consisting of *U. urens, Malva* sp., and *M. crtstallinum* and where the nesting material was plentiful, nests were well constructed. In December, incubation was the main activity taking place within Colony 6 and 7 although courting continued to take place at the edge of the nesting areas. Meanwhile, Colony 5 was unsynchronised in its activities. Adults appeared to come and go, congregating and some courting. Some eggs had hatched and a sizable crèche had also formed. In Colony 1, nearly fledged juveniles were present, and a second simultaneous breeding had taken place with many adults incubating eggs for the second time. It is not clear whether these were the same adults that had nested at this site previously, or different individuals.

In February 2010, Colony 1, 2, 4-7 remained on the island. Colony 3 had fledged. By the following month, Colony 1, 5-7 remained on NPI, along with Colony 5 at different stages of breeding, including birds incubating. In April 2010, Colony 1 and 7 remained, with juveniles from Colony 5 joining juveniles from Colony 7. Colony 6 had fledged. In May, an additional colony (Colony 8) formed and active nests were recorded, however, this colony was totally abandoned by June 2010. Most of Colony 1 had fledged for the second time. Colony 7 remained on the island in June 2010 and was made up of mostly nearly fledged juveniles. Noteworthy, was the simultaneous loss of 91 nearly fledged birds found dead in the southern section of the island, in the vicinity of where Colony 5-7 nested. The majority of these birds were found in a wings spread, neck extended position, and at similar stages of decomposition.

The synchronised nature of nests within colonies means that colonies are the relevant part for determining seasonality because nests within colonies are not independent of each other.

Figure 4. Average number of adults per colony on NPI 2009-10.



3.3.3 Seasonality

In 2009-10 colonies were formed between autumn and early summer. No new colony was initiated between January and April. In May 2010, the onset of autumn, a colony formed but abandoned by June 2010, when the nesting areas of Colony 1, 3 and 4 were re-occupied by new nesting colonies.

The breeding period was confined between June and March.

3.3.4 Hatching Success and Survivorship

The number of active nests, and chicks hatched and successfully fledged birds in Colony 1 were counted each month between August 2009 and June 2010, except for October 2009 (see section 3.3 Bird Counts). Colony 1 nested upon an exposed, gently sloping limestone outcrop where nests were commonly no more than a scarpe on the bare ground (Plate 4). Where there were areas of *Malva* sp., present and nesting material plentiful, nests were well constructed at ground-level and found lined with sticks, vegetation, feathers and, occasionally, skeletal remains of dead birds (dead pinkies notably).

Plate 4. Colony 1 nesting on bare limestone ground with individuals at the edge of the nesting area courting (left of nesting area), August 2009. Image courtesy of DENR CLL District.

In late August 2009, 258 adult birds were observed in Colony 1 (Figure 5). The mandible colours of these nesting adults appeared slightly faded compared to other adults courting at the edge of the nesting area. The average size of Colony 1 was 191 (see section 3.3.2), however in August 2009 the total number of nests was 254 (Figure 6), thus indicating at that time a colony size of 508. This implies that at the time of observation (1220pm), almost half of the colony was not present. The total number of nests also signifies that 508 eggs were laid. Clutches varied from one to three chalky white eggs, although the average eggs laid were two. No juveniles or chicks were noted at this time.

In September, a total of 176 active nests were recorded, signifying the colony size and number of eggs laid was 352. At this time, 61 chicks (all pinkies) were recorded indicating 12% of the eggs laid in August successfully hatched. Recently hatched chick mortality for the same period was 14.1%. No juveniles were noted for this period. Due to extreme weather conditions, no observations of active

nests, chicks or juveniles were recorded in October 2009, but a total adult abundance of 250 was recorded (Figure 5).

Compared to October the total adult abundance doubled to 500 adults in November 2009, and a total of 552 active nests were recorded (Figure 6), signifying the colony size and number of eggs laid at that time was 1104. At this time, 52 nearly fledge juveniles were noted, most advanced to seek safety by taking to the shallow waters on the western shore of North Pelican Island. The number of nearly fledge juveniles might suggest that up to 85% of the chicks successfully hatched in August were ~12 weeks old however without observations for the month of October this figure should be viewed with caution.

Between January and March 2010, active nest steadily increased from 9 to 47 (Figure 6), indicating a second group of birds may have bred in Colony 1. Between April and May 2010, no active nests were recorded. In June 2010 however, 48 nests were recorded at the site of where Colony 1 had previously nested, indicating a colony size of 96.

3.4 Human Disturbance

North Pelican Island is an isolated island surrounded by shallow water. Public access to the Pelican Islands, including NPI is strictly prohibited. Only DENR CLL District staff and accompanying community volunteers were encountered on the island throughout the breeding season. Visits to the breeding site were minimised to once per month, and intimate counts in Colony 1 lasted no more than 12 minutes. When approached by humans, nesting birds took to the air, but after each visit birds were observed to return to their nests within 10 minutes.

3.5 Animal Disturbance

Corvus coronoides (Ravens) and *Larus novae-hollandiae* (Silver Gulls) were noted at each visit, but particularly following egg hatching. Generally, <12 of each species was recorded. 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. In contrast, Ravens were seen to perch on the tops of Africa Boxthorn, before taking opportunity to feed on eggs or attack pinkies left alone. No other evidence of predation e.g. European red fox (*Vulpes vulpes*) was noted even when water levels fell below 1m.

3.6 Food

On several occasions adults were observed collecting *Cyprinus carpio carpio* (European carp) and *Nematalosa erebi* (Bony bream) at the Narrung Narrows on Lake Albert. At times, groups of <100 were observed working cooperatively to concentrate fish into a confined area before plunging head and beak underwater. On NPI, occasionally the food of young could be identified, which consisted mainly of fish and rarely crustacea. The most abundant fish were European carp ranging from 300mm to 554mm.

Figure 5. Total adult Australian pelican abundance ± 10% in Colony 1, North Pelican Island 2009-10.

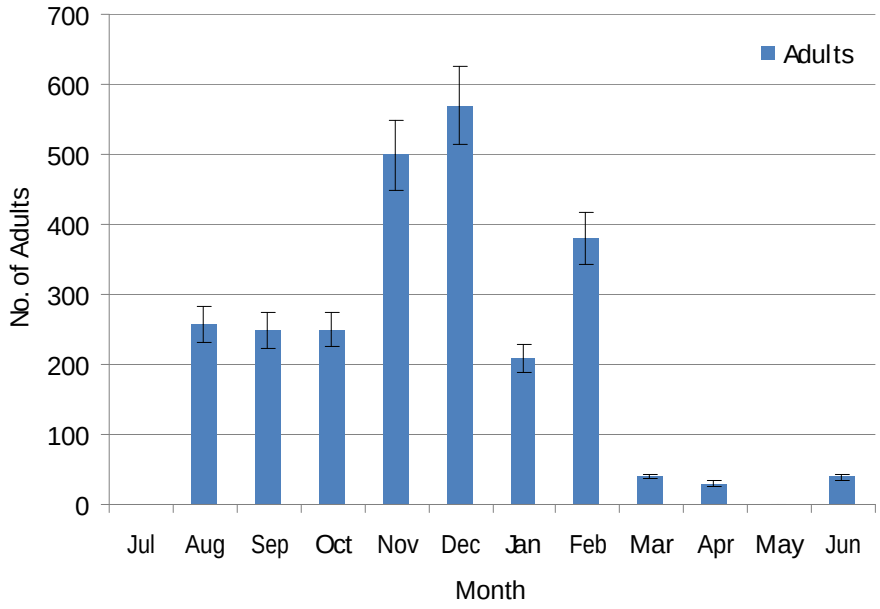
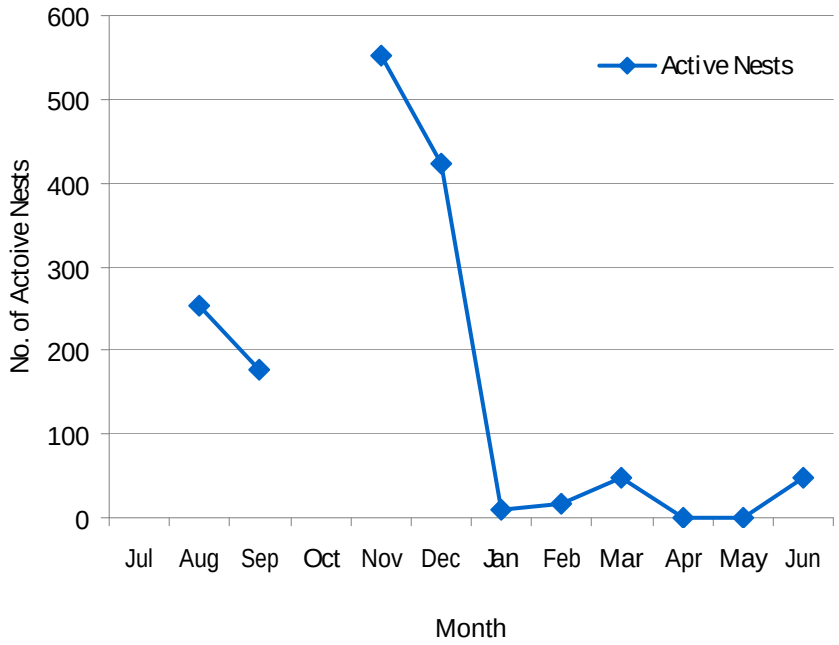


Figure 6. Number of active nests in Colony 1, North Pelican Island 2009-10. Active nest were defined as scrapes or material added to a scrape in which eggs, chicks or sitting adults were observed in.



4.0 Discussion

The results presented here are, to the author's knowledge, the first indication of hatching success and survivorship for Australian pelicans in the Coorong.

4.1 Breeding Sites and Food Availability

Water level in the South Lagoon fluctuates with the southernmost part of the South Lagoon becoming completely dry in summer (Paton, 2010). In contrast, water levels, influenced by wind rise during winter between 1-2.5m and low lying islands and reefs such as South Reef and Mellor Island became reduced in area (Chapman, 1963) suggesting these islands might be sub-optimal for Australian pelicans to breed.

Due to drought conditions, water quantity and quality in Lake Albert steady declined in 2009, and natural evaporation combined with reducing water levels resulted in a salinity level increase. To reduce the effects of a likely fish kill, particularly in the European carp that are sensitive to salinity above 15‰ (Geddes, 1979), and pose a risk to the amenity value of Lake Albert and the surrounding communities, the South Australian Government commenced pumping of freshwater from Lake Alexandrina to Lake Albert. The pumping of freshwater into Lake Albert attracted several hundred tonnes of European carp that congregated in the Narrung Narrows. The gathering of European carp provided an opportunity for the State Government to coordinate the removal of this introduced species thus allowing native fish to better thrive but more significantly the pumping of freshwater may have provided a readily available non-commercial food source for breeding Australian pelicans in the Coorong.

Breeding adults need to return to nest sites regularly, and so breeding birds might only risk travelling a further distance if there is a greater return on food. There is likely a maximum distance which individuals will travel from the nest to feed because after which the benefit of long trips may not meet the energy and risks involved of the trip. North Pelican Island is located approximately 60km south of Lake Albert, and hence, likely to be within the acceptable distance for the birds to travel to feeding grounds, combined with the islands size (6 hectares) and average height of 4.5m might indicate reasons why Australian pelicans in the Coorong have bred on the largest of the Pelican Islands, North Pelican Island.

4.2 Vegetation

In terms of diversity, the vegetation on NPI consists mostly of non-native species (55%) particularly *Lycium ferocissimum* (African Boxthorn), *Mesembryanthemum cristallinumis* (Common Ice Plant), *Malva* species (Mallows) and *Urtica* species (Stinging Nettle). All of these species are well established and widely spread, supporting previous observations (Chapman, 1963 and Seaman, 2005). With the exception of Africa Boxthorn, these latter species were also noted to provide nesting material for Australian pelicans, an observation noted by Seaman (2005). In recent years, the DENR CLL District have had some success to control African boxthorn on the Pelican Islands, the control of other non-native species however has been deemed unsuitable because of nesting use by Australian pelicans Thompson (2010, pers. comm. 1 March). Following previous weed control, native species such as *Muehleneckia gunnii* (Coastal lignum) appears to have taken advantage of the dead African Boxthorn structures, thus continuing to provide nesting birds shelter from severe meteorological conditions e.g. strong winds. This leads to the notion that future weed management should consider planting Coastal lignum following the die back and control of Africa Boxthorn.

4.3 Bird Counts

4.3.1 Total Abundance of Adult Australian pelican

Waterbird populations across a third of Australia are in series decline (Porter et al., 2006; Nebel et al., 2008). 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). Complete counts of all waterbirds including Australian pelican have been completed in the Coorong wetlands annually since 2000 (Paton, 2010) during which time the total abundance for Australian pelican in the Coorong has declined (Paton, 2005; Paton et al., 2009). In the same period Paton et al., 2009 noted annual counts of Australian pelicans in the South Lagoon also declined to <330 in the month of January between 2008 and 2009. In 2010, 1828 Australian pelican were reported in the South Lagoon Rogers (2010, pers. comm. 24 May), an increase of 384% compare to the January 2008 and 2009 observations however this figure is 30% of the total abundance of Australian pelicans reported in 1985. With 1828 Australian pelicans reported in the South Lagoon in January 2010, the results presented in Figure 3 suggest 73% of the total abundance of Australian pelican in the South Lagoon were on NPI i.e. 1341 Australian pelican. In this study evidence suggest that the total abundance of Australian pelican breeding on NPI was 2085, a reduction of 34.5% in abundance relative to the species abundance in 1985.

Declines of the number of Australian pelican are reported over large parts of Australia (Porter et al., 2006), but can be traced back to the 1865 when *fewer* Australian pelican were reported in the Murray-Darling Basin compared to when Captain Sturt made his voyage into the interior of South Australia, Gould 1865 (cited Chapman 1963: 8), although no comparative figures are available. In 1890, a reduction in the number of Australian pelicans in the Coorong was also noted (Chapman, 1963).

Historically, human disturbance including deliberate massacres (Condon, 1941; Chapman, 1963) would have had a negative impact on the number of Australian pelican, particularly in any one season although no detailed documents or records exist of the impacts these massacres had on the birds. In any case, since the islands were protected public access to the Pelican Islands is strictly prohibited and closely monitored by DENR. This is in contrast to other species of pelican including the Dalmatian pelican (*Pelecanus crispus*) in Palearctic that is in decline due to human disturbance, and considered to be vulnerable (Doxa et al., 2010; IUCN, 2001).

Changes to the natural environment such as water resource development, including water diversion and reclamation of wetlands for more intensive agriculture, river regulators including locks and storage of water in dams and barrage systems (which denies water to wetlands) and drainage of the lower South-East of South Australia are however proposed causes to the decline of waterbirds in the Murray-Darling Basin (Kingsford and Norman, 2002; Paton et al., 2009) including Australian pelican (Chapman, 1963; Porter et al., 2006). Water diversion and extraction and threats to river estuaries are particularly notably in the Murray-Darling Basin and have been further compounded by drought resulting in no significant flows out of the River Murray mouth since 2001 (Campbell et al., n.d.) with discharge from the barrages having ceased completely in 2006. Consequently, salinity levels in the Coorong and Lake Alexandrina and Lake Albert have increased, particularly in the South Lagoon, which has had profound effect on food resource availability and habitat, and therefore waterbirds (Paton 2005; Paton and Rogers, 2009). Australian pelican were however observed to harvest prey outside the CNP, this leads to the notion that the distribution of nest-sites is primarily driving their distribution (Paton et al., 2009). Paton et al., (2009) also argues that even these piscivorous birds are now vacating the South Lagoon, suggesting that the birds' presence in the South Lagoon is as much related to changes in food supply as to the presence of suitable nesting opportunities. Thus, the ability for Australian pelicans, and other waterbird populations, to remain stable is dependent on adequate and suitably timed flows of water from the Murray-Darling Basin (Jenson et al., 2000).

Between 1969 and 2000, 11,500 pelicans were banded in the CNP (De Smith, 2002) and from these birds over 150 bands have been recovered from most Australian states and Papua New Guinea (Kluske, 1996). It is therefore not surprising to have observed an adult Australian pelican from the Outer Harbour rockery at Port Adelaide on NPI in early 2010. The presence of these birds from the Outer Harbour rookery might be because of the presence of suitable nesting opportunities (Paton et al., 2009) compared to the low lying sandbar at Port Adelaide that is prone to water inundation due to high tides associated with storms that has accounted for the loss of 19.4% of juveniles at this rookery (Johnston, unpub. data).

4.3.2 Colony Structure within the Rookery

All but one nest were at ground-level, notably among *Mesembryanthemum cristallinumis* (Common Ice Plant) and *Malva* species (Mallows) or on bare limestone or ground. Approximately 2feet above ground level, on the branches of *Muehleneckia gunnii* (Coast lignum) however was one active nest. Similar observations have been noted by Vestjens (1977) who observed Australian pelicans at Lake George and Cowal, in New South Wales nesting on sand and clay islets and on bushes. Eckert (1965) noted nests as high as 5feet above ground level, although based on the number of few records nesting above ground level appears infrequent. The pelicans can be divided into two groups: those with mostly white adult plumage, which nest on the ground and included Australian, Dalmatian, Great White, and American White Pelicans, and those with gray or brown plumage, which nest in trees and include Pink-backed, Spot-billed, and Brown, plus the Peruvian Pelican, which nests on sea rocks.

Despite well established and widespread Common Ice Plant and Mallows, which have been reported to provide good nesting material (Seaman, 2005), the initial formation of Colony 1 came to nest on an exposed, gently sloping bare limestone cap, which is contradictory to Chapman (1963) who suggested that the most suitable nesting sites are used by those birds that come into breeding condition first. Nest platforms or materials also varied considerably and where material was plentiful, all nests were elaborately constructed and often found lined with sticks, vegetation, feathers and, occasionally, skeletal remains of dead birds. In contrast to other nesting area on NPI, the nesting site of Colony 1 appeared as the least suitable nesting site being open to predation and metrological conditions. This nesting area also lacked nesting material, leading to the notion that eggs laid in a scrape are more likely susceptible to rolling and therefore egg loss. On the other hand, Vestjens (1977) noted that nest material was added to a nest during incubation and as long as chicks were present in the nest, indeed nests which were only a scrape when the eggs were laid were reported 700mm in diameter and 90mm high at the rim.

With the exception of one colony, colony activities e.g. egg laying were synchronised within and between colonies, and this agrees with Johnston (unpub. data) who reported 80% of the nests laid were completed within 11 days of the colony being initiated. Birds from 11 to 21 days old, downies, generally leave the nest to form a crèche. Vestjens (1977) suggests that a crèche is started by the larger chicks (downies) when most nests are occupied by adult birds, which harass downies and that the crèche protects downies from high temperatures by providing shade and in cooler conditions helps maintain high body temperatures. This suggests that colony synchronisation might be an important factor to chick survivorship particularly survivorship of birds between crèche phases and juvenile phase of development.

Towards the end of the 2009-10 breeding season was the discovery of 91 nearly fledged birds found dead. These birds were found at similar stages of decomposition with wings spread and neck extended suggesting the birds simultaneous died perhaps as a result of abandonment and the birds unable to feed themselves or the parent birds were unable to maintain food demand, in both cases leading to starvation and ultimately death. The exact known cause of death however remains inconclusive.

4.3.3 Seasonality

Egg laying was confined to a period between June and March, and this agrees with (Chapman 1963) who reported a similar breeding period for Australian pelicans in the Coorong. This period of egg laying however 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 is August-November but often observations of Australian pelicans have been based on chance visits to colonies (Barrett, 1911; Arnold, 1927; Condon, 1941; Chapman, 1963; Vestjens, 1977; Paton 1982; Seaman, 2005). Observations of the Australian pelican rockery at Port Adelaide note egg-laying takes place in all months of the year, but mostly between June and October Johnston (2010, pers. comm. 9 July). Elsewhere in Australia, egg-laying has been reported to take place only in autumn Serventy and Whittell 1960 (cited Chapman 1963: 10). At Lake Cowal and George in New South Wales eggs were laid between August and December (Vestjens, 1977), which suggest a spring and summer nesting period but observations were restricted to short periodic visits for fear of disturbing the birds, reinforcing that it is not sensible to generalise the breeding season for the Australian pelican because observations of Australian pelicans have been based on chance visits to colonies (Marchant and Higgins, 1990).

4.3.4 Hatching Success and Survivorship

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 can be used as an index of colony size. Given that 254 active nests were recorded in August implies the size of Colony 1 was 508 individual adults. This suggests that at the time of observation (12:20pm), almost half of the colony was not present. Vestjens (1977) suggested that early morning co-inside with the parent birds being away from the breeding site in search of food, however observations of the Outer Harbour rookery at Port Adelaide in South Australia indicate adult birds constantly come to and from the colony and that there is no particular time of day when both adults are reliably at the nest Johnston (2010, pers. comm. 9 July).

According to Vestjens (1977) about a month before breeding, birds concentrate near or on their future nesting sites, walking over the area or standing and sleeping on it. During the August observation, the mandible colour of nesting adults in Colony 1 appeared slightly faded compared to other adults courting at the edge of the nesting area. This fading of the mandible has been reported once adult birds begin incubating (Vestjens, 1977). A number of active nests with unhatched eggs were noted in late-August and by late-September, 61 pinkies were recorded. Incubation lasts between 32-35 days (Vestjens, 1977). This suggests that birds in Colony 1 gathered on the island in mid-late July, after which courtship, pair formation, copulation and nest building occurred, before egg laying commenced in late August.

Studies of survivorship in colonies of Australian pelicans at the Outer Harbour rookery have shown that almost 40% of 1626 eggs (or 650 eggs) from a sixteen colonies successfully hatched in 2003 Johnston (2010, pers. comm. 9 July). In August 2009, 508 eggs were laid in Colony 1, about a third of the number of eggs recorded at the Outer Harbour rookery, of which 12% or 61 eggs successfully hatched. This means of the total eggs laid in August, there was a loss of 88.2% eggs in Colony 1. Low hatching success appears to be normal for nesting Australian pelicans Johnston (unpub. data), and not necessarily an artefact of disturbance. The optimal hatch success has been reported to occur in colonies containing about 80 nests or approximately 160 eggs Johnston (unpub. data).

Following successful hatching, studies have shown extraordinarily high mortality, almost 70%, during the ten day long nestling period Johnston (unpub. data). During the nestling period in this study, recently hatched chick mortality in Colony 1 was 14.1%, suggesting a greater survivorship of hatched chicks compared to those observed at the Outer Harbour rookery. The greater survivorship of hatched chicks in Colony 1 compared to the Outer Harbour rookery might be a reflection of greater food

availability from a continuous supply of European carp (See section 4.1). In contrast, nestling mortality by siblicidal brood reduction, driven by low food availability, was reported to have influenced the high mortality among nestlings to the Outer Harbour rookery Johnston (unpub. data).

Due to extreme weather conditions, no observations of active nests, chicks or juveniles were recorded in October 2009, however 52 nearly fledge juveniles were noted the following month (November 2009). The number of nearly fledge juveniles might suggest that up to 85% of the chicks successfully hatched in August were ~12 weeks old. 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. Without observations of active nests, chicks or juveniles for the month of October the percentage of nearly fledge juveniles from Colony 1 should however be viewed with caution.

Due to methodologies, chick counts between December 2009 and June 2010 became an accumulation of chicks and those same chicks in their grey-white down stage. The extrapolation of chick survivorship at various stage of development could not therefore be neither accurately nor precisely determined beyond November 2009.

Nonetheless, some observations were noted. Active nests steadily increased between January and March 2010 from 9 to 47 indicating a second group of birds may have bred in Colony 1. It was not clear whether these were the same individuals breeding a second time, or new individuals nesting there for the first time during the 2009-2010 breeding season. Between April and May 2010, no active nests were recorded. In June 2010 however, 48 nests were recorded at the site of where Colony 1 had previously nested, indicating a colony size of 96. It was not clear whether these birds were the same individuals that had bred between August 2009 and March 2010 but this event might have been the onset of the 2010-11 breeding season.

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). During the 2009-10 breeding season access to the island was only by DENR CLL District staff and volunteers. Nonetheless, to minimise human disturbance visits to the island were monthly. Within each visit, only one out of eight colonies was approached for a maximum of 12 minutes, after which staff and volunteers retreated and birds were observed to return to their nests within a few minutes.

4.5 Animal Disturbance

Predation has been a contributing factor in failed success of nesting waterbirds (Brunton 1997; Dowding and Murphy 2001; Johnston, unpub.data). *Corvus coronoides* (Australian Ravens) and *Larus novae-hollandiae* (Silver Gulls) were noted at each visit, which agrees with Chapman (1963). These species were most notably observed following egg hatching. 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. In contrast, Australian Ravens were seen to perch on the tops of Africa Boxthorn, before taking opportunity to feed on eggs or attack pinkies left alone, the latter of which agrees with the observations of Vestjens (1977). No other evidence of predation e.g. *Vulpes vulpes* (European red fox) was noted even when water levels fell below 1m. Given the locality of the Pelican Islands it is unlikely that the European red fox has had any effect on the number of Australian pelicans breeding on the islands. At low tide, predation by the European red fox accounted 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 foxes at this rookery 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. Foxes were reported to enter colonies and scare incubating adult Australian pelicans away from nests, which resulted in one colony abandoning active nests (Johnston, unpub. data). Elsewhere domestic dogs have disturbed Australian pelican rookeries resulting in a number of dead adults and loss of unhatched eggs (Vestjens, 1977).

4.6 Food

Adult Australian pelicans were observed collecting *Cyprinus carpio carpio* (European carp) and *Nematalosa erebi* (Bony bream) at the Narrung Narrows on Lake Albert (see section 4.1), the former of which is an introduced species and both of which were identified within nests. Australian pelicans are reported to mainly eat fish, but will eat a variety of aquatic animals including crustaceans and invertebrates (Vestjens, 1977; Smith and Munro, 2008). They are also opportunistic feeders (Vestjens, 1977; Smith and Munro, 2008) and during periods of starvation, Australian pelicans are reported to capture and eat Silver gulls and ducklings Lowe and Lowe 1976 (cited Smith and Munro, 2008, p. 632), suggesting Australian pelican may not be dependent on native prey but rather food availability (see section 4.1).

The Australian pelican may feed alone, but observations indicate that the birds feed as a cooperative group. Throughout 2009-10 groups of <100 individuals were observed working together, driving fish into a concentrated mass using their bills and sometimes by beating their wings. By working together, it is probable that fish are herded into shallow water or surrounded in ever decreasing circles. The width of bills' gape determines the size of the ingestible food item (Smith and Munro, 2008). Regurgitated European carp within the nests ranged from 300mm to 554mm, although fish that were greater than 400mm appeared to have been regurgitated and later discarded. The common length of European carp is reported to be 310mm but this species can grow to a maximum length of 1200mm with a maximum weight of ~ 40 kg (Machacek, 2007). This suggests that the maximum weight of European carp observed in the nests might have weighed~15-20 kg. Introduced *Carrassius auratus* (Goldfish) and *Perca fluviatilis* (English perch) at Lake Cowal in New South Wales have been reported within the nests of Australian pelican and ranged between 60 and 247mm in length (Vestjens, 1977).

An adult *Pelecanus occidentalis* (Brown pelican) weighs between 3.6 to 4.5kg and requires 4.5 to 6.5kg of fish per day (Karleskint et al., 2010). This is an average of 1.36 times their body weight of fish per day. An adult Australian pelican typically weighs between 4 to 6.8kg (Condon, 1941; Karleskint et al., 2010). Based on the food consumption of an adult Brown pelican this suggests an adult Australian pelican requires between 5.44 to 9.25kg of fish per day. When juvenile Australian pelicans fledge their weight is~10kg Rich (2010, pers. comms. 29 September), and therefore heavier than the parent birds. This is probably because the young are usually cared for so well and have few opportunities for physical movement until they fledge. Indeed, at hatching age when pinkies weigh about 0.1kg they require 0.029kg (or 29g) of food, the equivalent to 1 pilchard per day Rich (2010, pers. comms. 29 September). By the time the young bird joins the crèche, at about 4 weeks old, the bird weighs ~4kg and requires almost 0.5kg of food or 16 pilchards, and at 10-12 weeks just before the bird fledges they require 0.92kg (or 923g) of food or 32 pilchards per day Rich (2010, pers. comms. 29 September). Once juveniles have fledged, the weight likely decreases quickly as juveniles begin to seek their own food.

The Australian pelican is also reported to be cannibalistic, feeding on small live young Australian pelicans from unguarded nests, and attempt to grab nestlings from nests with brooding adults and swallow live large downie young pelican (1.2 to 1.5kg) have also been observed (Smith and Munro, 2008). No observation of Australian pelican cannibalism was observed during 2009-10.

5.0 Conclusion

Recent evidence suggests that the Coorong and Lakes Alexandrina and Albert wetland system is in decline but particularly the Coorong South Lagoon (Phillips and Muller, 2006; Paton et al., 2009). This decline is reflected in long-term (20-years) changes to the waterbird community (Paton et al., 2009). While the total abundance of Australian pelicans may have increased compared to previous years, a reduction of 33.5% in abundance of Australian pelican in the South Lagoon relative to the species abundance in 1985 was noted. This apparent increase in the total abundance of Australian pelicans can be associated to the several hundred tonnes of European carp that congregated in the Narrung Narrows in response to the pumping of freshwater into Lake Albert. The pumping of freshwater into Lake Albert however is itself an attribute of escalating demands for water and over-allocation of water resources in the Murray-Darling Basin, combined with severe drought that has changed the magnitude and the timing of River Murray inflows to the region. The Australian pelican needs an assured, adequate food supply and an undisturbed nesting area for at least 3-months in order to breed successfully. This is the time from the establishment of a nest site to growth of the young to near adult size. Thus, the ability for Australian pelicans, and other waterbird populations, to remain stable is dependent on adequate and suitably timed flows of water from the Murray-Darling Basin. To recover and maintain the ecological and cultural integrity of the Coorong and Lakes Alexandrina and Albert, indeed the Murray-Darling Basin, and waterbird communities, appropriate integrated management of water resources at Basin and local that recognises the conservation values of downstream ecosystems is now fundamental.

The monitoring program outlined in this report made advances to understanding the breeding status of Australian pelicans in the Coorong. The size of the Coorong Australian pelican breeding population in 2010 was 2085 with the breeding period confined between June and March. Within one colony, 12% of the eggs laid successfully hatched. Compared to chick mortality observed at other Australian pelican rookeries there was greater survivorship of hatched chicks within the observed colony in the Coorong.

In light of the few studies on breeding Australian pelican (Vestjens, 1977; Johnston, unpub. data) it is recommended further monitoring are under taken to ensure that all stages of the bird's life cycle are measured. Re-defining and classifying terminology to distinguish between chicks, downies and juveniles will provide greater understanding of survivorship at different stages of early life from point of lay to hatchling, crèche stage and fledged birds. As with any monitoring program and regardless of the level of interaction, it would be wise to ensure that one or more control colonies are applied to test for any effects caused by the monitoring of egg and chick survivorship. A control colony should not be visited but the number of adults, nests, chicks and downies could however be counted with binoculars from a distance of at least 50m. Monitoring predation should remain an important component of monitoring the Coorong Australian pelican rookery.

Given the cultural significance and that Australian pelicans from other rookeries were also noted to breed on the Pelican Islands partnerships with the Traditional Owners and with those monitoring other rookeries should continue to be built and maintained to ensure information and management options are shared and exchanged.

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Appendix 1 Total abundance of adult Australian pelicans on North Pelican Island 2009-10

Month	Total Adult Abundance	No. of Colonies
August 2009	894	4
September 2009	937	5
October 2009	1240	5
November 2009	1400	5
December 2009	2085	7
January 2010	1241	6
February 2010	1281	5
March 2010	1098	4
April 2010	110	2
May 2010	486	3
June 2010	381	4

Appendix 2 Colony 1 raw counts between August 2009-June 2010

Month	No. of Adults	No. of Juveniles	No of Live Chicks	No. of Dead Chicks	No of Unhatched Eggs	No. of Active Nests
August	258	0	0	0	348	254
September	249	0	61	10	261	176
October	250	Not counted	Not counted	Not counted	Not counted	Not counted
November	500	52	118	5	908	552
December	570	96	263	14	287	427
January	208	152	530	2	43	9
February	380	310	250	8	20	17
March	40	206	11	6	64	48
April	30	70	40	4	0	0
May	0	0	0	8	0	0
June	39	18	0	0	0	0