# A census of waterbird populations (2003 - 2012) at Walka Recreation and Wildlife Reserve near Maitland, NSW

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The lake at Walka Recreation and Wildlife Reserve (locally known as Walka Water Works) near Maitland NSW is subject to increasing social pressure as a consequence of the rapid urban expansion of Maitland. The lake is of high environmental significance in the Lower Hunter Region as it supports a diversity of waterbirds and it is also one of three regional wetlands with habitat requirements to support a resident population of the deep-water specialist, Great Crested Grebe *Podiceps cristatus*. The 18-hectare wetland is characterised by permanent, open, deep freshwater with fringing vegetation.

Straightforward methodology is used in this long-term study to acquire site-specific base-line data of diversity, frequency of occurrence, relative abundance and possible population change of waterbirds supported by the Walka Lake. The base data, presented in the comprehensive appendices, may be analysed and interpreted to inform future studies and also assist the development of land management strategies necessary to maintain the environmental health of this ecosystem. To assist future monitoring potential indicator species are identified and discussed. The role of the Walka Lake as a refuge for waterbirds during extended dry seasons elsewhere and as a potential site to promote the conservation of the near-threatened Blue-billed Duck *Oxyura australis* is also considered.

## INTRODUCTION

*Site Location:* The site is located at 55 Scobies Lane, Oakhampton Heights, Maitland, NSW (32°42'52" S, 151°32'57" E).

*Land use*: The Walka Water Works site has served the people of the Maitland and Lower Hunter Region throughout its recorded history. The discovery of artefacts and other evidence indicate that the site was used by indigenous people of the area before European settlement (Brayshaw 1986) and later the first European settlers used it for agriculture. The socially significant Walka Water Works scheme, designed by William Clarke, was constructed during 1882 to 1886 to provide a permanent supply of filtered, potable water for Newcastle, Maitland and the developing settlements in the lower Hunter (Turner 1986). The scheme was fully operational from 1887 to 1929 and was subsequently operated for emergency use until its closure in 1945. To meet post WW II demands for electricity a prefabricated powerhouse was operated from 1951 to 1978 (Turner 1986). Since 1978 the site has continued to serve the people of the region as a recreational and wildlife reserve.

*Habitat Significance*: The original natural swamp, bounded on the northern and western edges by a ridge line rising 30 metres above the level of the Hunter River, was changed irrevocably in 1882 by the construction of a 335 metre long embankment which formed the dam wall for the water storage impoundment for the Walka Water Works and which separates the impoundment from the ephemeral wetlands of the Hunter River flood plain. It should be noted that the existing sandstone-faced wall, the buildings and their related infrastructure are of outstanding cultural significance in the regional context and are heritage listed at both State and Federal levels.

The Lower Hunter Region has several water bodies associated with the Hunter River flood plain but amongst these Walka is exceptional due to its elevated position above the floodplain. Walka has an irregular shape and an open water surface area of 18 hectares, which is larger than most wetlands in the lower Hunter flood plain (Pressey 1981). The extensive, crenulated shoreline is a significant feature of the water body (**Figure 1**). The verge supports sub-emergent and emergent vegetation and has a healthy, but discontinuous, band of the conspicuous macrophyte *Typha orientalis* along a large proportion of its length. The *Typha* sp. band

is notable as it forms the essential habitat required for productive foraging, provision of shelter and the conditions necessary for the breeding success of waterbirds.

**Figure 1.** Walka Lake showing irregular shape and extensive verge compared to surface area.

The bottom profile of the lake is important as it dictates the depth of the water, which is rarely less than one metre close to the edges and reaches a maximum depth of 7.5 metres near the centre of the water body. Pressey (1981), in a survey of wetlands, estimated that deep open freshwater makes up only two percent of wetland area in the Lower Hunter. Deep water is necessary for waterbirds that primarily forage by diving; consequently water depth is a determining factor contributing to both the species composition at Walka and to the regional significance of this wetland. When the Walka Water Works complex was operational water was pumped from the Hunter River into the lake but since its closure in 1945 rainfall and surface drainage only supply water to the system. As the size of the catchment area is only four times the area of the lake there is restricted inflow of water to the lake. Additionally there is minimal outflow of water via the by-wash in the dam wall. This limited potential for flushing has resulted in significant nutrient loads and low levels of dissolved oxygen. Water levels fluctuate approximately 1 metre vertically in response to variable rainfall, the inflow of surface drainage water from the northern and western ridges, the evaporation rate and natural seepage.

The irregular fluctuations of the water level assist nutrient cycling and produce exposed sections of organically rich mud and benthic invertebrate populations which in turn provide foraging habitat for a number of species e.g. the Black-fronted Dotterel *Elseyornis melanops* and the migratory shorebird, Latham's Snipe *Gallinago hardwickii*. There are several ephemeral water bodies on the floodplain, separated from the lake by the dam wall, which provide similar foraging habitat.

Walka is a highly significant wetland as it is the only large body of open, permanent, deep freshwater with substantial fringing vegetation located in the Maitland Local Government area. Additionally, Walka is one of only three water bodies suitable for resident populations of the deep-water specialists, Great Crested Grebe *Podiceps cristatus)*, Hoary-headed Grebe *Poliocephalus poliocephalus* and Musk Duck *Biziura lobata* in the Lower Hunter Region. The others are Grahamstown Dam, and the imminently, industrially threatened Deep Pond on Kooragang Island (A. Stuart pers. comm.).

*Rationale/Purpose:* A major threat to both water birds and woodland birds is habitat loss. At Walka this threat is associated with the location of the site within the rapidly expanding urban matrix of Maitland. There is limited separation of the wetland from this urban development, afforded to the east of the site by the designated floodplain of the Hunter River. Social pressures will potentially escalate as the estimated resident population of Maitland City has increased, during the period of this study, from 56,492 residents to 70,296 (Australian Bureau of Statistics 2011). Population projections, from the same source, estimate 80,000 residents by 2020 and 110,000 by 2036. There is, therefore, a need for sensitive management of the Walka resource to ensure its long-term ecological integrity. Hence, there is a need for reliable ecological base-line data on which to base future decision-making by land managers.

The current study aims to place on record the results of a long-term (110 months) study that focuses on the diversity, occurrence and abundance of the common waterbirds that utilise the Walka Lake. Hence it considers only a selection of avian species, and even then deals only with those species that were observed on survey days. It is to be emphasised that many bird species other than waterbirds are regularly present while others make temporary use of the reserve. The very uncommon Australian Little Bittern *Ixobrychus dubius*, the endangered Australasian Bittern *Botaurus poiciloptilus*, the vulnerable Black Bittern *Ixobrychus flavicollis* and the vulnerable Eastern Osprey *Pandion cristatus* have been recorded historically as utilising the site. Therefore the results of this study present only a partial indication of the overall significance of the site to avian species.

The study will yield insights into the use of Walka as a dry-season refuge for waterbirds and as a potential site to enhance the conservation of the Blue-billed Duck *Oxyura australis*. It will generate a baseline against which future changes in frequency of occurrence, abundance and diversity of populations may be assessed.

Research has shown that birds are effective indicators of environmental health. This study seeks to identify those waterbird species that are relatively common, are easily recognised, possess specific habitat requirements and are potentially responsive to disturbance. It is proposed that species so identified would be suitable indicators to alert land managers to undesirable changes in the environmental health of the water body and its verging vegetation to allow implementation of timely management strategies.

## METHODS

*Data Collection:* The approach used to survey the waterbirds of Walka Lake, its immediate verge and the flood plain below the dam wall involved a fixed route and constant effort. The same team of three observers conducted 110 monthly surveys during the period April 2003 to May 2012. Surveys were conducted on, or as close as practical to, the second Wednesday of each month commencing at 0700 hours, with an average duration 2.5 hours.

The fixed route of 2.5 kilometres closely followed the edge of the water body providing excellent accessibility and ease of observation by binoculars and telescope. The shape of the water body and the diligence of the observers helped to reduce the chance of double counting. Any residual effects of double counting would be minimised by the long-term nature of the study.

A count of all waterbirds detected, (including those heard, and flying over) was recorded and these data have been published annually in the Hunter Bird Observers Club Annual Bird Report (Stuart 2004 - 2012). Data were also submitted to the Birds Australia Ongoing Atlas Project. Waterbirds verified as breeding at Walka during the survey period were noted. The presence of woodland birds was noted but these data do not form part of the analysis.

Note: The consistent use of the same observers, same route and same relative time for each survey should yield a high level of reliability in the data for its temporal analysis. Further, failure to observe cryptic species such as Baillon's Crake *Porzana pusilla*, Spotless Crake *Porzana tabuensis*, Buff-banded Rail *Gallirallus philippensis*, as indicated by a zero in the data bases does not necessarily mean that such species are absent (Barrett *et al*. 2003).

*Data Analysis:* The species *diversity* for the site was recorded as: the waterbird species present by taxonomic family; the number of different waterbird species present for each monthly survey for the period 2003 to 2012; the total number of different species for 2003 to 2012. Waterbird species known to breed regularly at Walka Lake were also recorded.

To assess the *frequency of occurrence* of a given species a percentage reporting rate (%RR) was used. For a stated time period, the %RR is the ratio of the number of surveys in which the species was recorded to the total number of surveys for that period, expressed as a percentage. The large sample size and systematic acquisition of data should result in reliable reporting rates as a measure of the frequency of occurrence (Barrett *et al.* 2003). Trends in occurrence were evaluated as variation in annual and monthly percentage reporting rates. The overall %RR for the period 2003-2012 was used to assign a species occurrence rating as follows: %RR >80, occurs *Regularly;* %RR 60-79, occurs *Frequently*; %RR 40-59, occurs *Often*; %RR 20-39, occurs *Moderately often*; %RR<20 occurs *Occasionally.*

Species *abundance*, for a given time period, was indicated by the mean number of birds of each species present (when present) per survey (N). Abundance ratings were assigned as High (N>10), Moderate (5<N<10), Low (N<5). The maximum number of birds of a given species present, when used in conjunction with %RR, allowed irruptive species to be identified.

To identify any *population changes*, the survey period of 110 surveys was divided into two sets of 55 surveys, before and after 31 October 2007. As indicators of possible population change, two change ratios (CR) were calculated for each species, one based on frequency data ($CR_{RR}$) and the other on abundance data ($CR_N$). The change ratio $CR_{RR}$ is the ratio of the number of surveys in which a species was present in the first set of surveys compared to the second set of surveys. The change ratio $CR_N$ was calculated for each species as the mean number of birds present per survey (when present) for the first set of surveys compared with the mean number of birds present per survey (when present) for the second set of surveys. A change ratio equal to one (CR=1) indicates no change while a change ratio greater than one (CR>1) indicates the possibility of a population decrease and a change ratio less than one (CR<1) represents a possible population increase. For the purposes of this study a variation greater than 20% in the change ratio, (CR>1.2, or CR< 0.8) was arbitrarily regarded as meaningful.

*Note*: Only count data directly collected by the observers as part of the regular surveys have been used to generate indicators of diversity, frequency of occurrence, abundance, and population change. Supplementary data sourced elsewhere have been used for discussion purposes. It should also be noted that a straightforward approach was used to examine the data for change and that the indicators were not subject to

rigorous statistical evaluation. They are however, considered to be sufficiently discriminating to develop meaningful outcomes consistent with the aims of the study.

## RESULTS

The raw data acquired during the survey process has been tabulated and published in the Hunter Bird Observers Club Inc publication the Annual Bird Report 2003–2011 (Stuart 2004-2012). Data derived from the raw data and used in the analysis are included in **Appendices A–C**. Species nomenclature has followed Christidis & Boles (2008).

### Species Diversity

A total of 35 waterbird species belonging to ten families was recorded during the survey period (**Table 1**). Some species, viz. Australian White Ibis *Threskiornis molucca*, Straw-necked Ibis *Threskiornis spinicollis*, were almost exclusively associated with the ephemeral water bodies situated on the Hunter River flood plain situated below the Walka Lake dam wall

The level of species diversity was indicated by the mean number of species present each month (rounded up to the nearest whole number) (see **Appendix A, Table A1**). On average 19 waterbird species were detected each month for the period 2003 - 2012. The highest level of annual diversity, 22 species/month occurred in 2009; the lowest level, 16 species/month was recorded in 2003.

During the survey period breeding records were noted for eight of the 35 waterbird species recorded (**Table 2**).

**Table 2**. Waterbirds known to breed at Walka Lake

| | | |
|---|---|---|
| Musk Duck | Pacific Black Duck | Australasian Grebe |
| Black Swan | Eurasian Coot | Great Crested Grebe |
| Dusky Moorhen | Purple Swamphen | Blue-billed Duck* |

* Breeding records for the Blue-billed Duck were noted during the 1970s when this species was known to breed at Walka (A. Stuart pers. comm.). Although breeding was suspected, due to the presence of apparently dependent young birds, a breeding record for the Blue-billed Duck was not verified during the period of this study.

**Table 1**. Waterbird species - Walka Lake and verge.

| Order | Family | Species |
|---|---|---|
| Anseriformes | Anatidae | Musk Duck *Biziura lobata*, Black Swan *Cygnus atratus*, Australian Wood Duck *Chenonetta jubata*, Pink-eared Duck *Malacorhynchus membranaceus,* Australasian Shoveler *Anas rhynchotis*, Grey Teal *Anas gracilis*, Chestnut Teal *Anas castanea*, Pacific Black Duck *Anas superciliosa*, Hardhead *Aythya australis*, Blue-billed Duck *Oxyura australis* |
| Podicipediformes | Podicipedidae | Australasian Grebe *Tachybaptus novaehollandiae*, Hoary-headed Grebe *Poliocephalus poliocephalus*, Great Crested Grebe *Podiceps cristatus* |
| Phalacrocoraciformes | Anhingidae | Australasian Darter *Anhinga novaehollandiae* |
| | Phalacrocoracidae | Little Pied Cormorant *Microcarbo melanoleucos*, Great Cormorant *Phalacrocorax carbo*, Little Black Cormorant *Phalacrocorax sulcirostris*, Pied Cormorant *Phalacrocorax varius* |
| Ciconiiformes | Pelecanidae | Australian Pelican *Pelecanus conspicillatus* |
| | Ardeidae | Eastern Great Egret *Ardea modesta*, Intermediate Egret *Ardea intermedia*, White-faced Heron *Egretta novaehollandiae*, Little Egret *Egretta garzetta* |
| | Threskiornithidae | Australian White Ibis *Threskiornis molucca*, Straw-necked Ibis *Threskiornis spinicollis*, Royal Spoonbill *Platalea regia* |
| Gruiformes | Rallidae | Purple Swamphen *Porphyrio porphyrio*, Buff-banded Rail *Gallirallus philippensis*, Baillon's Crake *Porzana pusilla*, Spotless Crake *Porzana tabuensis*, Dusky Moorhen *Gallinula tenebrosa*, Eurasian Coot *Fulica atra* |
| Charadriiformes | Charadriidae | Black-fronted Dotterel *Elseyornis melanops*, Masked Lapwing *Vanellus miles* |
| | Scolopacidae | Latham's Snipe *Gallinago hardwickii* |

## Frequency of Occurrence

The overall percentage Reporting Rate (%RR) for each species for the period April 2003-May 2012 was calculated. Fourteen species were recorded as occurring *regularly* (%RR >80), three species were *frequently* reported (60<%RR<79), ten species were *often* or *moderately often* recorded (20<%RR<59) while six species were only *occasionally* reported (%RR<20) (**Table 3**).

## Species Abundance

The Eurasian Coot was by far the most abundant species, with the highest mean monthly number of birds, 71 birds, a maximum number of 319 birds and an overall %RR = 96. The Pink-eared Duck, showing the third highest mean number of birds (25), when present, and a maximum number of 111 was only occasionally present with a %RR = 12. The Pink-eared Duck is therefore considered an irruptive species at Walka. The least abundant species recorded was the Spotless Crake with a %RR = 7 and a low mean number of birds present (one bird). Due to its elusive and cryptic nature the probability of finding this species is low but it is most likely under recorded, as the habitat of the surrounding verge is appropriate for this species. **Table 4** lists species with High (N>10), Moderate (5<N<10) and Low (N<5) abundance levels in descending order of the abundance indicator (N).

**Table 3.** Species Frequency of Occurrence according to Overall Reporting Rate (%RR)

| **Occasionally** (%RR<20) | **Moderately Often** (20<%RR<39) | **Often** (40<%RR<59) | **Frequently** (60<%RR<79) | **Regularly** (%RR>80) |
|---|---|---|---|---|
| Pink-eared Duck (12)<br>Intermediate Egret (12)<br>Latham's Snipe (9)<br>Spotless Crake (7)<br>Baillon's Crake (6)<br>Buff-banded Rail (5) | Eastern Great Egret (39)<br>Little Egret (28)<br>Australasian Darter (25)<br>Australasian Shoveler (23)<br>Australian White Ibis (22)<br>Blue-billed Duck (21)<br>Straw-necked Ibis (20) | Black-fronted Dotterel (45)<br>Australian Pelican (42)<br>Royal Spoonbill (40) | White-faced Heron (67) Hoary-headed Grebe (66)<br>Australian Wood Duck (66) | Pacific Black Duck (100)<br>Dusky Moorhen (98)<br>Purple Swamphen (97)<br>Eurasian Coot (96) Great Crested Grebe (95)<br>Little Black Cormorant (94)<br>Little Pied Cormorant (93)<br>Chestnut Teal (91)<br>Black Swan (91)<br>Australasian Grebe (89)<br>Hardhead (86)<br>Grey Teal (86)<br>Musk Duck (84)<br>Masked Lapwing (83) |

**Table 4**. Abundance level

| **High Abundance** (N, Nmax, %RR) | **Moderate Abundance** (N, Nmax, %RR) | **Low Abundance** (N, Nmax, %RR) |
|---|---|---|
| Eurasian Coot (71,319,96)<br>Hardhead (35,422,86)<br>Pink-eared Duck (25,111,12)<br>Pacific Black Duck (23,72,100)<br>Grey Teal (18,97,86)<br>Australasian Grebe (18,85,89)<br>Dusky Moorhen (16,90,98)<br>Chestnut Teal (14,105,91)<br>Great Crested Grebe (13,41,95)<br>Little Black Cormorant (13,66,94)<br>Purple Swamphen (10,66,97) | Hoary-headed Grebe (8,45,66)<br>Australian Pelican (7,87,42)<br>Australian Wood Duck (7,42,66)<br>Little Pied Cormorant (6,28,95) | Masked Lapwing (4,20,83)<br>Black Swan (4,17,91)<br>Australasian Shoveler (4,9,23)<br>Black-fronted Dotterel (4,13,40)<br>Royal Spoonbill (4,13,40)<br>Musk Duck (3,10,84)<br>Latham's Snipe (3,4 9,8)<br>Australasian Darter (3,10,25)<br>White-faced Heron (2,15,67)<br>Blue-billed Duck (2,7,21)<br>Buff-banded Rail (2,3,5)<br>Eastern Great Egret (1,4,39)<br>Baillon's Crake (1,2,6)<br>Little Egret (1,3,28)<br>Intermediate Egret (1,3,12)<br>Spotless Crake (1,2,7) |

N= Mean number of birds present (when present) per monthly survey.
Nmax= Maximum number of birds recorded on any one occasion.
%RR= Overall percentage reporting rate.

## Population Change

The assignment of species population change classifications was based primarily on the change ratios derived from the frequency data ($CR_{RR}$) while in some cases (e.g. Hoary-headed Grebe, Australian Pelican) consideration was given to the change ratios based on abundance ($CR_N$). By including an arbitrary factor of +/- 20% to accommodate variability, a stable population was generally defined as having a change ratio ($CR_{RR}$) range between 0.8 and 1.2. A $CR_{RR}$ less than 0.8 is indicative of possible population increase and $CR_{RR}$ greater than 1.2, a possible decrease in population. (It should be noted that this arbitrary measure, although regarded as meaningful in this context, is not necessarily a strong test of population change as indicated by Chi-square tests conducted at various percentage reporting rates. These tests indicate that a change ratio, e.g. $CR_{RR}$ = 1.2 falls somewhat short of the value required for significant confidence in a change not occurring by chance at the p=0.05 level). **Table 5** provides a baseline against which future population changes can be assessed.

## DISCUSSION

Walka provides valuable habitat that supports a high diversity of waterbird species, including deep-water specialists, on a permanent and recurring basis. Although this study provides evidence of the fluctuating occurrence, relative abundance, species composition and possible population changes of the common waterbirds frequenting the Walka site, it does not attempt to fully explain this variability for all species included in the study. Rather it seeks, with limited interpretation, to provide base-line data for future studies and to inform the development of management strategies particularly with respect to possible indicator species, the use of the site as a drought refuge and also as a potential site to enhance the conservation of the Blue-billed Duck.

## Potential Indicator Species

The selection of potential indicator species to assist land managers to monitor the site was based on both site specific environmental attributes (permanent, deep freshwater with substantial marginal vegetation) and the desirable criteria for indicator species (relatively common at the site, stable population, easy identification, specific environmental requirements, and potentially responsive to change). Permanent deep water and the verge vegetation habitats appear to be the determining factors for the suite of birds frequently reported at the site, as a significant proportion comprise the deep-water specialists, such as Great Crested Grebe, Hoary-headed Grebe, Musk Duck, and Hardhead. Other birds such as the cormorant species, Australasian Darter, Australasian Grebe and, to a lesser extent, the Eurasian Coot are also reliant on deep water for feeding. The generally

**Table 5**. Population change for the period before 31 October 2007 compared to after 31 October 2007.

| **Species showing a possible population increase** ($CR_{RR}$, $CR_N$) | **Species showing a stable population** ($CR_{RR}$, $CR_N$) | **Species showing a possible population decrease** ($CR_{RR}$, $CR_N$) |
|---|---|---|
| Australian Wood Duck (0.6, 0.4) | Musk Duck (1.1, 1.0) | Pink-eared Duck (2.3, 1.0) |
| Blue-billed Duck (0.4, 0.5) | Black Swan (0.9, 1.3) | Intermediate Egret (11, 1.25) |
| Australasian Darter (0.1, 0.6) | Australasian Shoveler (1.2, 1.3) | Little Egret (4.2, 0.8) |
| Eastern Great Egret (0.6, 0.7) | Grey Teal (1.2, 0.8) | Buff-banded Rail (6.0, 1.5) |
| White-faced Heron (0.7, 0.9) | Great Crested Grebe (1.0, 0.5) | Spotless Crake (5.0, 1.2) |
| Baillon's Crake (0.4, 0.8) | Chestnut Teal (0.8, 0.8) | Black-fronted Dotterel (2.4, 2.0) |
| | Pacific Black Duck (1.0, 1.0) | Latham's Snipe (2.3, 3.1) |
| | Hardhead (0.8, 1.9) | |
| | Australasian Grebe (0.8, 1.0) | |
| | Hoary-headed Grebe (1.3, 0.9) | |
| | Little Pied Cormorant (0.9, 0.8) | |
| | Little Black Cormorant (1.0, 1.1) | |
| | Royal Spoonbill (0.8, 0.6) | |
| | Purple Swamphen (1.0, 0.8) | |
| | Dusky Moorhen (1.0, 0.6) | |
| | Eurasian Coot (0.9, 1.0) | |
| | Masked Lapwing (1.1, 0.9) | |
| | Australian Pelican (1.9, 0.2) | |

$CR_{RR}$= Change ratio based on the occurrence indicator %RR.
$CR_N$ = Change Ratio based on abundance indicator, mean number birds present/month (N)

high water level and the verge vegetation provide food, shelter, breeding stimulus, and nesting materials necessary for breeding success and population stability.

Site specific data for potential indicator species, shown in **Table 6**, has been derived from data included in the Results and **Appendices B** and **C**. The table is included here as a summary for discussion purposes.

The species listed in **Table 6** satisfy the habitat requirements as outlined above, although some species fulfil the role of an indicator species better than others. The Eurasian Coot and the Australian Grebe were regularly reported, have high abundance and stable populations. However their widespread distributions negatively impact on their suitability. The Pacific Black Duck, not listed due to its variable habitat and widespread distribution, was the only species to have a percentage reporting rate of 100%. Interestingly this species has the capacity to exploit environments, such as public parklands, where interaction with humans is common (Chapman & Jones 2012, Feletti & Feletti 2012). Hence there is the potential for the Pacific Black Duck population, which is presently stable (**Table 5**), to increase in response to increasing urbanisation. Any future population increase of the Pacific Black Duck at Walka could be one factor indicative of increasing anthropogenic influence.

The Hardhead is a deep-water specialist. **Table 1** in **Appendix C** shows the considerable variation in its monthly abundance levels and this, together with a high maximum number of birds, reflects the irruptive nature of this species. This precludes it as an effective indicator of environmental health at Walka. The Blue-billed Duck and the Musk Duck are also recognised deep-water specialists but the indicated low abundance levels for both these species reduce their suitability as indicators. While the restricted distribution of the Hoary-headed Grebe and its reliance on a deep-water habitat are positive selection attributes the non-breeding status of this species at Walka is an impediment to its selection.

Inspection of the data (Stuart 2004-2012) and the **Appendices A–C** reveals that a number of species suffered an unexpected decrease in numbers around June 2007 followed by a short recovery period. Notably the Great Crested Grebe was one of these species (others included: Little Black Cormorant, Little Pied Cormorant, Australasian Grebe, Chestnut Teal, Grey Teal and Hardhead.) At that time, the puddle core (clay/sand mixture) of the dam wall started to dry due to the very low water level resulting from the extended drought period. To prevent damage, turbid water was pumped from the Hunter River into the lake to wet the core by restoring the water level.

**Table 6.** Site-specific data for potential indicator species.

| Species | Occurrence | Abundance | Population | Distribution | Status | Breeding | Habitat |
|---|---|---|---|---|---|---|---|
| Great Crested Grebe | Regular | High | Stable | Very restricted in lower Hunter Valley | Resident | Yes | Deep freshwater and dense marginal vegetation |
| Hoary-headed Grebe | Frequent | Moderate | Stable | Very restricted in lower Hunter Valley | Present throughout the year | No | Larger wetlands, fresh and brackish water |
| Musk Duck | Regular | Low | Stable | Several locations in lower Hunter Valley | Resident | Yes | Permanent, open water, well vegetated margins |
| Blue-billed Duck | Moderately often | Low | Possible increase during survey period | Restricted in lower Hunter Valley | Vulnerable *Threatened Species Conservation Act 1995* Uncommon visitor | Past records | Deep freshwater, dense vegetation e.g. *Typha* |
| Hardhead | Regular | High | Stable | Widespread | Irruptive visitor | No | Deep, vegetated, permanent open water |
| Australasian Grebe | Regular | High | Stable | Widespread | Resident | Yes | Permanent, open water, well vegetated margins |
| Eurasian Coot | Regular | High | Stable | Widespread | Resident | Yes | Deep, vegetated, permanent open water |

This action increased the turbidity in some sections of the lake, and this physical change to water conditions may offer a potential explanation for the observed short-term decrease in abundance of the Great Crested Grebe at that time and be indicative of this species' responsiveness to environmental change at the site, a desirable attribute of an indicator species. (Further investigation of the effects of turbidity would be warranted before a firm conclusion could be drawn in this case). Additionally the Great Crested Grebe has the specific habitat requirements provided by Walka, restricted distribution in the Lower Hunter valley, regular frequency of occurrence with high abundance level, breeding success and a stable population against which future changes could be assessed. These features coupled with ease of identification and visual appeal support this species as a suitable indicator species for the environmental health of Walka Lake.

## Drought Refuge

In times of extended dry seasons waterbirds are forced to move great distances in search of habitat refuges. This movement has a bias towards the coast (Scott 1997). These habitat refuges often provide food resources that will ultimately determine the number of birds that can take advantage of the next breeding opportunity (Maher 1991). Briggs (1994) regards the support of these residual populations through the use of drought refuges so that they may later recolonise affected breeding habitats, as a waterbird conservation priority. Kingsford, as cited in Scott (1997) contends that the decline in the area of wetland in western NSW will have a long-term impact on waterbird numbers, further highlighting the importance of drought refuges. During the first half of the survey period the Lower Hunter and extensive areas of NSW were subject to below-average rainfall and drought conditions. The presence of permanent deep freshwater and fringing vegetation at Walka provide habitat suitable for a drought refuge.

This study has provided evidence to strengthen the proposition that Walka has a role as a drought refuge for some species. Roderick & Stuart (2010) report that Walka appears to be the most consistent area in the Hunter Region for records of the Blue-billed Duck and that local sightings seem to be consistent with the Region being a drought refuge. The annual percentage reporting rate for the Musk Duck showed a substantial downward trend from its peak in 2009 until the end of the survey period. This decrease may be a reflection of the increased availability of suitable habitat elsewhere due to the widespread inland rains since the break of the drought mid-2007. Prior to the drought breaking in 2007 abundance levels of the Hardhead increased, peaking in 2007. Since then abundance has decreased possibly due to the replenishment of wetland habitats elsewhere. The annual percentage reporting rate for the Pink-eared Duck also peaked in 2007 and with the exception of 2009 decreased markedly in the second half of the survey. Similarly, the annual percentage reporting rate for the Hoary-headed Grebe declined after 2007. Further long-term study is needed to verify the proposition by establishing species movements correlated with rainfall in the Upper Hunter Valley and western NSW.

## Blue-billed Duck Conservation

The frequency of occurrence (**Appendix B - Table B1**) and abundance (**Appendix C - Table C1**) data reflect the fluctuating use of the Walka site by the Blue-billed Duck over the survey period and past breeding records support the proposition that Walka could provide future breeding habitat. The increases in frequency and abundance (2007 to 2011) may be a response to the higher water level at Walka due to the above-average rainfall. High water levels result in water surrounding the verge vegetation and this may act as one stimulus to breeding. Experienced breeding birds tend to be more site faithful while younger birds move to the non-breeding areas (Scott 1997). The maintenance of dense marginal vegetation, especially *Typha sp*. is critical to breeding success. The Blue-billed Duck is classified as "vulnerable" under the *NSW Threatened Species Conservation Act 1995* and "near threatened" under the International Union for the Conservation of Nature (Roderick & Stuart 2010). Walka, as a wetland fulfilling this species' habitat requirements, has potential to support its conservation.

# CONCLUSIONS / RECOMMENDATIONS

The data sets, generated through basic methodology and presented in this paper, provide a useful baseline to inform both future local and regional studies and the development of site management strategies.

Ecological systems, such as the Walka wetland, exhibit a high level of natural variability so the detection of any long-term change in the occurrence, abundance and diversity of avian species is difficult to substantiate. There is a need

for constant effort monitoring over many years to establish these changes. However, comprehensive monitoring of all species may not always be possible so the use of an indicator species may assist the process. It is proposed that, for ease of monitoring, the Great Crested Grebe would be a suitable site-specific indicator species for land managers to use to monitor the long-term environmental health of the Walka wetland. The Pacific Black Duck, through its capacity to exploit increasingly urbanised environments, also has a potential role as an indicator species.

Within the Lower Hunter Valley, Walka has the habitat attributes of an effective drought refuge suitable for a range of waterbirds, including the deep-water specialists. As effective refuges are regarded as a priority for waterbird conservation, it is strongly recommended that the existing verge vegetation at Walka be retained and enhanced to ensure the availability of food resources and nesting habitat in times of extended dry seasons elsewhere. The implementation of sensitive management practices to limit human impact on the Walka site must be regarded as a priority in order to preserve the ecological integrity of the Walka wetland. Deep water and a healthy, undisturbed verge habitat at Walka will not only sustain existing levels of diversity but also develop suitable foraging and breeding habitat vital for the conservation of the Blue-billed Duck which is classified as vulnerable in NSW.

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# APPENDICES

## Appendix A. Species diversity

**Table A1.** Species diversity- Mean number of species /monthly survey 2003-2012

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean No. Spec/Month/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2003** | NR | NR | NR | 14 | 19 | 19 | 16 | 15 | 17 | 10 | 18 | 16 | **16** |
| **2004** | 17 | 14 | 13 | 12 | 16 | 24 | 18 | 20 | 20 | 17 | 17 | 18 | **17** |
| **2005** | 18 | 19 | 21 | 18 | 22 | 20 | 18 | 17 | 18 | 19 | 20 | 20 | **19** |
| **2006** | 17 | 22 | 25 | 23 | 19 | 19 | 17 | 18 | 20 | 21 | 22 | 21 | **20** |
| **2007** | 20 | 26 | 22 | 20 | 19 | 13 | 16 | 15 | 17 | 16 | 18 | 13 | **18** |
| **2008** | 15 | 15 | 14 | 17 | 19 | 19 | 24 | 24 | 24 | 17 | 18 | 22 | **19** |
| **2009** | 21 | 21 | 20 | 22 | 20 | 24 | 22 | 22 | 23 | 23 | 23 | 26 | **22** |
| **2010** | 24 | 17 | 14 | 21 | 18 | 18 | 16 | 15 | 16 | 18 | 14 | 12 | **17** |
| **2011** | 23 | 13 | 15 | 16 | 18 | 18 | 19 | 21 | 19 | 23 | 19 | 18 | **19** |
| **2012** | 18 | 17 | 16 | 17 | 18 | NA | NA | NA | NA | NA | NA | NA | **17** |
| **Mean No. Species /Month** | **19** | **18** | **18** | **18** | **19** | **19** | **18** | **19** | **19** | **18** | **19** | **18** | **Mean No. Species /Month all years: 19** |

## Appendix B. Frequency of occurrence

**Table B1.** Annual variation - percentage reporting rate (%RR) 2003-2012

| Species | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| Musk Duck | 100 | 75 | 92 | 92 | 100 | 100 | 100 | 75 | 67 | 0 |
| Black Swan | 78 | 92 | 92 | 83 | 83 | 92 | 100 | 92 | 100 | 100 |
| Australian Wood Duck | 44 | 42 | 67 | 67 | 75 | 100 | 83 | 75 | 92 | 100 |
| Pink-eared Duck | 22 | 17 | 8 | 17 | 25 | 8 | 25 | 0 | 8 | 0 |
| Australasian Shoveler | 11 | 25 | 17 | 33 | 42 | 42 | 42 | 8 | 0 | 0 |
| Grey Teal | 89 | 92 | 83 | 100 | 100 | 92 | 100 | 50 | 67 | 60 |
| Chestnut Teal | 89 | 100 | 58 | 92 | 83 | 100 | 100 | 100 | 92 | 100 |
| Pacific Black Duck | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Hardhead | 33 | 67 | 92 | 100 | 92 | 100 | 100 | 83 | 83 | 100 |
| Blue-billed Duck | 0 | 0 | 8 | 8 | 50 | 25 | 50 | 25 | 25 | 0 |
| Australasian Grebe | 67 | 50 | 100 | 100 | 83 | 92 | 100 | 100 | 100 | 100 |
| Hoary-headed Grebe | 89 | 42 | 58 | 83 | 92 | 67 | 75 | 8 | 75 | 60 |
| Great Crested Grebe | 89 | 100 | 100 | 92 | 83 | 100 | 100 | 83 | 100 | 100 |
| Australasian Darter | 0 | 0 | 33 | 0 | 0 | 0 | 58 | 50 | 92 | 80 |
| Little Pied Cormorant | 100 | 100 | 100 | 92 | 50 | 100 | 100 | 92 | 100 | 100 |
| Little Black Cormorant | 78 | 100 | 100 | 100 | 58 | 100 | 100 | 100 | 100 | 100 |
| Australian Pelican | 33 | 42 | 67 | 67 | 50 | 50 | 33 | 33 | 17 | 0 |
| Eastern Great Egret | 44 | 17 | 33 | 25 | 25 | 67 | 67 | 25 | 25 | 80 |
| Intermediate Egret | 0 | 17 | 58 | 25 | 0 | 0 | 8 | 0 | 0 | 0 |
| White-faced Heron | 56 | 58 | 50 | 42 | 67 | 58 | 83 | 83 | 100 | 100 |
| Little Egret | 56 | 50 | 58 | 33 | 25 | 33 | 8 | 0 | 8 | 0 |
| Australian White Ibis | 0 | 8 | 8 | 25 | 8 | 50 | 67 | 8 | 25 | 0 |
| Straw-necked Ibis | 11 | 17 | 8 | 42 | 17 | 33 | 50 | 17 | 25 | 20 |
| Royal Spoonbill | 67 | 25 | 25 | 42 | 25 | 25 | 92 | 58 | 17 | 20 |

## Appendix B. Frequency of occurrence cont.

**Table B1.** Annual variation - percentage reporting rate (%RR) 2003-2012 cont.

| Species | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| Purple Swamphen | 89 | 92 | 92 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Buff-banded Rail | 0 | 8 | 17 | 17 | 8 | 0 | 0 | 0 | 0 | 0 |
| Baillon's Crake | 0 | 0 | 0 | 17 | 0 | 0 | 17 | 8 | 17 | 0 |
| Spotless Crake | 0 | 8 | 8 | 33 | 0 | 8 | 8 | 0 | 0 | 0 |
| Dusky Moorhen | 89 | 100 | 92 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Eurasian Coot | 56 | 100 | 100 | 100 | 100 | 92 | 100 | 100 | 100 | 100 |
| Black-fronted Dotterel | 22 | 75 | 92 | 100 | 58 | 33 | 42 | 25 | 33 | 0 |
| Masked Lapwing | 89 | 92 | 83 | 83 | 83 | 33 | 92 | 92 | 83 | 100 |
| Latham's Snipe | 0 | 8 | 17 | 25 | 8 | 0 | 25 | 0 | 0 | 0 |

**Table B2**. Monthly Variation - percentage reporting rate (% RR)

| Species | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Musk Duck | 89 | 67 | 67 | 80 | 80 | 100 | 89 | 89 | 89 | 100 | 78 | 89 |
| Black Swan | 89 | 78 | 78 | 90 | 100 | 100 | 100 | 89 | 100 | 89 | 89 | 89 |
| Australian Wood Duck | 78 | 78 | 56 | 60 | 70 | 100 | 67 | 78 | 67 | 78 | 78 | 78 |
| Pink-eared Duck | 22 | 11 | 22 | 20 | 0 | 0 | 22 | 0 | 11 | 11 | 22 | 22 |
| Australasian Shoveler | 33 | 11 | 11 | 21 | 0 | 33 | 44 | 22 | 22 | 22 | 44 | 22 |
| Grey Teal | 100 | 89 | 67 | 80 | 90 | 100 | 67 | 78 | 89 | 78 | 89 | 89 |
| Chestnut Teal | 100 | 100 | 100 | 100 | 80 | 56 | 89 | 78 | 89 | 100 | 100 | 100 |
| Pacific Black Duck | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Hardhead | 100 | 67 | 67 | 80 | 80 | 89 | 89 | 100 | 78 | 89 | 100 | 89 |
| Blue-billed Duck | 44 | 22 | 0 | 0 | 0 | 33 | 22 | 22 | 44 | 22 | 22 | 22 |
| Australasian Grebe | 78 | 89 | 89 | 90 | 100 | 89 | 100 | 100 | 100 | 89 | 78 | 67 |
| Hoary-headed Grebe | 56 | 33 | 44 | 60 | 60 | 78 | 67 | 78 | 89 | 78 | 78 | 56 |
| Great Crested Grebe | 100 | 100 | 100 | 100 | 100 | 89 | 67 | 78 | 100 | 100 | 100 | 100 |
| Australasian Darter | 33 | 33 | 22 | 30 | 30 | 33 | 22 | 22 | 33 | 33 | 33 | 22 |
| Little Pied Cormorant | 100 | 100 | 100 | 100 | 100 | 89 | 89 | 78 | 89 | 89 | 89 | 89 |
| Little Black Cormorant | 100 | 100 | 100 | 100 | 100 | 89 | 89 | 89 | 100 | 78 | 89 | 89 |
| Australian Pelican | 78 | 56 | 33 | 10 | 40 | 33 | 22 | 44 | 44 | 33 | 67 | 44 |
| Eastern Great Egret | 56 | 44 | 33 | 40 | 60 | 33 | 33 | 22 | 44 | 44 | 11 | 33 |
| Intermediate Egret | 0 | 0 | 22 | 20 | 20 | 22 | 22 | 11 | 22 | 0 | 0 | 0 |
| White-faced Heron | 56 | 89 | 78 | 60 | 60 | 56 | 56 | 78 | 67 | 78 | 56 | 89 |
| Little Egret | 11 | 22 | 22 | 20 | 30 | 33 | 44 | 44 | 33 | 11 | 22 | 44 |
| Australian White Ibis | 0 | 11 | 0 | 30 | 10 | 56 | 33 | 22 | 22 | 44 | 11 | 22 |
| Straw-necked Ibis | 0 | 11 | 33 | 10 | 50 | 44 | 44 | 56 | 22 | 11 | 0 | 11 |
| Royal Spoonbill | 33 | 33 | 56 | 50 | 60 | 56 | 56 | 44 | 44 | 22 | 11 | 11 |
| Purple Swamphen | 89 | 89 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 89 | 100 | 100 |
| Buff-banded Rail | 0 | 22 | 0 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 11 | 11 |
| Baillon's Crake | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 22 | 22 |
| Spotless Crake | 0 | 22 | 11 | 10 | 10 | 0 | 11 | 11 | 0 | 0 | 0 | 11 |
| Dusky Moorhen | 100 | 89 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Eurasian Coot | 100 | 100 | 100 | 90 | 90 | 89 | 89 | 100 | 100 | 89 | 100 | 100 |
| Black-fronted Dotterel | 67 | 44 | 78 | 50 | 60 | 67 | 22 | 33 | 44 | 44 | 56 | 56 |
| Masked Lapwing | 10 | 78 | 56 | 90 | 90 | 67 | 89 | 89 | 89 | 89 | 89 | 56 |
| Latham's Snipe | 0 | 33 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 11 |

## Appendix C. Abundance

**Table C1.** Annual Variation - mean numbers/survey when present 2003-2012

| Species | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| Musk Duck | 3.1 | 3.1 | 3.9 | 4.1 | 2.5 | 2.9 | 4.0 | 3.7 | 3.3 | 0 |
| Black Swan | 3.0 | 5.2 | 5.1 | 3.4 | 4.7 | 3.5 | 3.5 | 3.6 | 2.7 | 2.6 |
| Australian Wood Duck | 3.0 | 5.2 | 4.3 | 2.8 | 7.1 | 8.3 | 13.5 | 6.0 | 6.5 | 11.6 |
| Pink-eared Duck | 49.0 | 1.5 | 2.0 | 2.5 | 41.7 | 4.0 | 38.3 | 0 | 3.0 | 0 |
| Australasian Shoveler | 1.0 | 5.0 | 3.0 | 2.0 | 3.2 | 5.8 | 2.0 | 2.0 | 0 | 0 |
| Grey Teal | 29.6 | 16.8 | 8.1 | 15.6 | 13.8 | 15.9 | 32.5 | 9.8 | 27.0 | 7.7 |
| Chestnut Teal | 13.0 | 14.1 | 6.3 | 8.7 | 14.7 | 16.3 | 16.3 | 12.5 | 11.0 | 17.4 |
| Pacific Black Duck | 36.8 | 24.9 | 15.4 | 18.8 | 19.7 | 27.8 | 25.2 | 25.4 | 24.8 | 14.2 |
| Hardhead | 28.0 | 39.4 | 18.6 | 34.3 | 92.5 | 43.0 | 33.6 | 9.6 | 18.3 | 11.0 |
| Blue-billed Duck | 0 | 0 | 1.0 | 2.0 | 1.3 | 1.0 | 4.3 | 1.3 | 1.0 | 0 |
| Australasian Grebe | 6.7 | 11.8 | 25.8 | 27.1 | 10.8 | 12.5 | 33.3 | 10.5 | 16.8 | 15.6 |
| Hoary-headed Grebe | 5.4 | 7.4 | 14.4 | 6.3 | 4.6 | 3.9 | 16.8 | 9.0 | 5.7 | 7.7 |
| Great Crested Grebe | 7.0 | 9.3 | 9.7 | 9.5 | 5.4 | 22.5 | 19.8 | 17 | 14.9 | 17.4 |
| Australasian Darter | 0 | 0 | 1.3 | 0 | 0 | 0 | 2.4 | 1.8 | 4.0 | 2.5 |
| Little Pied Cormorant | 5.7 | 5.3 | 5.3 | 5.5 | 2.5 | 5.0 | 9.2 | 6.0 | 5.4 | 5.6 |
| Little Black Cormorant | 15.7 | 14.7 | 13.6 | 14.8 | 9.0 | 8.0 | 17.8 | 15.7 | 9.1 | 10.8 |
| Australian Pelican | 1.7 | 2.2 | 2.3 | 4.5 | 1.8 | 22.8 | 3.5 | 5.8 | 9.5 | 0 |
| Eastern Great Egret | 1.0 | 2.0 | 1.0 | 1.3 | 1.0 | 1.8 | 1.6 | 1.0 | 1.3 | 1.8 |
| Intermediate Egret | 0 | 1.0 | 1.4 | 1.0 | 0 | 0 | 1.0 | 0 | 0 | 0 |
| White-faced Heron | 1.6 | 1.9 | 1.5 | 1.6 | 3.6 | 2.0 | 3.5 | 1.8 | 2.0 | 2.0 |
| Little Egret | 1.6 | 1.5 | 1.1 | 1.0 | 1.0 | 2.0 | 1.0 | 0 | 1.0 | 0 |
| Australian White Ibis | 0 | 1.0 | 1.0 | 1.0 | 1.0 | 4.5 | 4.3 | 2.0 | 8.3 | 0 |
| Straw-necked Ibis | 109.0 | 54.5 | 1.0 | 106.0 | 53.5 | 14.5 | 20.7 | 9.5 | 28.0 | 24.0 |
| Royal Spoonbill | 3.8 | 3.0 | 1.0 | 2.4 | 3.0 | 5.0 | 4.5 | 4.4 | 4.5 | 1.0 |
| Purple Swamphen | 14.5 | 6.5 | 4.3 | 13.3 | 8.6 | 9.3 | 13.3 | 11.3 | 9.8 | 17.8 |
| Buff-banded Rail | 0 | 2.0 | 1.0 | 2.0 | 1.0 | 0 | 0 | 0 | 0 | 0 |
| Baillon's Crake | 0 | 0 | 0 | 1.0 | 0 | 0 | 1.0 | 2.0 | 1.0 | 0 |
| Spotless Crake | 0 | 1.0 | 1.0 | 1.3 | 0 | 1.0 | 1.0 | 0 | 0 | 0 |
| Dusky Moorhen | 17.3 | 10.4 | 9.4 | 10.7 | 9.7 | 17.4 | 24.8 | 19.9 | 19.6 | 18.6 |
| Eurasian Coot | 50.8 | 67.6 | 94.8 | 67.8 | 55.7 | 56.0 | 119.8 | 27.9 | 62.4 | 129 |
| Black-fronted Dotterel | 1.5 | 2.7 | 3.5 | 3.4 | 9.1 | 2.5 | 2.4 | 1.7 | 3.0 | 0 |
| Masked Lapwing | 4.6 | 5.7 | 3.0 | 3.6 | 2.4 | 2.8 | 5.0 | 2.4 | 4.0 | 6.0 |
| Latham's Snipe | 0 | 8.0 | 1.5 | 2.0 | 5.0 | 0 | 1.0 | 0 | 0 | 0 |

## Appendix C. Abundance cont.

**Table C2.** Monthly variation - mean numbers /survey cont.

| Species | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Musk Duck | 4.0 | 2.5 | 3.2 | 2.6 | 2.8 | 3.7 | 2.9 | 3.5 | 3.3 | 4.4 | 4.7 | 3.0 |
| Black Swan | 5.1 | 4.7 | 3.0 | 3.1 | 3.1 | 4.8 | 3.4 | 4.4 | 3.6 | 3.4 | 4.3 | 3.0 |
| Australian Wood Duck | 8.7 | 6.3 | 9.0 | 8.7 | 9.4 | 4.3 | 4.2 | 3.3 | 4.7 | 7.7 | 10.6 | 9.4 |
| Pink-eared Duck | 66.5 | 92.0 | 6.5 | 47.0 | 0 | 0 | 2.0 | 0 | 4.0 | 6.0 | 1.5 | 3.0 |
| Australasian Shoveler | 3.3 | 2.0 | 8.0 | 3.0 | 0 | 2.7 | 3.8 | 7.5 | 3.0 | 1.0 | 1.3 | 5.0 |
| Grey Teal | 19.4 | 8.0 | 11.8 | 20.1 | 8.0 | 27.8 | 14.0 | 21.0 | 22.3 | 30.9 | 24.8 | 12.1 |
| Chestnut Teal | 14.6 | 8.9 | 10.1 | 11.7 | 18.5 | 34.4 | 12.6 | 9.4 | 15.0 | 10.2 | 10.1 | 11.0 |
| Pacific Black Duck | 21.0 | 22.9 | 27.9 | 28.8 | 30.9 | 32.7 | 22.9 | 24.8 | 16.8 | 13.9 | 20.1 | 18.0 |
| Hardhead | 11.1 | 22.7 | 16.8 | 12.4 | 17.3 | 16.5 | 54.9 | 79.0 | 73.7 | 80.0 | 18.8 | 13.1 |
| Blue-billed Duck | 1.0 | 1.5 | 0 | 0 | 0 | 1.0 | 4.0 | 4.0 | 3.0 | 1.0 | 1.5 | 2.0 |
| Australasian Grebe | 11.3 | 6.3 | 12.0 | 21.3 | 23.9 | 28.0 | 31.1 | 22.1 | 17.3 | 13.6 | 9.4 | 17.8 |
| Hoary-headed Grebe | 6.6 | 4.3 | 5.8 | 3.8 | 6.2 | 9.6 | 3.7 | 7.4 | 10.3 | 10.6 | 9.0 | 14.2 |
| Great Crested Grebe | 13.1 | 18.1 | 19.1 | 17.1 | 18.4 | 10.4 | 8.2 | 9.6 | 9.2 | 7.0 | 11.3 | 14.3 |
| Australasian Darter | 3.3 | 2.3 | 3.0 | 5.0 | 1.3 | 1.0 | 1.0 | 2.0 | 2.3 | 3.3 | 4.3 | 3.0 |
| Little Pied Cormorant | 5.2 | 4.0 | 7.2 | 7.7 | 8.3 | 6.0 | 6.4 | 5.7 | 6.3 | 2.6 | 4.4 | 3.8 |
| Little Black Cormorant | 21.7 | 22.7 | 10.7 | 17.9 | 8.3 | 10.0 | 10.5 | 10.0 | 10.2 | 7.6 | 14.1 | 11.4 |
| Australian Pelican | 3.0 | 4.2 | 1.3 | 1.0 | 8.0 | 1.7 | 45.4 | 10.5 | 7.0 | 2.0 | 1.3 | 3.8 |
| Eastern Great Egret | 1.2 | 1.0 | 2.0 | 1.8 | 1.5 | 1.7 | 1.7 | 1.5 | 1.8 | 1.0 | 1.0 | 1.0 |
| Intermediate Egret | 0 | 0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | 1.0 | 0 | 0 | 0 |
| White-faced Heron | 2.2 | 2.4 | 1.4 | 3.8 | 2.3 | 2.0 | 4.4 | 1.7 | 1.3 | 2.4 | 2.0 | 1.5 |
| Little Egret | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.3 | 2.0 | 1.8 | 1.7 | 1.0 | 1.0 | 1.3 |
| Australian White Ibis | 0 | 2.0 | 0 | 8.0 | 1.0 | 2.0 | 7.0 | 6.0 | 2.0 | 4.0 | 1.0 | 1.5 |
| Straw-necked Ibis | 0 | 3.0 | 182.0 | 33.0 | 30.2 | 46.3 | 16.8 | 29.0 | 11.0 | 12.0 | 0 | 1.0 |
| Royal Spoonbill | 5.7 | 3.3 | 3.4 | 4.6 | 2.8 | 3.6 | 4.4 | 3.8 | 3.0 | 3.5 | 1.0 | 3.0 |
| Purple Swamphen | 10.8 | 9.6 | 10.6 | 10.1 | 11.4 | 9.2 | 10.2 | 16.0 | 9.6 | 8.6 | 8.4 | 9.8 |
| Buff-banded Rail | 0 | 1.0 | 0 | 1.0 | 1.0 | 0 | 0 | 0 | 0 | 0 | 3.0 | 2.0 |
| Baillon's Crake | 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.0 | 1.0 | 1.0 |
| Spotless Crake | 0 | 1.0 | 1.0 | 2.0 | 1.0 | 0 | 1.0 | 1.0 | 0 | 0 | 0 | 1.0 |
| Dusky Moorhen | 11.1 | 16.5 | 24.2 | 16.4 | 13.9 | 18.7 | 22.1 | 18.2 | 13.9 | 12.8 | 9.8 | 9.3 |
| Eurasian Coot | 97.7 | 56.8 | 47.8 | 47.6 | 51.1 | 69.9 | 74.9 | 80.6 | 86.3 | 78.3 | 102.3 | 61.2 |
| Black-fronted Dotterel | 2.5 | 3.8 | 5.6 | 6.8 | 5.0 | 2.8 | 3.0 | 5.0 | 2.0 | 1.8 | 2.2 | 2.6 |
| Masked Lapwing | 4.4 | 3.7 | 4.0 | 3.6 | 5.2 | 7.2 | 3.5 | 3.5 | 2.0 | 3.4 | 3.4 | 3.6 |
| Latham's Snipe | 0 | 2.7 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.0 | 8.0 |