Hunter Estuary surveys: results for large waterbirds

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Although the Hunter Estuary at Newcastle New South Wales is a well-known site for migratory shorebirds, its utilisation by other waterbirds has not previously been closely examined. This report presents the results for 21 species, representing five families of large waterbirds, from a 22-year study involving monthly surveys of the estuary.

Most of the species were found to have stable populations or the changes over 22 years were modest. The populations of eight species had increased – Black-necked Stork *Ephippiorhynchus asiaticus*, Royal Spoonbill *Platalea regia* Australian White Ibis *Threskiornis moluccus*, Glossy Ibis *Plegadis falcinellus*, White-faced Heron *Egretta novaehollandiae*, Great Egret *Ardea alba*, Little Black Cormorant *Phalacrocorax sulcirostris* and Great Pied Cormorant *Phalacrocorax varius*. The increased numbers of the two cormorant species perhaps reflect improvements to water quality in the lower estuary and Newcastle harbour. The other species have benefitted from local rehabilitation projects which have restored tidal flushing to wetlands located at Ash Island, Hexham Swamp and Tomago. Conversely, the Australasian Bittern *Botaurus poiciloptilus* may have been negatively affected by those projects.

Seven species had greater populations in the estuary in summer and autumn: Royal Spoonbill, Australian White Ibis, Glossy Ibis (in summer only), Great Egret, Cattle Egret *Bubulcus ibis*, Australian Pelican *Pelecanus conspicillatus* and Great Pied Cormorant. The populations of White-faced Heron and Australasian Darter *Anhinga novaehollandiae* rose in winter.

INTRODUCTION

In March 2021, members of the Hunter Bird Observers Club Inc (HBOC) completed 22 continuous years of monthly surveys of shorebirds and waterbirds in the Hunter Estuary ("the estuary"). The surveys are continuing indefinitely but it seemed timely to analyse the results to date and identify any trends for the populations of the main species recorded. To achieve this we are examining, in turn, groups of like species. In earlier reports we assessed shorebird population trends (Stuart & Lindsey 2021) and the status of gull and tern species (Lindsey & Stuart in preparation). In this report we present the findings for large waterbird species viz the members of five families of birds from the orders Ciconiiformes, Pelecaniformes and Suliformes.

The order Pelecaniformes comprises five families of birds (Gill *et al*. 2021), of which three families are represented in the Hunter Region – Threskiornithidae, Ardeidae and Pelecanidae. The storks (family Ciconiidae) are placed into a separate order, Ciconiiformes. However, these six families are closely related and in some previous taxonomies they were grouped, as the order Ciconiiformes (Marchant & Higgins 1990). All the members of those two orders are medium to large long-legged wading birds (except for Pelicans) with a large bill and a well-developed hallux (hind toe). They prefer to walk rather than run.

The local representative from the Ciconiidae family is the Black-necked Stork *Ephippiorhynchus asiaticus*. Five Threskiornithidae representatives have been recorded in the estuary: Yellow-billed Spoonbill *Platalea flavipes*, Royal Spoonbill *P. regia*, Australian White Ibis *Threskiornis moluccus*, Straw-necked Ibis *T. spinicollis* and Glossy Ibis *Plegadis falcinellus*, and nine Ardeidae species: Australasian Bittern *Botaurus poiciloptilus*, Nankeen Night-Heron *Nycticorax caledonicus*, Striated Heron *Butorides striata*, Cattle Egret *Bubulcus ibis*, White-necked Heron *Ardea pacifica*, Great Egret *A. alba*, Plumed Egret *A. plumifera*, White-faced Heron *Egretta novaehollandiae* and Little Egret *E. garzetta*. The sole local representative from the Pelecanidae family is the Australian Pelican *Pelecanus conspicillatus*.

Within the order Suliformes are two families which are represented in the estuary – the Phalacrocoracidae (cormorants and shags) and the Anhingidae (darters). Both these families are piscivores and hence they forage differently to the families in the other two orders and are not considered to be estuarine birds. However, many of them commonly roost in trees or on rock platforms within estuaries and thus are often encountered during surveys. The five locally-occurring species are Little Pied Cormorant *Microcarbo melanoleucos*, Great Cormorant *Phalacrocorax carbo*, Little Black Cormorant *P. sulcirostris*, Great Pied Cormorant *P. varius* and Australasian Darter *Anhinga novaehollandiae*.

Hunter Wetlands National Park and wetlands around the suburbs of Shortland, Tarro and Woodberry

Figure 1 shows the estuary and the main areas surveyed. Most of the sites monitored in HBOC monthly surveys are in Hunter Wetlands National Park (HWNP) much of which was listed in 1984 under the Ramsar Convention which aims to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. The process involves identifying wetlands of international importance (Department of Agriculture, Water and the Environment 2013). Key wetlands such as Hexham Swamp and Ash Island were however not included at the time of designation (NSW National Parks & Wildlife Service 2020). The park, especially Ash Island, is affected by a number of public utilities such as powerlines and pipelines and a corridor across Ash Island has been identified and zoned for future infrastructure development (NSW National Parks & Wildlife Service 2020). This corridor effectively cuts Ash Island into two sections and crosses the most important waterbird sites on the island. Sites included in HBOC surveys that are not in HWNP are Stockton Channel and parts of Kooragang Island.

It must be noted that the prime motivation for the monthly surveys has been to monitor shorebirds in the estuary. Thus, the focus was to visit tidally-influenced sites where shorebirds were more likely to be found. Several sites which only comprised freshwater wetlands were not surveyed – most notably the wetlands around Shortland and Tarro/Woodberry. The most important of these wetlands is at Hunter Wetlands Centre Australia (HWCA) at Shortland. It has a system of wetlands which were once a part of Hexham Swamp but the 45-ha site has been extensively modified over the years and its hydrological regime is no longer connected to Hexham Swamp. HWCA was listed as a Ramsar site in 2002 and is the only remaining colonial bird breeding site in the lower estuary. Wetlands at Shortland Waters Golf Club are breeding sites for cormorants and Australasian Darter and were also once part of the Hexham Swamp system.

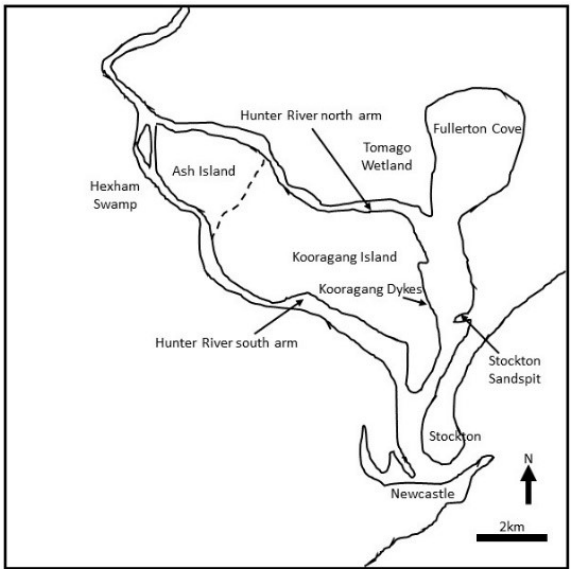


Figure 1. Hunter Estuary and the main sites surveyed.

METHODS

Once each month, coinciding with a Saturday morning high tide in the estuary, teams of HBOC members simultaneously visited sites where shorebirds could be expected to be found. At those sites, counts were made of all the shorebirds present and of all other waterbirds. A detailed description of the survey methodology is available (BirdLife Australia 2021).

Each month the results from each individual site were entered into Birdata (www.birdata.com.au). The monthly total numbers were also entered into a Microsoft Excel spreadsheet along with general notes (e.g. if any site had not been able to be surveyed that month). We used that spreadsheet as the basis for this report. To analyse the results, we used standard Excel graphing and data analysis tools. When comparing populations for two time periods we assessed if the changes were statistically significant by carrying out two-tailed t-tests assuming unequal variances ($\alpha < 0.05$) and determining the probability P of the change being significant. For P values below 0.05 we classified the differences as significant, and as highly significant for $P < 0.01$.

To assess long-term population trends, we compared the counts for two time periods – those for the first 11 years of surveys and those for the subsequent 11 years. For

seasonal comparisons, we grouped the data into December – February ("summer"), March-May ("autumn"), June-August ("winter") and September-November ("spring"). Where it was deemed relevant, we also compared seasonal data for the two 11-year time periods.

RESULTS

There were 263 surveys done in the 22-year period, of the 264 possible. In some surveys not every site was visited, because of access problems on the given day. When we assessed shorebird and gull and tern populations in the estuary (Stuart & Lindsey in preparation; Lindsey & Stuart in preparation), some of those surveys were excluded from analysis. However, for the present study we concluded that the total waterbird counts would not have been greatly affected, and thus we have used the results from all 263 surveys.

Twenty-one species from the three orders were recorded in the estuary during 1999-2021. **Table 1** lists the species, the number of records for each and their Reporting Rate (RR, the ratio of number of records to number of surveys, expressed as a percentage). Two species – White-faced Heron and Australian Pelican – were recorded in every survey, while six other species had RRs above 90% – Royal Spoonbill, Australian White Ibis, Great Egret, Little Egret, Little Pied Cormorant and Little Black Cormorant. The species with more than 90 records were analysed for trends, as detailed further below.

Black-necked Stork

Prior to September 2013 there were only two records of Black-necked Stork during the monthly surveys – in January 2000 and May 2001. Since then there have been 30 records (thus the RR since September 2013 was 39%, compared with an RR of 1.0% for the preceding period.

There were insufficient records for a close analysis of seasonal patterns. The four winter records involved a single bird and the three other seasons each had 7-11 records and often with multiple birds.

Yellow-billed Spoonbill

Apart from a record of seven birds in the first survey in April 1999, and another of three birds in August 2002, all the other records were of 1-2 birds and they were infrequent. No seasonal pattern was apparent.

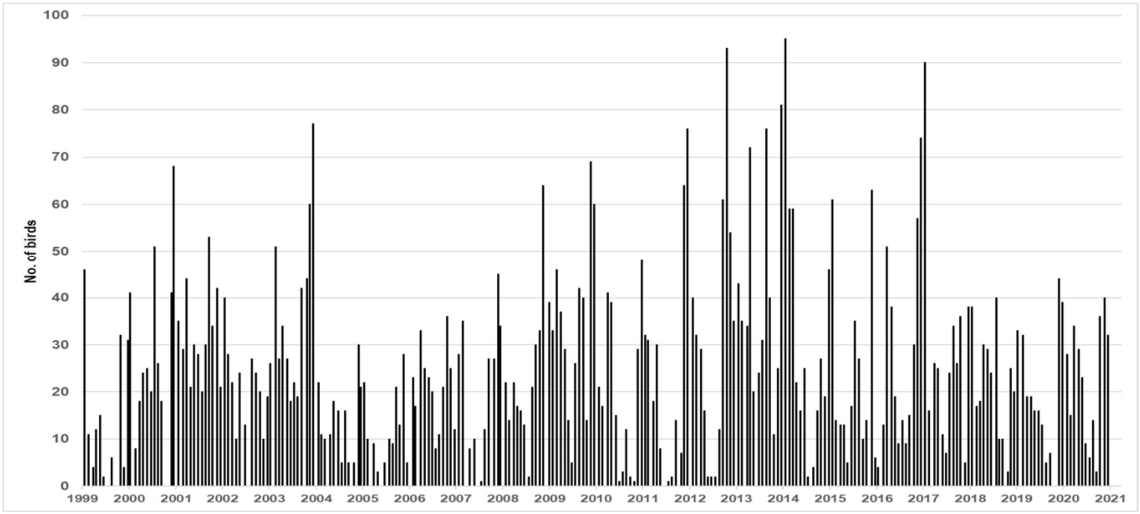
Table 1. Large waterbird species recorded in monthly surveys of the Hunter Estuary spanning 1999-2021, with their number of records and Reporting Rates (RR).

Species	Times recorded	RR (%)	Maximum count
Black-necked Stork	32	12.2	5
Yellow-billed Spoonbill	26	9.9	7
Royal Spoonbill	255	97.0	95
Straw-necked Ibis	162	61.6	965
Australian White Ibis	259	98.5	1126
Glossy Ibis	11	4.2	52
Australasian Bittern	4	1.5	1
Nankeen Night-Heron	15	5.7	21
Striated Heron	116	44.1	5
Cattle Egret	183	69.6	233
White-necked Heron	91	34.6	30
Great Egret	258	98.1	77
Plumed Egret	121	46.0	32
White-faced Heron	263	100	339
Little Egret	244	92.8	20
Australian Pelican	263	100	783
Little Pied Cormorant	259	98.5	41
Great Cormorant	203	77.2	51
Little Black Cormorant	261	99.2	151
Great Pied Cormorant	208	79.1	69
Australasian Darter	234	89.0	14

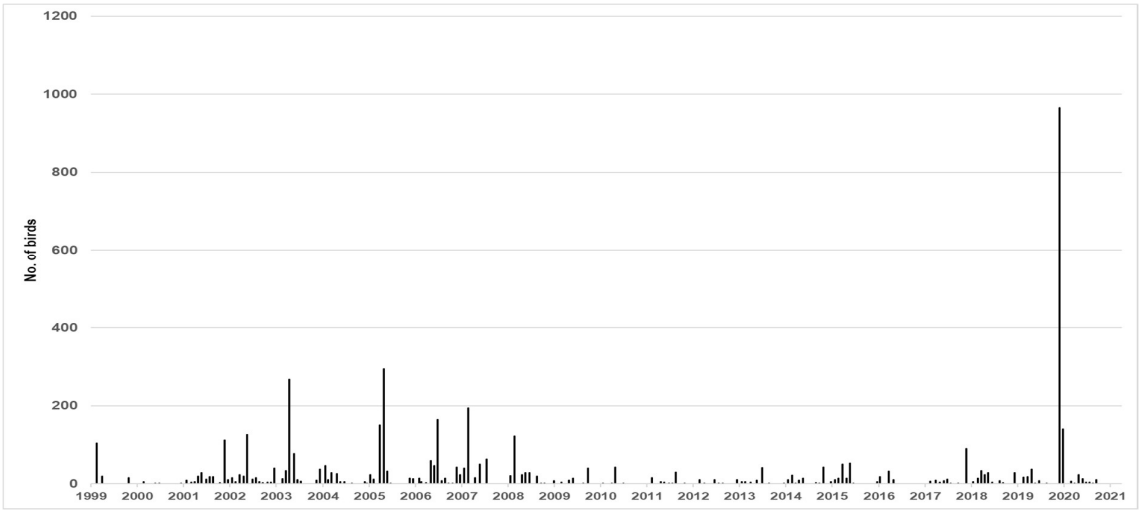
Royal Spoonbill

Birds were present most months, with most of the records being of 15-30 birds but there were frequent influxes when more than 60 birds were recorded (**Figure 2a**). Those influxes occurred in every season. Overall, the population has increased slightly. That change was mainly associated with a rise in autumn numbers in the second 11-year period, as shown in **Figure 3a**. The autumn means for the two periods were 29 and 43 birds respectively. The change was not statistically significant.

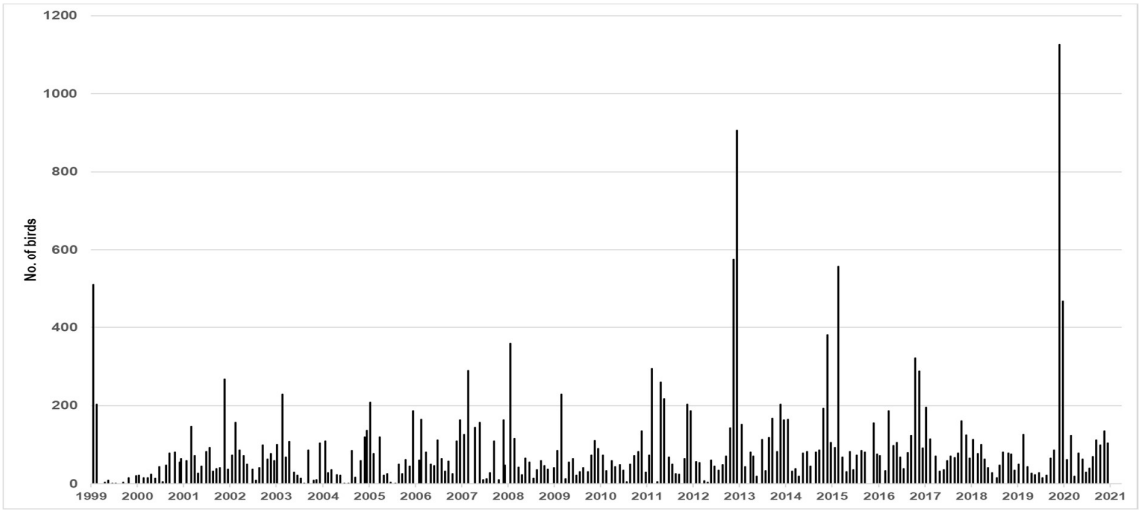
Seasonal analysis indicated that Royal Spoonbill was present in greater numbers in summer and autumn (22-year means of 29 and 35 birds, respectively) than winter and spring (22-year means



(a) Royal Spoonbill

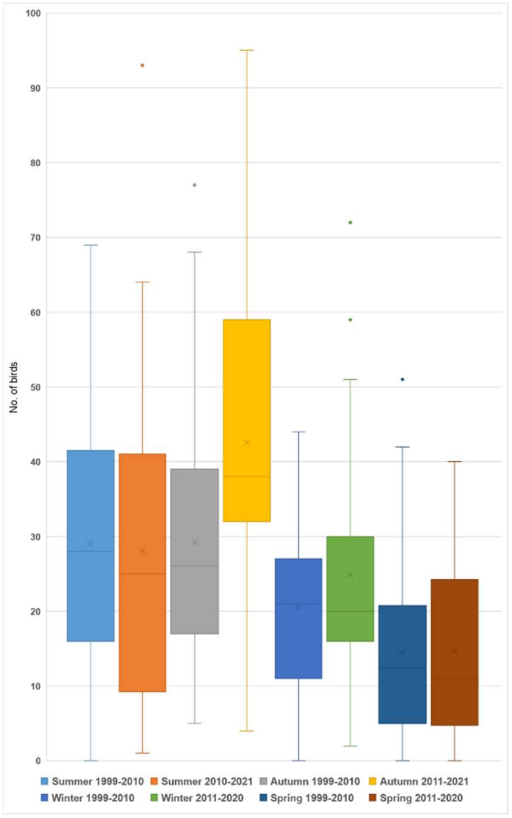


(b) Straw-necked Ibis

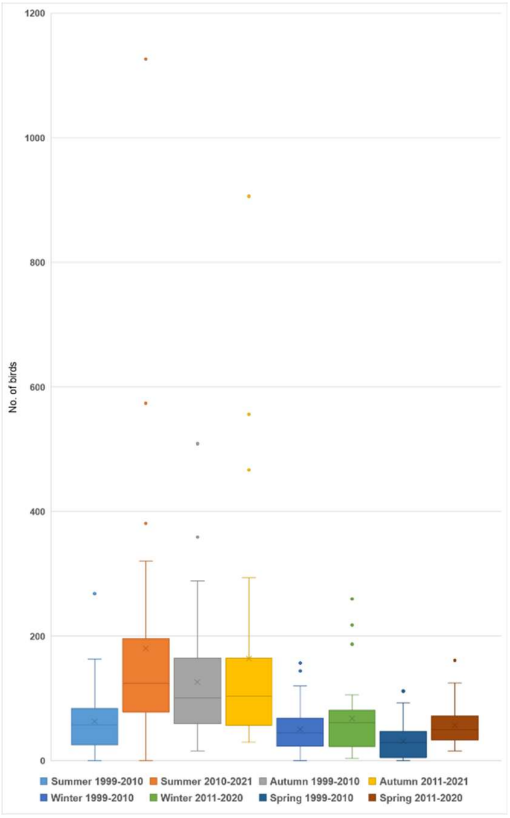


(c) Australian White Ibis

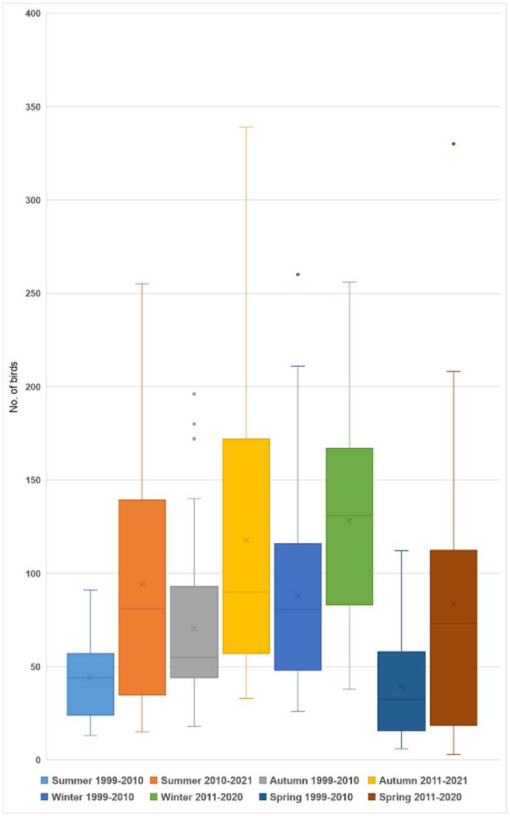
Figure 2. Monthly counts for a) Royal Spoonbill, b) Straw-necked Ibis and c) Australian White Ibis in the Hunter Estuary 1999-2021.



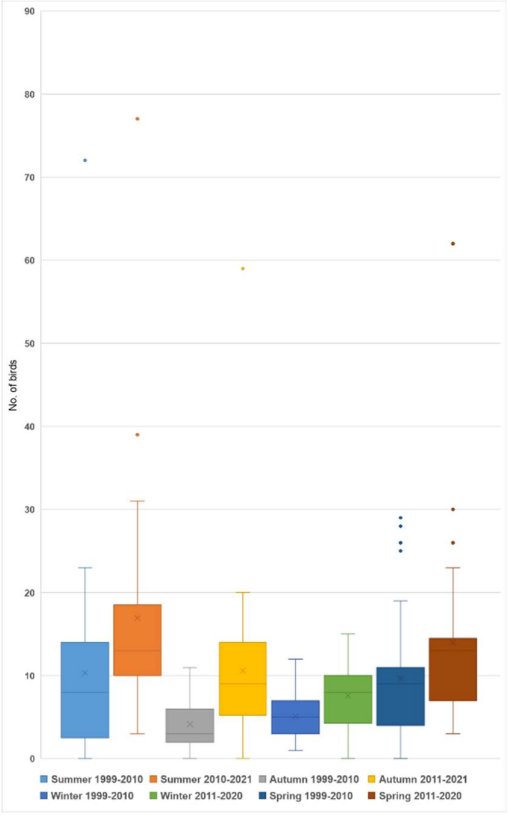
(a) Royal Spoonbill



(b) Australian White Ibis



(c) White-faced Heron



(d) Great Egret

Figure 3. Box and whisker plots for seasonal counts for a) Royal Spoonbill, b) Australian White Ibis, c) White-faced Heron and d) Great Egret in the Hunter Estuary for two time periods.

of 22 and 15 birds, respectively). The differences between the spring and either the summer or autumn numbers were statistically highly significant ($P < 0.01$). The differences between the winter and autumn numbers were also statistically significant ($P < 0.05$).

Straw-necked Ibis

Birds were recorded frequently, usually as counts of around 50 birds and with occasional spikes to 150-300 birds. There was no obvious seasonal pattern and the population was stable or slightly increasing (**Figure 2b**). The peak count, of 965 birds in February 2020, was anomalous being about three times as large as any previous count. Almost all of those birds were at Hexham Swamp where there were also more than 1,000 Australian White Ibis present.

Australian White Ibis

Usually 50-150 birds were recorded, and 200-400 birds occasionally (**Figure 2c**). There were five counts of more than 500 birds, with all of those being from the period February-May. The peak count of 1,126 birds occurred in February 2020, with most of those birds being at Hexham Swamp. The results indicated an increasing population although the change was dominated by counts of more than 500 birds in 2013, 2015 and 2020. The rise in summer numbers (see **Figure 3b** for seasonal changes) was statistically significant (means of 63 and 180 birds respectively for the two 11-year time periods) and so was the population change in spring (means of 31 and 57 birds respectively).

Seasonal analysis (**Figure 3b**) indicated that Australian White Ibis was present in greater numbers in summer and autumn (22-year means of 119 and 143 birds, respectively) than in winter and spring (22-year means of 58 and 43 birds, respectively). The differences between the spring and either the summer or autumn numbers were statistically highly significant ($P < 0.01$), as were the differences between the winter and autumn means. The differences between the winter and summer numbers were statistically significant ($P < 0.05$).

Glossy Ibis

All eleven records occurred from February 2013 onwards, with one record in spring (13 birds in November 2019), three records in autumn (52 birds in April 2014, the peak count from all surveys, and 2-4 birds in March 2014 and March 2017). There were no winter records. There were 42 birds in February 2013 and 27 birds in January 2017; all other summer records were of less than 20 birds.

Australasian Bittern

All four records were of single birds, and all were from prior to February 2013. Two of the records were from Kooragang Island, and one each from Ash Island and Tomago Wetland.

Nankeen Night-Heron

Of the 15 records of Nankeen Night Heron, one was in summer and two in autumn. Those three latter records involved 1-2 birds. There were six records in both winter and spring, with several of those being of multiple birds. The peak counts were of 21 birds in July 2002 and 14 birds in September 2001. Twelve of the records occurred in the first five years of the surveys. There were insufficient records for a more detailed analysis.

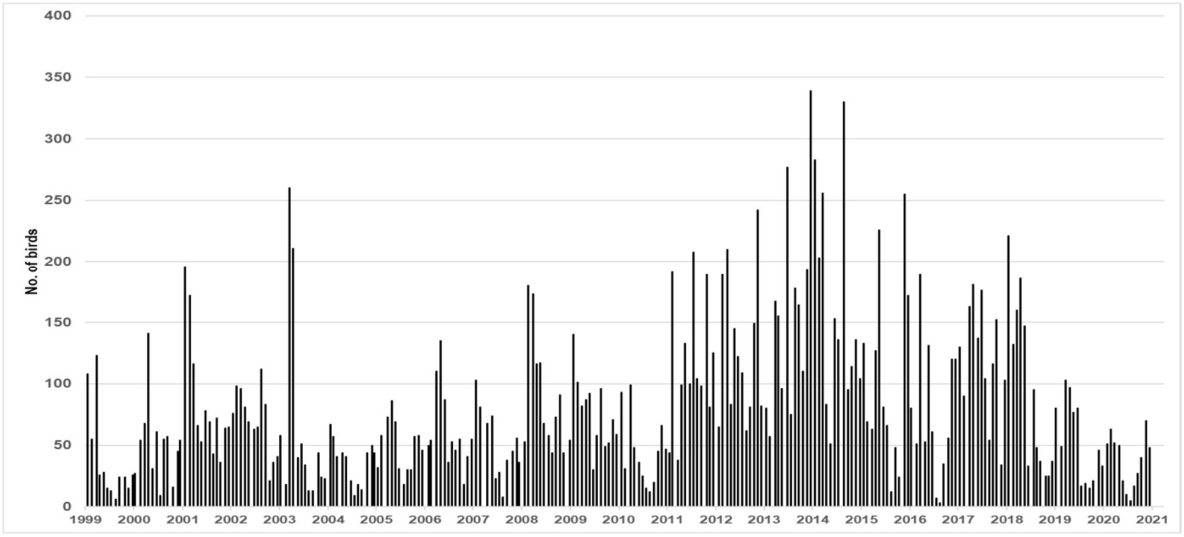
White-faced Heron

Birds were regularly present in the estuary. The long-term trend has been an increasing population (**Figure 4a**) although since 2019 the trend has reversed.

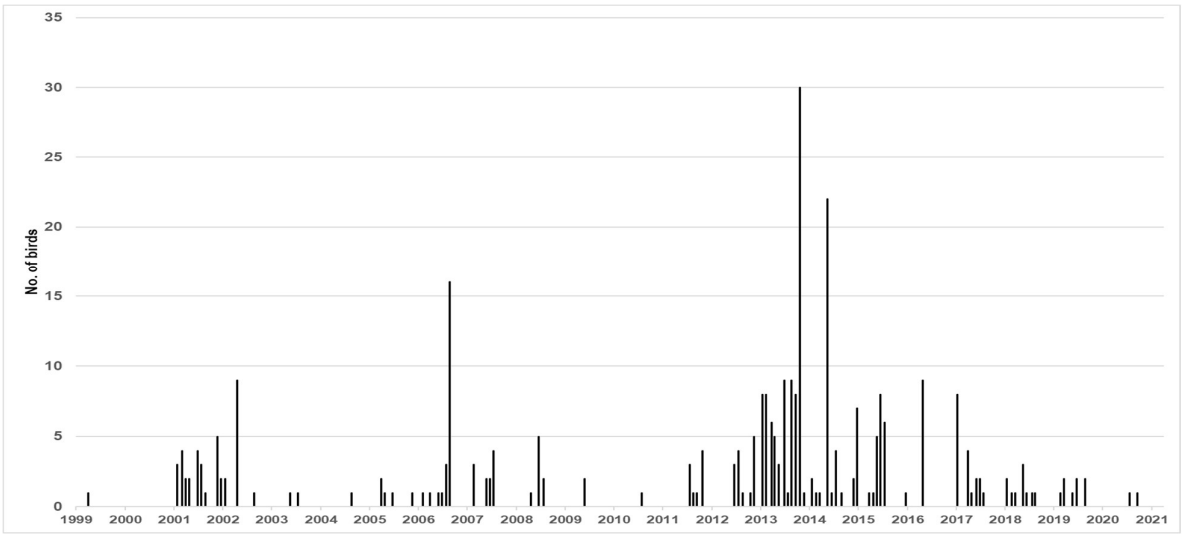
Data were analysed seasonally and for two time periods (**Figure 3c**). For three seasons – winter, spring and summer – the increase in numbers in the second time period was statistically highly significant. There is no significant difference for the autumn results although there probably has been an increase (means of 94 and 117 respectively for the two 11-year time periods). The differences between the summer and winter numbers in either of the two time periods were statistically significant (highly significant for the first time period). The differences between the summer and autumn numbers in the first time period were statistically significant.

White-necked Heron

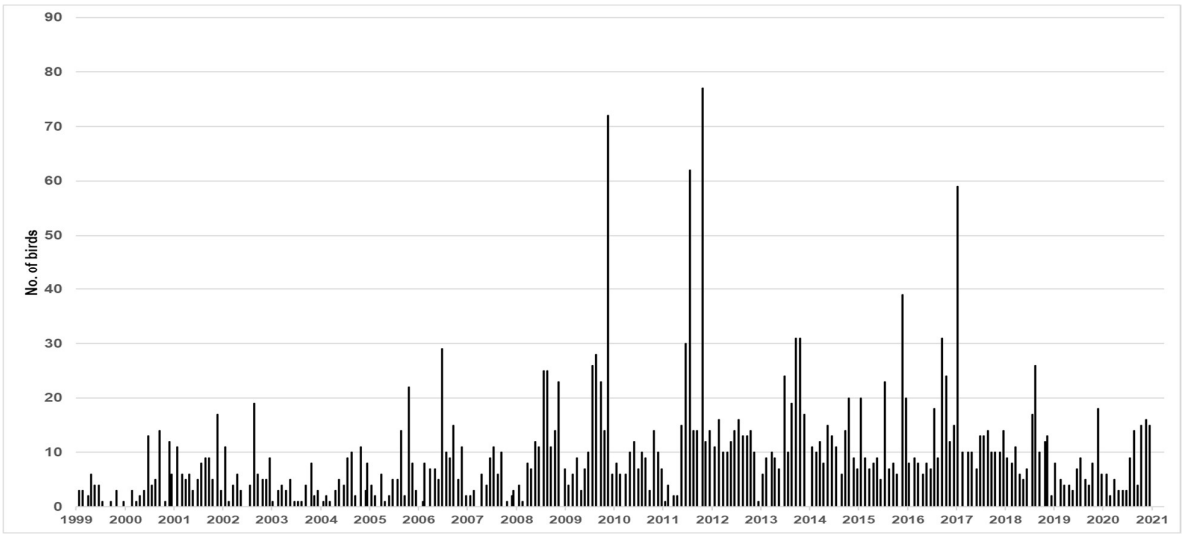
Birds were occasionally present in the estuary, usually in low numbers but with occasional spikes (**Figure 4b**). The main spikes were in November 2006 (16 birds), January 2014 (30 birds) and August 2014 (22 birds). There were no obvious seasonal differences or trends.



(a) White-faced Heron



(b) White-necked Heron



(c) Great Egret

Figure 4. Monthly counts for a) White-faced Heron, b) White-necked Heron and c) Great Egret in the Hunter Estuary 1999-2021.

Great Egret

Birds were regularly present in the estuary, usually as 5-15 birds, but with occasional larger influxes to 20+ birds (**Figure 4c**). The peak numbers were 72 birds (February 2010), 62 birds (October 2011), 77 birds (January 2012) and 59 birds (April 2017). The population in the estuary has increased. The increases have mainly occurred in the summer and autumn numbers. However, only the difference between the first and second autumn periods was statistically significant.

Figure 3d shows the seasonal differences for the two 11-year time periods. Although numbers are more likely to be lower in autumn and winter than in the other seasons (mean counts of seven and six birds respectively) than for spring and summer (mean counts of 12 and 13 birds respectively), the differences were assessed to be not statistically significant.

Plumed Egret

Birds were often present in the estuary, usually as 1-3 birds, but with occasional larger influxes (**Figure 5a**). The peak numbers have been 17 birds (November 2006), 32 birds (December 2012) and 22 birds (April 2017). The small population has in general remained stable over the survey period. This is supported by the observation that for any season there were no significant differences in the means between the first and second time periods. Also, there were no statistically significant differences in the seasonal numbers.

Little Egret

Small numbers of birds were present, with occasional spikes to 15-20 birds (**Figure 5b**). There was no change in the overall population across the survey period. This was confirmed when the seasonal data for two 11-year time periods were compared – for each of the seasons there were no significant differences for the two time periods, nor were there any significant differences in the seasonal populations.

Cattle Egret

Twenty to thirty birds were often present, with occasional spikes to 100-200+ birds (**Figure 5c**). The results indicated that there had been a small decrease in the overall population across the survey period. That was mainly associated with a decrease in summer numbers – the mean counts were of 33 and 19 birds for the first and second 11-year time periods respectively (**Figure 6a**). Those differences were not statistically significant. Numbers were greater in summer and autumn than in winter and spring, although the seasonal differences were not statistically significant. The two largest counts occurred in autumn (233 birds in May 2008 and 210 birds in March 2006).

Striated Heron

Small numbers of birds were recorded occasionally. The peak count, of five birds, occurred in December 2016, and also there were four birds in December 2012 and April 2017.

Australian Pelican

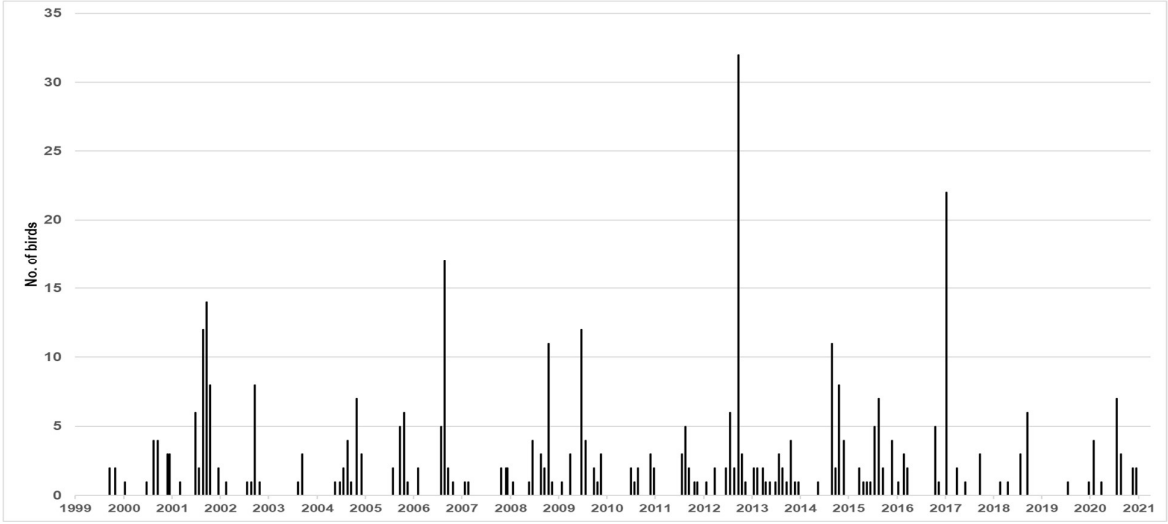
Most of the monthly counts were of 50-150 birds (**Figure 7a**). From October 2002 for six months there was a substantial influx, including the peak count overall of 783 birds in February 2003. Excepting for that short-term rise in numbers, the overall population was fairly stable. Seasonal analysis indicated that Australian Pelican was present in greater numbers in summer and autumn (22-year means of 134 and 119 birds, respectively) than winter and spring (22-year means of 72 and 97 birds, respectively). The differences between the winter and either the summer or autumn numbers were statistically highly significant ($P < 0.01$). **Figure 6c** shows the range of the seasonal counts for the first and second 11-year time periods.

Little Pied Cormorant

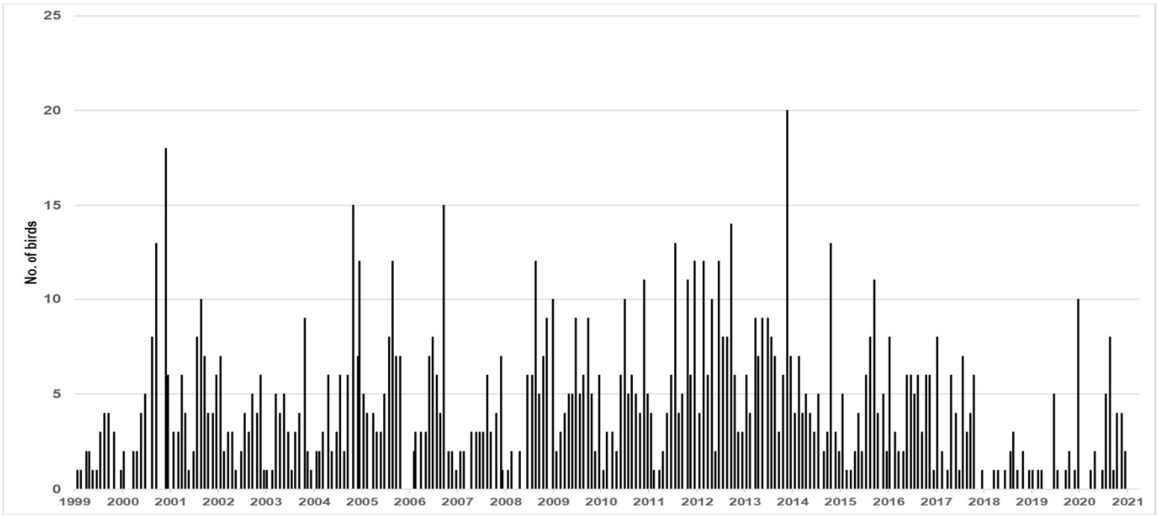
Little Pied Cormorant were recorded in most surveys, usually as total counts of 5-15 birds (**Figure 7b**). The peak count was 41 birds in March 2015. The population was stable and there were no significant seasonal differences in numbers.

Great Cormorant

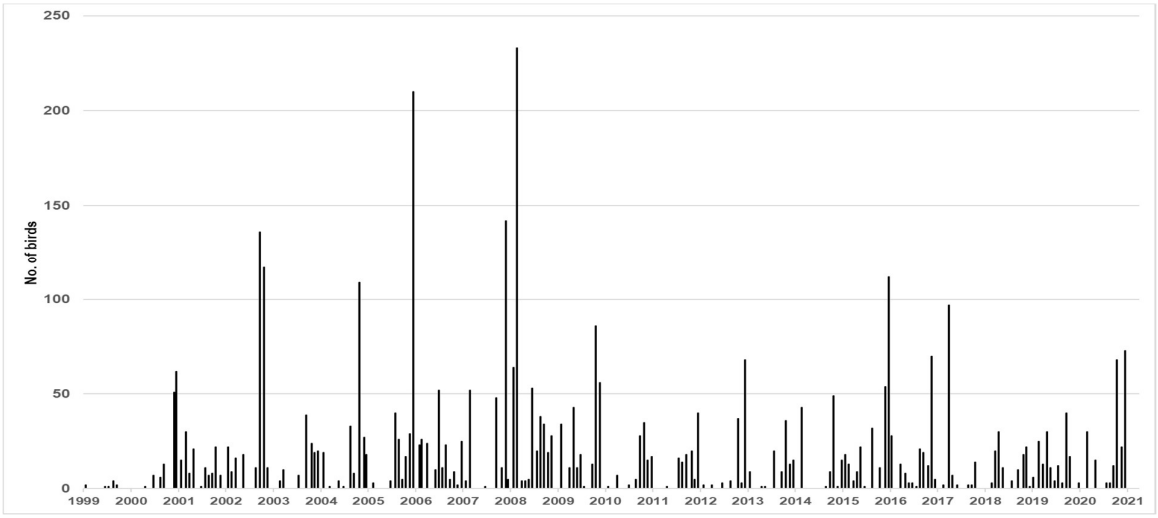
Great Cormorant were recorded in most surveys, usually as total counts of 5-15 birds. The peak count was 51 birds in September 2013. The results (**Figure 7c**) indicated a declining population which was mostly from decreases in the summer and spring numbers (see **Figure 6c**). For the first and second 11-year time periods the summer mean counts were eight and four birds respectively, and the means were eight and three birds for the two spring 11-year periods. However, the changes were not statistically significant nor were there any significant seasonal differences in the population.



(a) Plumed Egret

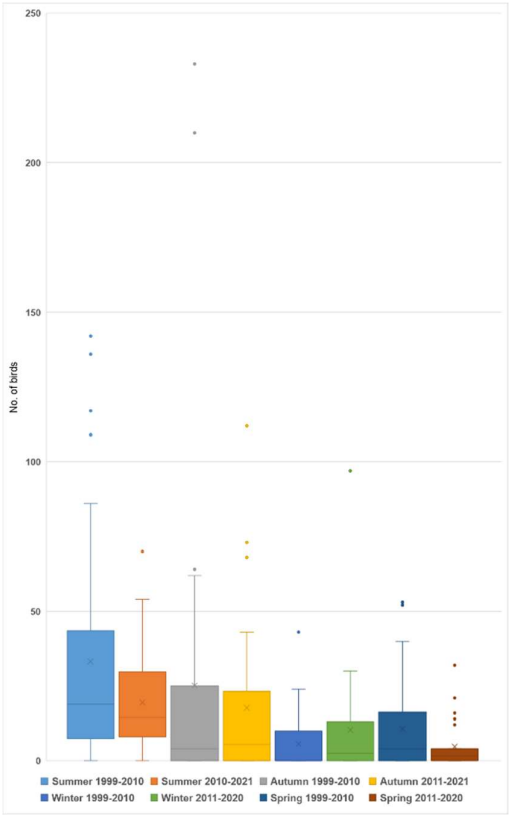


(b) Little Egret

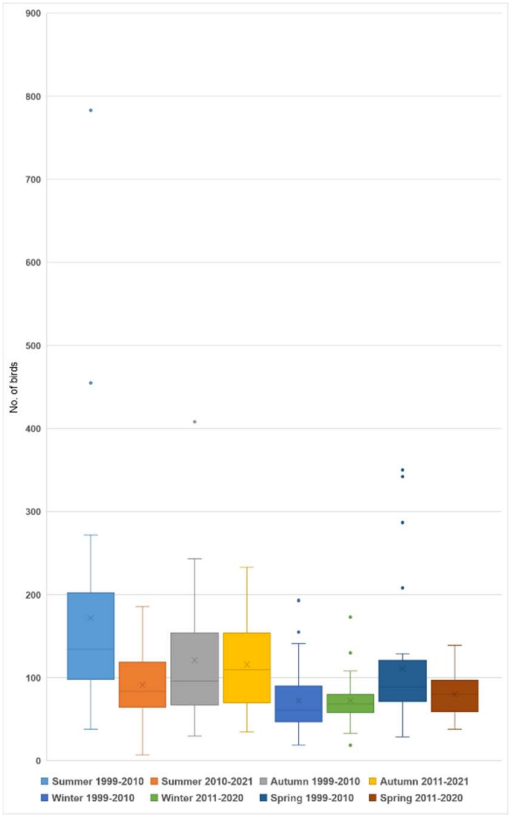


(c) Cattle Egret

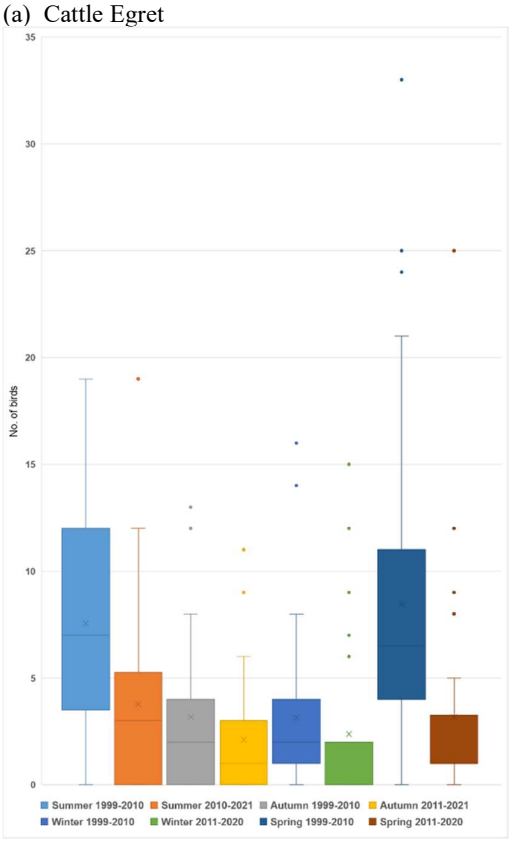
Figure 5. Monthly counts for a) Plumed Egret, b) Little Egret and c) Cattle Egret in the Hunter Estuary 1999-2021.



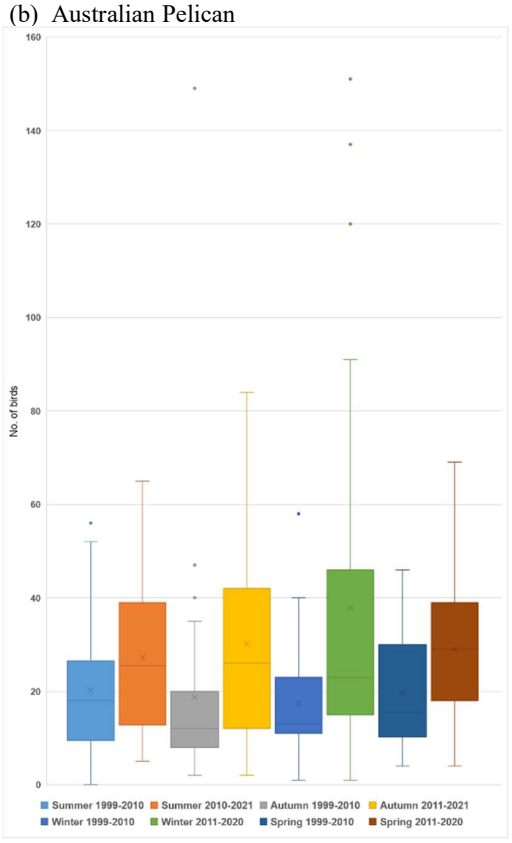
(a) Cattle Egret



(b) Australian Pelican

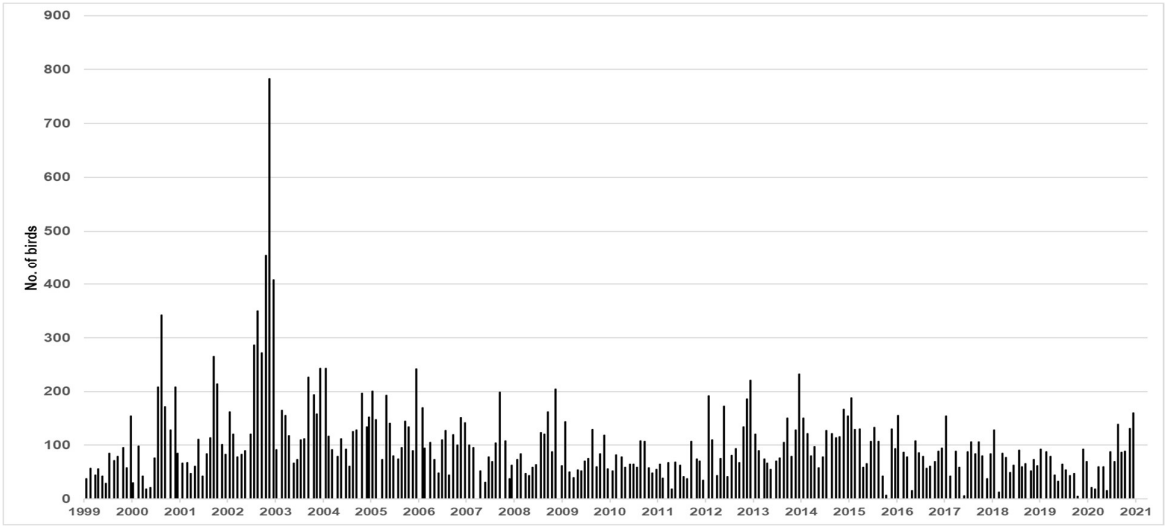


(c) Great Cormorant

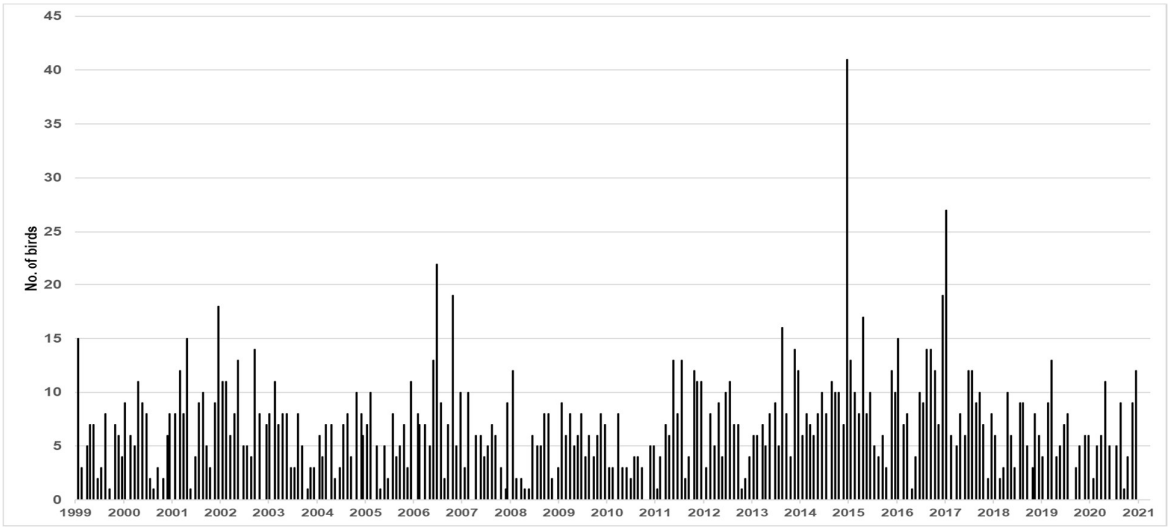


(d) Little Black Cormorant

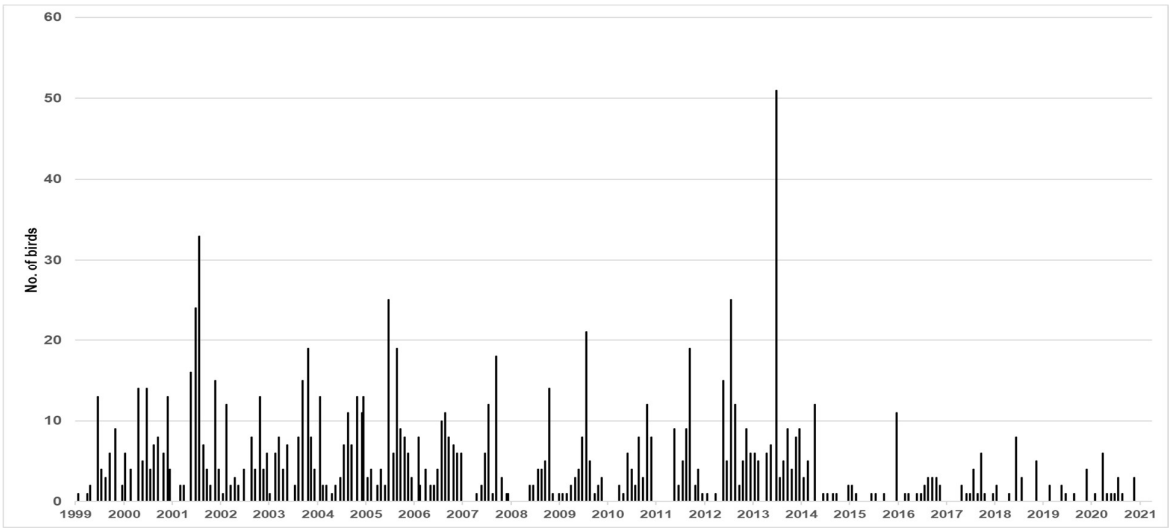
Figure 6. Box and whisker plots for seasonal counts for a) Cattle Egret, b) Australian Pelican, c) Great Cormorant and d) Little Black Cormorant in the Hunter Estuary for two time periods.



(a) Australian Pelican



(b) Little Pied Cormorant



(c) Great Egret

Figure 7. Monthly counts for a) Australian Pelican, b) Little Pied Cormorant and c) Great Cormorant in the Hunter Estuary 1999-2021.

Little Black Cormorant

Birds were regularly recorded, with seasonal mean counts of 24-26 birds but occasionally much greater numbers including four counts of more than 120 birds and a peak count of 151 birds in July 2020 (**Figure 8a**). There were no seasonal differences in the numbers present. In all four seasons there was evidence that the population had increased in the second 11-year time period (see **Figure 6d**), from means of 17-20 birds to means of 27-38 birds. Only the winter change was statistically significant ($P < 0.05$), with the mean rising from 17 birds to 38 birds.

Great Pied Cormorant

Birds were regularly recorded in the estuary, and the population increased over the 22-year period (**Figure 8b**). Prior to July 2014 there were no counts of more than 30 birds, subsequently there were twenty such occurrences. Comparisons of the counts for the first and second 11-year time periods showed that the mean counts had increased for every season (**Figure 9a**). The differences were statistically significant ($P < 0.05$) for summer (mean counts of eleven and 22 birds respectively) and spring (mean counts of nine and 20 birds respectively).

In both of the 11-year periods, numbers for Great Pied Cormorant were greater in summer and spring than in autumn and winter; however, the differences were statistically significant ($P < 0.05$) in the second 11-year period only.

Australasian Darter

Australasian Darter was recorded frequently, usually in counts of 1-4 birds but with occasional spikes including a peak count of 14 birds in April 2013 (**Figure 8c**). There were indications that birds were present in greater numbers in winter (see **Figure 9b**) but the seasonal differences were not statistically significant.

DISCUSSION

Population trends

Increasing populations

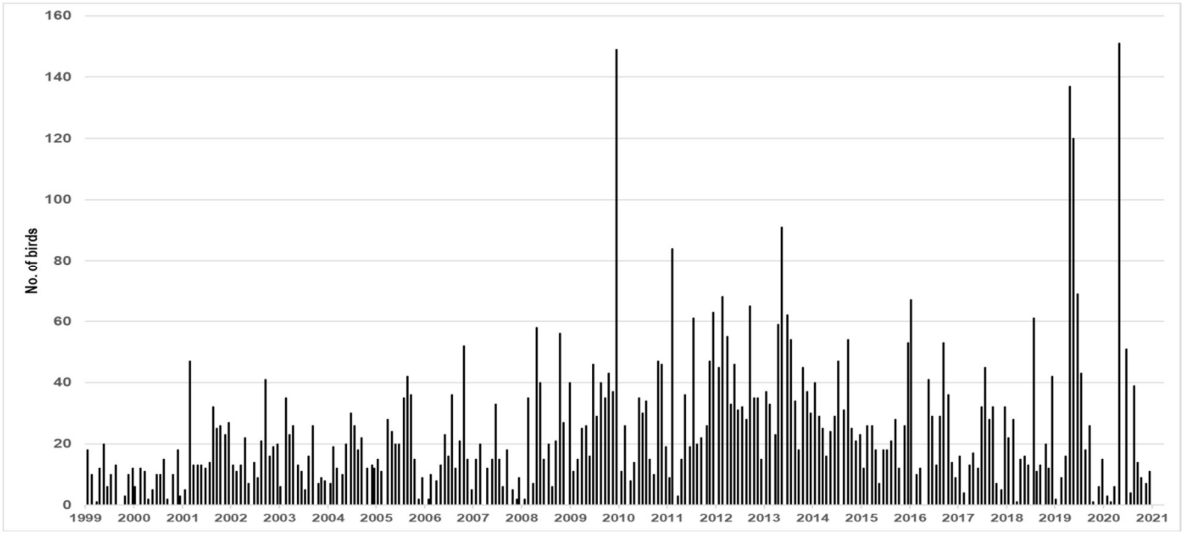
Most of the species were found to have stable populations or the changes over 22 years were modest. The populations of eight species were found to have increased – Black-necked Stork, Royal Spoonbill, Australian White Ibis, Glossy Ibis, White-faced Heron, Great Egret, Little Black Cormorant and Great Pied Cormorant.

The Black-necked Stork is listed as Endangered under the NSW *Biodiversity Conservation Act 2016*. Until relatively recently, it was an uncommon species within the estuary. In the Hunter Region Annual Bird Report series (the issues for 1993-2019 are currently available), there were only occasional records from within the estuary between 1993 and 2005 and there were no records for 2006-2008. In mid-January 2009, an immature bird, which had been taken into care in Sydney, was released at HWCA. After an interval of about two weeks with frequent sightings, there were no further records of that bird. However, from October 2009 onwards, records of Black-necked Stork began to become more frequent although they still were intermittent (and none was on a survey date). During 2010-13, most reports were of a single male or female but occasionally a pair were recorded together.

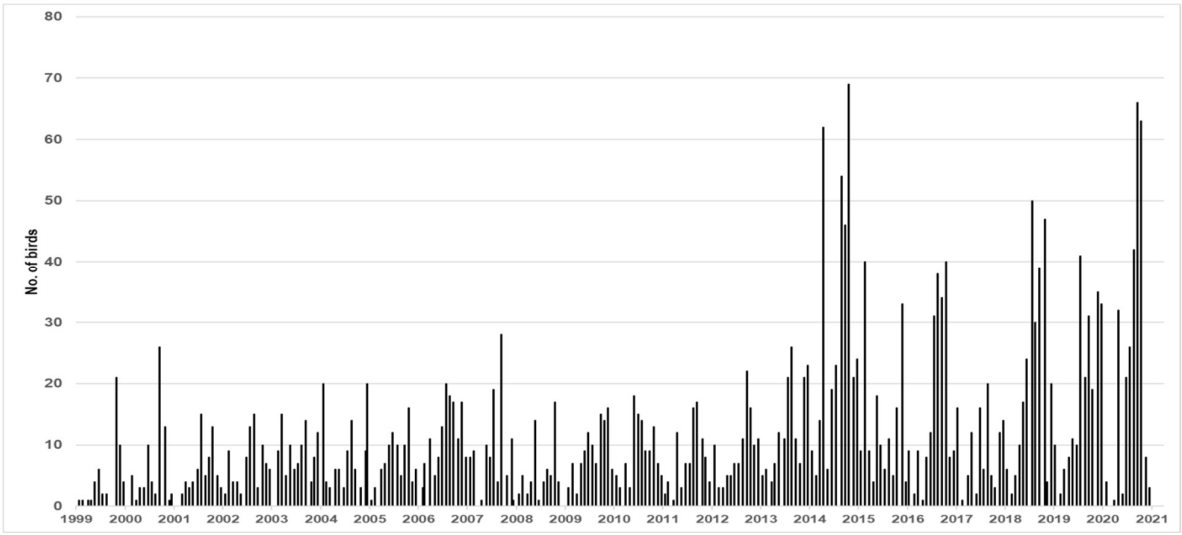
The increase in records in the estuary since 2013 eventually was accompanied by the first documented evidence of local breeding activity. By 2020 there were at least two breeding pairs within the estuary, one pair at Tomago and the other at Hexham Swamp (Lindsey 2019; 2021). The Tomago pair were confirmed to have bred successfully in the 2017 and 2018 seasons and possibly they had also bred there earlier (Lindsey 2019). The only confirmed breeding record for the Hexham Swamp pair was in 2020 but birds possibly bred there, or nearby, in 2014 and 2015 (Lindsey 2020; Stuart 2017).

The increases in Royal Spoonbill population were modest and were mainly associated with greater numbers in autumn. This species, which preferentially feeds on intertidal mudflats (Lowe 1982), is generally considered to be sedentary (Marchant & Higgins 1990).

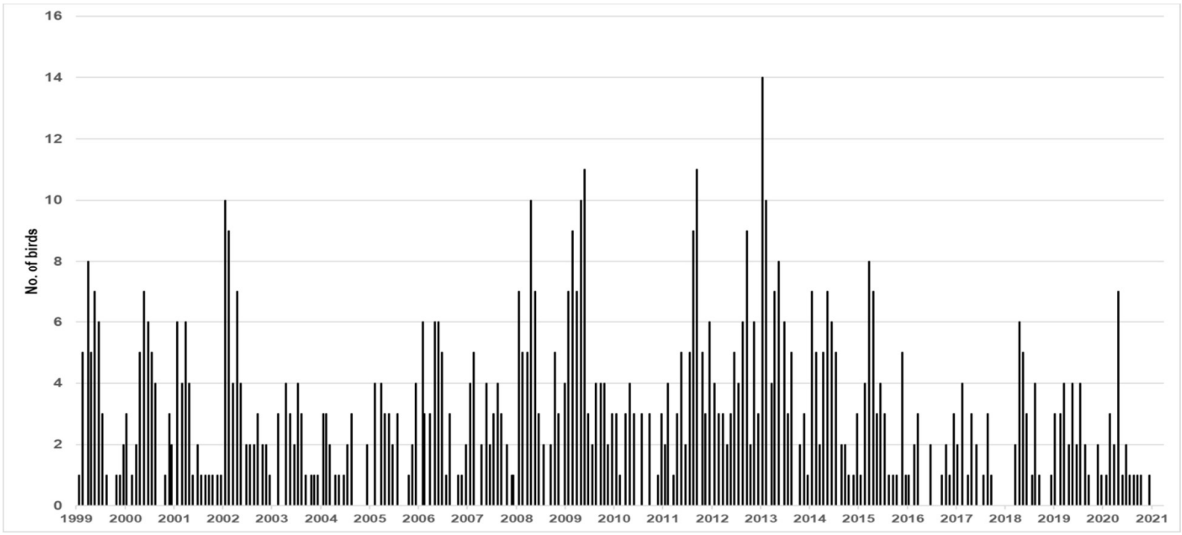
Australian White Ibis is widespread in NSW (Marchant & Higgins 1990; Cooper *et al*. 2014) and is equally at home in saline or freshwater habitats. The rise in numbers in the estuary was unexpected, as there has been a significant decline in numbers in eastern Australia over a 30-year period (Kingsford *et al*. 2017) and there have been fewer nests at a breeding colony at HWCA. Regular breeding at HWCA, mainly over the winter period, commenced in 2003-04 and peaked in 2011-12 with 303 nests



(a) Little Black Cormorant

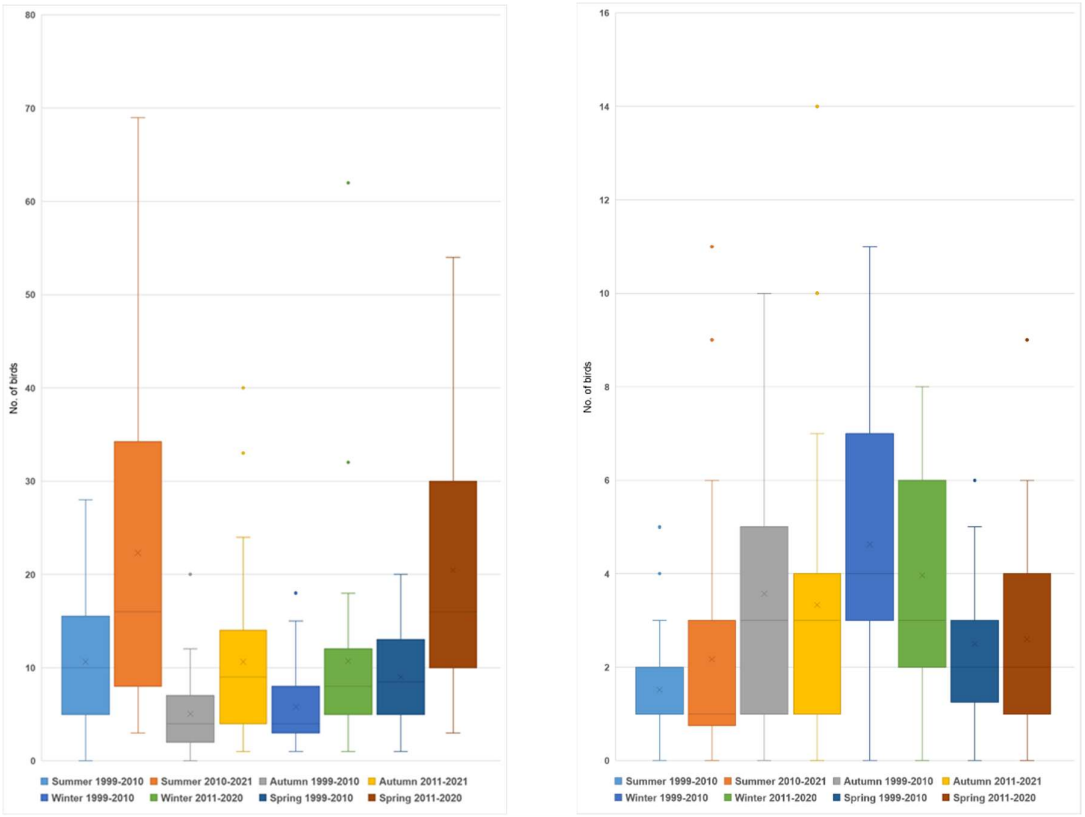


(b) Great Pied Cormorant



(c) Australasian Darter

Figure 8. Monthly counts for a) Little Black Cormorant, b) Great Pied Cormorant and c) Australasian Darter in the Hunter Estuary 1999-2021.



(a) Great Pied Cormorant (b) Australasian Darter

Figure 9. Box and whisker plots for seasonal counts for a) Great Pied Cormorant and b) Australasian Darter in the Hunter Estuary for two time periods.

(Nicholls 2019). There has been a steady decrease in the number of nests since then and there were only 76 nests in July 2020 (G. Nicholls unpublished reports).

In the Hunter Region the Glossy Ibis is an uncommon, irruptive species which occurs in small numbers, mainly on freshwater wetlands (Williams 2020). Its numbers in Australia fell by almost 38% between the two national Atlas surveys in 1977-1981 and 1998-2002. There was a decrease in the reporting of this species from 1986-2006 (Cooper *et al*. 2014).The increased number of records in the estuary since 2013 may be a result of improved habitat as discussed further below (in *Effects from local rehabilitation projects*).

White-faced Heron was one of two species recorded on every survey (the other species with an RR of 100% was the Australian Pelican). Across the two 11-year time periods its numbers increased significantly or highly significantly, depending upon which season was being considered. A combination of dry conditions inland and the effects of local rehabilitation projects probably account for the changes. The recent decrease in numbers of White-faced Heron may have been as a result of the Millennium Drought breaking, with some birds thus able to return to inland wetland sites. The changes observed for Great Egret might be similarly explained (although, see the discussion about *Egrets*, further below).

The increased numbers of Little Black Cormorant and Great Pied Cormorant could be due to a number of factors including changes in portside land use, pollution reduction programs, restoration of natural tidal flows and the rehabilitation of estuarine habitats (Office of Environment and Heritage 2017).

Declining populations

The absence of Australasian Bittern records from the monthly surveys since 2013 suggests that its population may have declined. However it is a cryptic species and there were only four records in the first 14 years. In 2020-21, some birds were recorded occasionally at both Hexham Swamp and Ash Island during targeted surveys (I. Benson pers.

comm.). Nevertheless, there have been some loss of habitat for this species, as discussed below under *Effects from local rehabilitation projects*.

Although there were insufficient records of Nankeen Night-Heron from the surveys for any trends to become apparent, the results confirm that the estuary's population of this species has not recovered since the progressive destruction of the Kooragang Island colony near Stockton Bridge (Maddock 2008). The destruction was complete by 1972. Gosper reported roosting assemblages of up to 300 birds and up to 60 breeding pairs (Gosper 1981). During the 1980s Maddock reported a range of 11-51 birds as semi-permanent residents at HWCA (Maddock 2008). Small numbers continue to be reported from that site (M. & R. Stewart pers. comm.). The only confirmed breeding record in the estuary since the 1970s was from near HWCA in 2009 (Stuart 2010). We speculate that this species leaves HWCA to forage in Hexham Swamp. In October 2012 one bird was seen flying from the direction of HWCA to Hexham Swamp where it landed in the early evening (AL pers. obs.) and in September 2017, seven birds were seen flying from HWCA to Hexham Swamp (www.birdlife.birdata.com). Williams (2020) describes this species as resident and an irruptive visitor to the Hunter Region.

Egrets

The results for the egrets do not reflect the trends occurring for them at the HWCA and Seaham colonial breeding sites, where all four species breed or have bred in the past (Maddock 2008; Nicholls 2019). The monthly survey results suggest that the Great Egret population had increased, that Cattle Egret had decreased although not statistically significantly, and that the Plumed and Little Egret populations had been stable. Maddock (2008) reported declines between the 1981/82 and 2007/08 seasons for the numbers of nests of Great, Plumed and Little Egrets at HWCA and Seaham as being well in excess of 90% and the decline for Cattle Egret nests at both colonies exceeded 70%. The Seaham colony ceased to exist in about 2010. More recent nest counts at HWCA for the 2010/11 to 2018/19 seasons, when compared to the 1995/96 to 2007/08 time period, showed a further decline in the median counts of Great Egret and Plumed Egret nests, an increase in Cattle Egret nests and the same median count for Little Egret nests (Nicholls 2019).

The differences in the trends being seen from the two types of survey may be due, at least in part, to the estuary surveys not providing the full picture for the egrets, all of which have differing habitat preferences. Plumed Egret and Cattle Egret were less commonly recorded during the surveys because the habitat in the surveyed areas of the estuary was not optimal for them. The Plumed Egret prefers freshwater wetlands while Cattle Egret prefers low-lying or poorly drained pasture (Marchant & Higgins 1990). These habitats are not common at the monitored sites. The two other species had RRs above 90% in the surveys but neither species was present in large numbers. The Great Egret uses both saline and freshwater wetlands and forages in open shallow water, while the Little Egret prefers saline wetlands and also forages in open shallow water (Marchant & Higgins 1990). There are many other wetlands in the lower Hunter which provide such required habitats, i.e. the estuary surveys find only a subset of the total local population.

Seasonal population changes

Summer and autumn

Seven species had greater populations in the estuary in summer and autumn: Royal Spoonbill, Australian White Ibis, Glossy Ibis (in summer only), Great Egret, Cattle Egret, Australian Pelican and Great Pied Cormorant.

The Royal Spoonbill breeds in the Hunter Region (Williams 2020) and the higher numbers in autumn may be related to post-breeding dispersal. An analogous situation may apply for the Australian White Ibis. At HWCA it breeds mainly in winter and the rise in its numbers in spring and summer may also be due to post-breeding dispersal to other wetlands in the estuary, particularly to nearby Hexham Swamp. Consistent monitoring in the Sydney region, however, showed that banded juveniles were rarely resighted after leaving the nesting sites and they comprised only 10% of the population (Smith 2009). Juvenile Straw-necked Ibis were likewise infrequently observed after leaving nest sites (Smith 2009). Both species may be benefitting from scavenging opportunities at the waste management facility at Maryland, a suburb on the edge of Hexham Swamp (Maddock 2008).

The Glossy Ibis is described as migratory with local movements driven by food availability (Marchant & Higgins 1990; Cooper *et al*. 2014) and the pattern of records from the estuary accords with that description. Cattle Egret departs its breeding colonies in March or April, dispersing widely (Maddock 2008), which would account for the fewer numbers in the estuary over winter and early spring. Great Egret (and Little Egret) are also

described as dispersive and possibly migratory (Marchant & Higgins 1990), which may account for the seasonal aspect to the Great Egret records. Cooper *et al*. (2014) noted that there did not seem to be significant regular movements out of NSW.

The reason for the greater numbers of Australian Pelican in summer and autumn is unclear. Cooper *et al*. (2014) found no evidence for regular seasonal movements. This species breeds throughout the year at Wallis Lake, north of Newcastle and thus the seasonal changes do not seem to be related to dispersal after breeding. At Wallis Lake, eggs were present in nests in all months from January through to October although peak laying seemed to be in August-September (Marchant & Higgins 1990). At the colony in 2012, many birds had nests with eggs in August and chicks of varying ages were present in November (Stuart *et al*. 2012).

The seasonal increase in Great Pied Cormorant numbers may be associated with the colony at Shortland where breeding was first recorded in 1998 (Stuart 1999). Foraging presumably becomes more locally focussed in the breeding season whereas at other times of the year, birds are more widely dispersed including when they are foraging at beaches away from Newcastle harbour.

Winter

The numbers for White-faced Heron rose in autumn and peaked in winter. This was also found to be the case in Westernport Bay in Victoria where there was a spring dispersal away from the coast presumably to breed inland and the largest flocks were observed in May and June (Lowe 1983). Gosper (1981) noted that in north-east NSW this species congregates on coastal mudflats during winter. White-faced Heron will also move to coastal estuaries during summer after breeding (Marchant & Higgins 1990). Cooper *et al*. (2014) noted that birds are absent from high-altitude parts of NSW in winter, with a corresponding increase in coastal records.

Very little is known about the movements of Australasian Darter but when not breeding it disperses sometimes over long distances (Marchant & Higgins 1990). Its increased numbers in the estuary in winter may be associated with post-breeding dispersal (Cooper *et al*. 2014).

Irruptions

Several species had short-term irruptions into the estuary, when their numbers briefly were much greater than average. Mostly these irruptions can be accounted for by a combination of inland conditions and conditions within the estuary. When inland wetlands begin to dry out, the birds there disperse to coastal refuges where there is sufficient suitable habitat to sustain them at least temporarily. For example, the irruption of Australian Pelican from October 2002 may have been caused by the intensification of drought conditions inland which started to abate by March 2003 (Bureau of Meteorology 2003).

For another example, we considered the irruptions by White-necked Heron. In NSW this species is more common in the Riverina, Western Slopes and North Coast (Cooper *et al*. 2014). It is known to be affected by water conditions which may lead to irruptions and fluctuations in numbers (Marchant & Higgins 1990). Irruptions in the estuary have been small compared to a report of "hundreds of these herons being seen on Burswood Island" near Perth in 1923 (Pringle 1985). Four irruptions occurred in the estuary between 1999 and 2021, one of which was not on a survey date. These irruptions could be linked to the local and inland NSW water conditions. For instance, in 2006 (when 16 birds were present), 2008 (26 birds – see Lindsey & McNaughton 2012) and January 2014 (30 birds present) the rainfall in the Hunter Region was average to above-average whereas conditions inland were particularly dry. Three heatwaves in January 2014 caused extreme temperatures. (Bureau of Meteorology 2006, 2009, 2014a). Although most of the state had good rainfall in August 2014, there was about double the average rainfall in the coastal regions (Bureau of Meteorology 2014b) which may account for the spike of 22 birds in that month.

Water levels in the estuary were high in April 2017 in the aftermath of Cyclone Debbie the previous month (Bureau of Meteorology 2017) and this may have attracted both Great and Plumed Egret to wetlands in larger than usual numbers.

Some of the other large counts may be associated with chance observations of larger congregations of birds. For example, the peak counts of Australian White Ibis (1,126 birds) and Straw-necked Ibis (965 birds) occurred in February 2020 when a large mixed flock of ibis rose out of dense vegetation at Hexham Swamp and was briefly sighted (AL pers. obs.).

Effects from local rehabilitation projects

The Hunter River has a long history of wetland decline due to interventions commencing in the mid-19th century, which altered the hydrology and

vegetation of the coastal floodplain (Rogers 2016). One of the main changes was that floodgates were installed at Ash Island, Hexham Swamp and Tomago Wetland. The floodgates prevented tidal exchange and created freshwater wetlands, which often were ephemeral. Commencing with the Kooragang Wetland Rehabilitation Project in 1993, reinstatement of tidal flushing was established as a long-term objective for the lower Hunter Estuary in 1998 (Russell *et al*. 2012). Reinstatement of tidal flushing was accomplished at Hexham Swamp between 2008-2013 and at Tomago Wetland between 2012-2015 (Lindsey 2021). A fourth project at Fish Fry Flats on Ash Island known as the Newcastle Coal and Infrastructure Group Shorebird Compensatory Habitat Construction, commenced in 2016 (Reid 2019; Lindsey 2021).

The expansion and improvement in estuarine habitat through the reinstatement of tidal flushing resulted in significant improvement in aquatic species diversity and abundance in Hexham Swamp, for example fish, including eel and prawn species. Monitoring of the prawn populations at Hexham Swamp after staged reintroduction of tidal flushing between 2008 and 2013 found that there was positive recruitment of Eastern King Prawn *Melicertus plebejus a*nd School Prawn *Metapenaeus macleayi* as well as fish including eel species (Boys 2015).

At Westernport Bay, Victoria, the dominant prey for Royal Spoonbill and White-faced Heron were prawn species (Lowe 1982; 1983). The diet of Black-necked Stork includes fish (Clancy 2012). The populations of these three species in the estuary have increased, almost certainly as a result of the rehabilitation projects. It seems reasonable to conclude that most other bird species which forage in estuarine habitat in the Hunter have benefitted from the growing food supply. For example, the four irruptions by White-necked Heron occurred at rehabilitated wetlands (Lindsey 2021).

The several successful breeding events by Black-necked Stork in recent years very likely are a direct result of the improved foraging opportunities for this species. The nests established at Tomago and Hexham were immediately adjacent to the newly-rehabilitated wetlands where food had become abundant.

One species may have been adversely affected by the rehabilitation projects – the Australasian Bittern, which is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*. Before tidal flushing was reinstated at Tomago Wetland, there were regular records from there and birds possibly were breeding (Lindsey & McNaughton 2012). After the reintroduction of tidal flushing, there have not been any records of bitterns at the surveyed parts of Tomago Wetland. However, there continue to be records from nearby freshwater wetlands and also at Hexham Swamp.

CONCLUSIONS

Twenty-one species of large waterbirds of five families were recorded in systematic surveys commencing in 1999. Of these, 13 species had reporting rates of over 50% and most species were found to have stable populations. The populations of eight species increased and the populations of four species decreased slightly (Cattle Egret, Australian Pelican, Great Cormorant, Australasian Darter). Two resident species, Black-necked Stork and Australasian Bittern, are listed threatened species. The wetlands of the Hunter Estuary form an integrated ecological system of interdependent units. Improvement in water quality and the expansion of estuarine habitat through rehabilitation projects have had a positive effect on aquatic fauna thus providing more food resources for waterbirds.

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