

# The Birds of Brisbane Water Estuary



Prepared for BIO-ANALYSIS Pty Ltd, 2006

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## **Acknowledgements**

The author gratefully thanks and acknowledges the contribution of Mr Alan Morris not only because his information greatly improves our understanding of the birds of Brisbane Water estuary but also he has provided a major contribution to ornithological knowledge in this state. I thank Dr Peter Driscoll for providing some useful information when formulating this study. I would also thank Andrew Silcocks (Birding Australia) for providing data from the Bird Atlas database which greatly improved our understanding of the richness and the distribution of birds of Brisbane Water estuary

I would like to thank E. Harrison & R. Albery for hospitality whilst undertaking this survey. A big thanks to my family for understanding why I enjoy slipping through muddy mangroves looking at the birdies!

The cover photographs are from:

Webster Publishing (1995) *Australian Birds: The multimedia Experience* Frenches Forest

## EXECUTIVE SUMMARY

The Brisbane Water estuary provides a diverse array of habitats suitable for birds and though near one major city (Sydney) and near the major NSW urban centre of Gosford-Wyong area its bird assemblage is poorly studied. Local ornithologists have contributed greatly to the pool of bird knowledge of the area (e.g. as part of national census programs or bird club annual reports) but until this study there has been no major review or survey of the estuary's birds. The aim of this study is to collate and review available information and collect additional data on the birds of the estuary so that it can be incorporated in the Estuary Management Plan. The field survey targeted tidal mudflats, mangroves and saltmarshes in disturbed and less disturbed habitats (137 samples).

The survey results are yet to have a detailed analysis undertaken but preliminary assessment reveals that the Brisbane Water estuary is habitat to a variety of shorebirds, waterbirds and forest birds. There are at least 110 species (including 4 exotic species) from 13 Orders, 34 families (including 1 exotic family) and 79 genera (including 3 exotic genera) documented from Brisbane Water estuary.

Brisbane Water estuary is on the route of East Asian-Australasian Flyway and has been used as habitat for twenty-one species of regular migrant shorebirds which are 58% of the migratory shorebird species documented in Australia. There were no shorebird species considered vagrant to Australia recorded in the Brisbane Water and eight migratory waders' species have not been recorded recently in the estuary. Recorded in the Brisbane Water estuary are eight species of resident shorebirds which are 44% of all Australian resident species.

Australia is signature to bilateral agreements with Japan (JAMBA, 1981) and China (CAMBA 1988) that has expressed aims to conserve migratory birds and their environment. Brisbane Water estuary is habitat for at least twenty-six JAMBA and twenty-four CAMBA listed species. There are no threatened species as listed under the Commonwealth's Environment Protection and Biodiversity Act EPBC Act (1999) though there are two species listed as endangered and about nine species that are considered vulnerable under NSW Threatened Species Conservation Act (1995). One species of migratory wader that regularly uses the Brisbane Water estuarine habitat's global population is considered Near Threatened.

Among the species recorded in estuarine habitats, there are twenty-five species whose populations have probably increased across Australia. The Brisbane Water estuarine bird assemblage includes fifteen species that have declined nationally and twenty-eight species that have declined in the Sydney Basin Bioregion. Furthermore three species that reach their southern geographic limit in the Sydney Basin Bioregion have been known to use Brisbane Water habitats.

The main management issues identified for Brisbane Water estuary avifauna are disturbances to birds by pedestrians, dog-walkers and watercraft, predation by feral and domestic animals, weed invasions altering habitat, estuarine vegetation dynamics, climate change, the environmental effects of oyster leases and jetties and bird influenza. However there is not enough data or modelling for some of these issues to be resolved in the absence of further research. A crucial initial element to improve the conditions for birds within the estuary is further education of the community on the ecological and biological attributes of the diversity of bird species present in the Brisbane Water estuary that is recognised as a nationally significant wetland habitat.

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# 1.0. Introduction

Estuaries are known as important habitats as nursery sites for fish (Griffiths, 2001; Morrissey, 1995a; Bell & Andrew, 1995) and are used as habitats for commercial, consumptive and recreational fishery (Roy *et al*, 2001). The Brisbane Water commercial fishery catch is relatively small compared to other NSW estuaries (see Roy *et al*, 2001 Appendix 1) though is recognised and valued as a socio-economic resource (EPA, 1994). Oyster farming is widespread throughout the estuary and oyster leases have occupied 1.2km<sup>2</sup> surface area of inter-tidal habitats along 11km of Brisbane Water estuary foreshore with the economic value of oyster production in the early 1990's estimated at over \$2 000 000.00 (EPA, 1994). Additionally there are over 1.3 million visitors to the Central Coast area (including Brisbane Water) and 6800 (5.2%) of the region's workforce is employed in the tourism industry (NSW Tourism, 2006). Brisbane Water is one of the most heavily populated catchments in eastern NSW, is highly urbanised and is regularly used by tourists and residents for water-based recreation activities such as boating and recreational fishing.

Brisbane Water Estuary is also along the route of the East Asian-Australasian Flyway used by shorebirds to move between Australia/New Zealand, East Asia and the Arctic region of the northern hemisphere (Watkins, 2003; Lane, 1987). In addition to several small coastal lagoons (e.g. Wamberal Lagoon) and creeks (Dee Why Creek), Brisbane Water is one of five major estuaries (Roy *et al*, 2001) that occur between two significant Sydney Basin Bioregion coastal estuaries that have been identified as wetlands of international significance (Towra Point NR in Botany Bay and Kooragang Island NR in the Hunter River estuary). These wetlands of international significance (also called Ramsar wetlands) are recognised for their role in supporting migratory birds that visit the southern hemisphere in summer during the northern winter (Lane, 1987). Other estuaries than those recognised as nationally and internationally significant may provide a link between them or during the birds passage north and south (Rohweder, 2004) along the East Asian-Australasian Flyway. Additionally coastal wetlands act as drought refugia in Australia for waterbirds with species moving to the coast during inland droughts (Keating & Pegler, 2003; Kingsford & Norman, 2002; Chafer *et al*, 1999; Norman & Brown, 1988).

Despite the proximity of large urban population centres of the Central Coast and Sydney (and associated increase potential 'pool' of available ornithologists) and the possible conflicting goals of existing land and water use (e.g. residential development & recreational activities) and wildlife conservation there has been no review or systematic survey to identify the estuarine bird assemblage in the Brisbane Water Estuary. This study aims to identify the estuarine bird assemblage as reviewed from literature and an early autumn survey.

## 2.0. Methods

### 2.1. Study Site

The Brisbane Water is a barrier estuary that has a water area of 27.241km<sup>2</sup> with a catchment of 170km<sup>2</sup> (Roy *et al*, 2001) approximately 45 km north of Sydney, southeast Australia. The estuary periphery and catchment are occupied by a variety of land cover including residential areas, industrial developments, roads, national park estate (national park and nature reserves) and council reserves. Associated with residential areas and council reserves are seawalls, public and private piers wharves, marinas and open space grassland parks and picnic areas. Brisbane Waters also has a well-developed oyster farming industry with oyster leases on the margins of channels and lagoons.

Brisbane Water has the following estuarine avifauna macro habitats (Benson, 1986; NSW NPWS, 2000; Roberts & Sainty, *in press*; pers. obs.):

- ❑ Swamp Mahogany Forest
- ❑ Swamp Oak Forest
- ❑ Saltmarsh (high and low marsh)
- ❑ Mangrove Forest
- ❑ Tidal flats adjacent to mangrove and/or urban/industrial habitats exposed at low tide
- ❑ Tidal flats or sandbars exposed in the estuarine waterbody at low tide
- ❑ Estuarine waterbody
- ❑ Drainage lines (creeks and gullies) including lower sections with tidal influence
- ❑ Rocky shores
- ❑ Artificial habitats e.g. piers, moored boats, seawalls and oyster leases

Bare substrata are exposed at low tide though in some areas they are vegetated by seagrass species (*Zostera capricorni*) that are also exposed at low tide. Generally the vegetation grades from predominately Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*) at the water edge (Harty, 1994).

Saltmarshes are divided into low and high marsh, with the former characterised by Beaded Glasswort (*Sarcocornia quinqueflora*), and Marine Couch (*Sporobolus virginicus*) and the latter characterised by Sea Rush (*Juncus kraussii*). On the landward side, high marsh is adjacent to Swamp Oak (*Casuarina glauca*) that is rarely inundated except during very high tides or after localised flooding. The high marsh can merge with Swamp Oak forest with Sea Rush forming a swathe below the canopy with other saltmarsh species. On poorly drained sites near Swamp Oak Forest, Swamp Mahogany (*Eucalyptus robusta*) forest may occur. Swamp Oak and Swamp Mahogany forest can merge with mixed dry sclerophyll that varies with geology (e.g. Terrigal Formation or Hawkesbury Sandstone) forest (see map of Benson, 1986) or form an abrupt boundary with urban areas.

## 2.2. Data Collection

### 2.2.1. Literature Review

The literature reviewed included papers from Australia's international bird journal, *Emu*; specialist wader journal, *The Stilt* and other minor bird journals such as *Corella* and *Australian Bird Watcher*. Recent issues from specialist aquatic and conservation biology journals will be perused to obtain possible papers. The 'grey' literature such as government reports and important 'local' data were also obtained from the local ornithologist community. Literature whose study areas were extensive but included Brisbane Water were only cited if they mentioned Brisbane Water or localities therein which thus excluded any birds whose generic habitats were cited as mangroves, mudflats, saltmarsh or estuarine. The exclusion of these birds is because these studies include several estuaries (e.g. Tuggerah Lakes) and thus is spatially inapplicable for this report or as these birds are widespread they will likely be 'captured' in site specific data sets (e.g. Chestnut Teal, *Anas castanea*). An extensive Birds Australia *Bird Atlas* data set has been obtained but the data has yet to be sorted and analysed with the field data collected for this report, none-the-less these data were collated to provide an initial list of the birds that use estuarine habitats in the Brisbane Water.

### 2.2.2. Field Survey

The systematic field survey focused on several strictly estuarine habitats (saltmarsh, mangroves and tidal-flats) though opportunistic records of birds using other habitats were noted. The survey design is a hierarchical structure with samples selected initially on the sites condition, which for convenience was divided into disturbed and less disturbed. The disturbed and undisturbed estuarine habitats studied include saltmarsh (surveyed high tide), mangroves (high tide) and tidal-flats (low tide) adjacent to mangroves (herein mangrove mudflats). A less disturbed habitat sampled was estuarine mudflats which are those exposed during low tides and are unconnected to adjacent shore. An extremely disturbed site sampled was mudflats adjacent to highly urbanised foreshore (herein disturbed edge mudflat) (surveyed low tide) that would have probably been occupied by a fringe of mangroves prior to development.

#### Information Box 1

##### Summary of survey methods used in the *New Atlas*

- *2 ha searches* for 20 minutes (recommended as a transect 100m x 200m though could be other dimensions)
- *Area searches* for at least 20 minutes *within 500m* of a central point (any shape)
- *Area searches* for 20 minutes *within a 5km* range of a central point (any shape)
- *Incidental searches*, no time or area limits, usually one-off sightings of rare or unexpected species
- The *2 ha searches* could be nested within the other *area searches* (*500m* or *5km*).

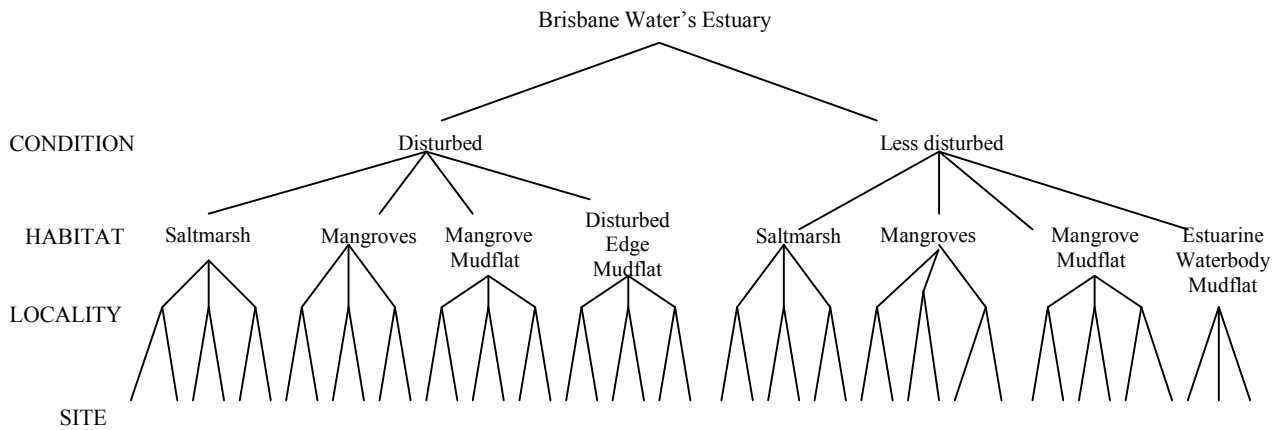
Barrett *et al* (2003)

Each habitat was sampled at three different localities with two sample sites at each locality except for estuarine waterbody mudflats (Figure 1). The mangrove forest and mangrove mudflat sample sites were adjacent to each other and where possible, saltmarsh sites were also adjacent but landward to the mangrove forest; however there were several sites where this arrangement were unable to be met due to the space occupied by other vegetated habitats (e.g. Swamp Forest) and so the saltmarsh was sampled at the same general locality but as close as possible to the mangrove and mangrove mudflat sites.

Each sample site (n = 137) was surveyed using the twenty minutes area searches that was one of several prescribed methods for the New Atlas survey (Barrett *et al*, 2002) (see information box 1).

During the 20 minute area search the author meandered through the survey site keeping observations to a relatively homogenous sample unit. The boundary between mangrove and mudflats was identified by the outer-canopy of the mangrove trees and the edge and shallows of estuary water. The boundary between mangrove and saltmarsh was not always clearly defined as mangrove and saltmarsh could occur in mosaics. Subsequently, subjective interpretation of the boundary was undertaken with more open areas assigned to saltmarsh when there was a dense cover of saltmarsh species (e.g. Beaded Glasswort), conversely where mangrove clumps were denser and saltmarsh extremely sparse or absent these areas were only included in mangrove sampling and excluded during saltmarsh surveys. Some opportunistic additional twenty minutes area searches were conducted but results are not detailed here however will be referred to when necessary. Opportunistic observation were noted e.g. birds flying in adjacent habitats.

Optical equipment used were a Nikon Monarch 10 x 42 DCF binocular and Gerber Montana spotting scope 15-45 (mostly used at 15-25) x 60mm mounted on a Veldon CX 686 tripod.



**Figure 1: Hierarchical design used to survey birds.**

### 2.2.3. Data Presentation

A list of estuarine birds documented from literature and the field survey was collated so that an initial estuarine bird assemblage for Brisbane Water was identified. The percentage frequency of each species identified during the survey or other suitable data sets were graphed. A list of threatened species and species listed on international treaties was provided.

Waterbirds species identified during the survey were broadly classed according to major taxonomic/functional group of Keating and Pegler (2003) including:

- Waterfowl (Anatidae family)
- Piscivores (includes species from the Spheniscidae, Anhingidae, Phalacrocoracidae & Pelecanidae families)
- Large Wading Birds (Ardeidae & Threskiornithidae families)
- Waders (Scolopacidae, Haematopodidae, Recurvirostridae & Charadriidae families),

Variation to Keating and Pegler (2003) classification is the inclusion of most Laridae with Piscivores (as opposed to gulls and tern of Keating and Pegler, 2003) as terns predominately consume fish though using different foraging techniques than Phalacrocoracidae. In addition to Large Wading Birds adopted from Keating and Pegler (2003) there is also a Medium Wading Birds waterbird group (Ardeidae family). Furthermore Silver Gulls (*Larus novaehollandiae*) have been identified as Omnivores-scavengers (c.f. gulls & terns or piscivores). Rallidae and Podicepedidae have not been classed as waterfowl but allotted to a dietary functional group.

The forest birds group include species that also inhabit woodlands and more open habitats (e.g. parkland) and though Ford (1989) provides a more detailed breakdown of the forest bird assemblage (using food, substrate & foraging methods) it is simplified for the purpose of this report. Forest birds include the following groups:

- Carnivore (Halcyonidae family)
- Carnivore (diurnal raptor)(Accipitridae family)
- Insectivore (various passerine families)
- Insectivore (aerial)( Hirundinidae family)
- Insectivore/nectarivore (Meliphagidae family)
- Seed eaters (Columbidae, Cactuidae & Psittacidae families)



The functional dietary classification used above is not strictly applied to all species, for example Crested Terns (*Sterna bergii*) occasionally eat prawns and squid but as their diet is predominately fish (Higgins & Davies, 1993) they have been identified as piscivores in this report. Additionally, taxonomic groups (waterfowl, large wading birds & waders) poorly recognise variation within each group (e.g. diet, foraging methods, and habitat) however it provides an initial group that coarsely separates their species from other groups.

## 3.0. Results

### 3.1. Literature Review

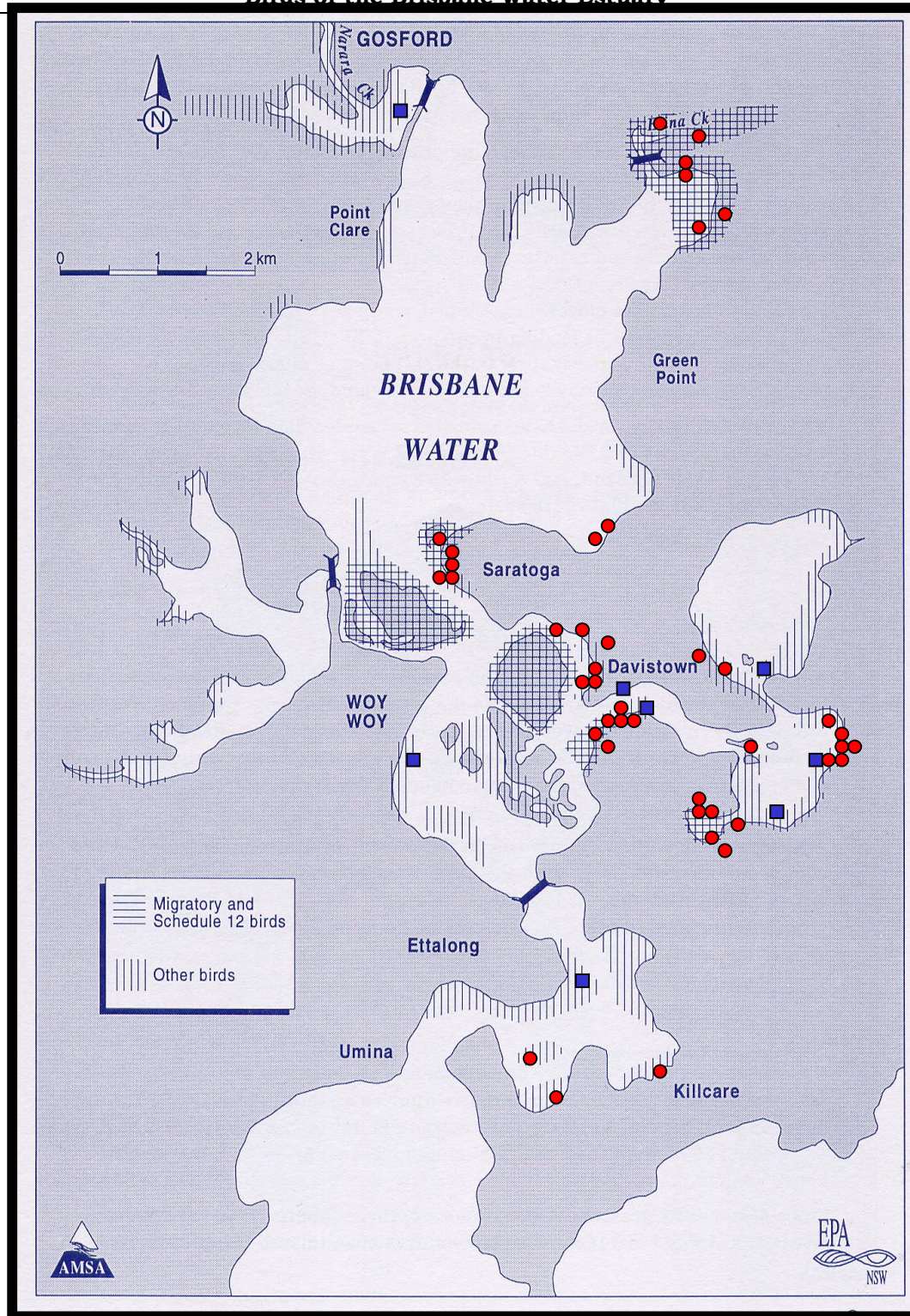
There is no peer reviewed published literature specifically referring to the avifauna of Brisbane Water estuarine habitats though a review of the birds of the region include citations for Brisbane Water (Morris, 1975). The ‘grey literature’ provides further information on Brisbane Water birds with literature only on that estuary (Department of Environment and Planning, 1983; EPA, 1994; Morris, unpublished data 1997-2003), shorebirds in NSW (Smith, 1991) or the bird assemblage of the region (Morris, 2003, 2002, 2000, 1999, 1998, 1996; Morris *et al.*, 1997) that include Brisbane Water observation records (Appendix 3, 4, 5). A list of birds from 1986-2002 Kincumber Creek recorded by local ornithologist, Dennis O’Toole was collated by Warman (2004; Appendix 3) however it includes species that would use Swamp Forest habitats as well as the estuarine habitats targeted in this report.

Two targeted surveys for the Bush Stone Curlew (*Burhinus grallarius*) in the Brisbane Water estuary have been commissioned by Gosford City Council (Morris, 2002; Staines, 2006) and provide valuable data on that species.

Morris (unpublished data 1997-2003) most frequently recorded species (100% of surveys) are:

- Waders (Masked Lapwing *Vanellus miles*, Pied Oystercatcher *Haematopus longirostris*, Eastern Curlew *Numenius madagascariensis*, Bar-tailed Godwit *Limosa lapponica*),
- Large Wading Birds (Australian White Ibis, White-faced Heron),
- Piscivores (Great Cormorant *Phalacrocorax carbo*, Pied Cormorant *Phalacrocorax varius*, Little Pied Cormorant *Phalacrocorax melanoleucos*), and
- Waterfowl (Black Swan *Cygnus atratus*, Chestnut Teal *Anas castanea*, Pacific Black Duck *Anas superciliosa*)(Figure 5; Appendix 4)

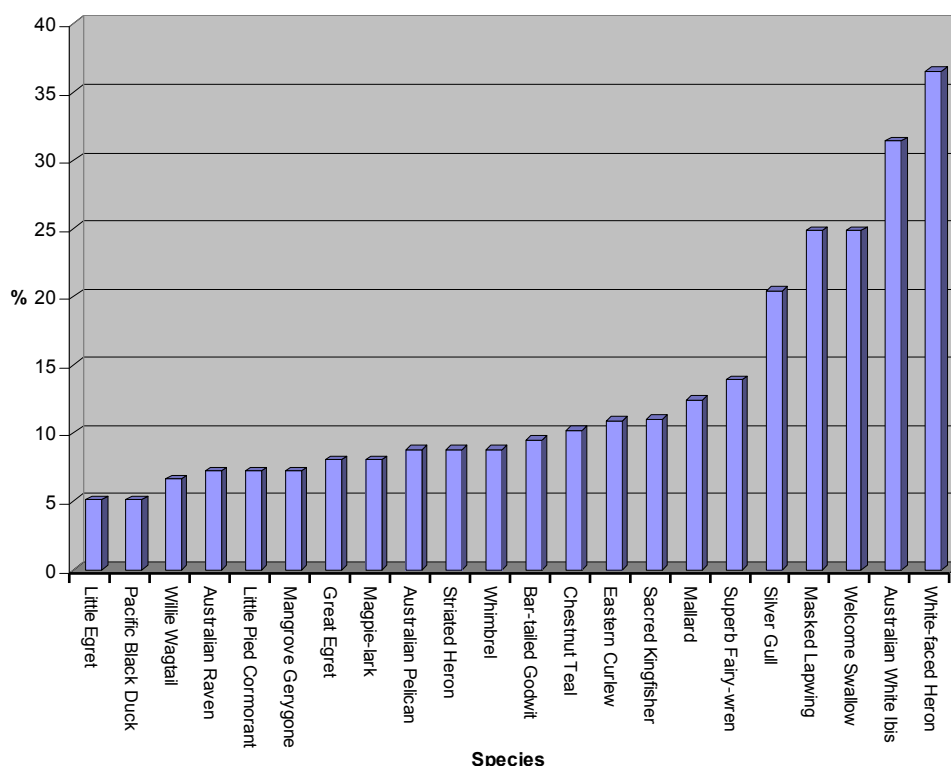
The most species rich major taxonomic/functional group of birds recorded between 1997-2003 (Morris unpublished data) are the piscivores (9 species), waders (7 species), large wading birds and waterfowl (6 species each) (Figure 7). Morris unpublished data (1997-2003) records two carnivores (diurnal raptors) (Swamp Harrier *Circus approximans*, Peregrine Falcon *Falco peregrinus*) and one piscivores (Little Tern *Sterna albifrons*) each with one record (Figure 5; Appendix 4).



**Figure 2: Approximate location of twenty minute area search survey sites (this study). Red circles indicate systematic survey sites; blue squares are opportunistic survey sites (not reported here) (Base map source: EPA, 1994; NB: [a] Hatching refers to feeding resting & roosting for birds protected by international treaty, and [b] for Schedule 12 birds that are now listed as threatened species under the Threatened Species Conservation Act**



Figure 3: Brisbane Water estuarine birds with >5 % frequency during early Autumn survey, 2006 (n=137)

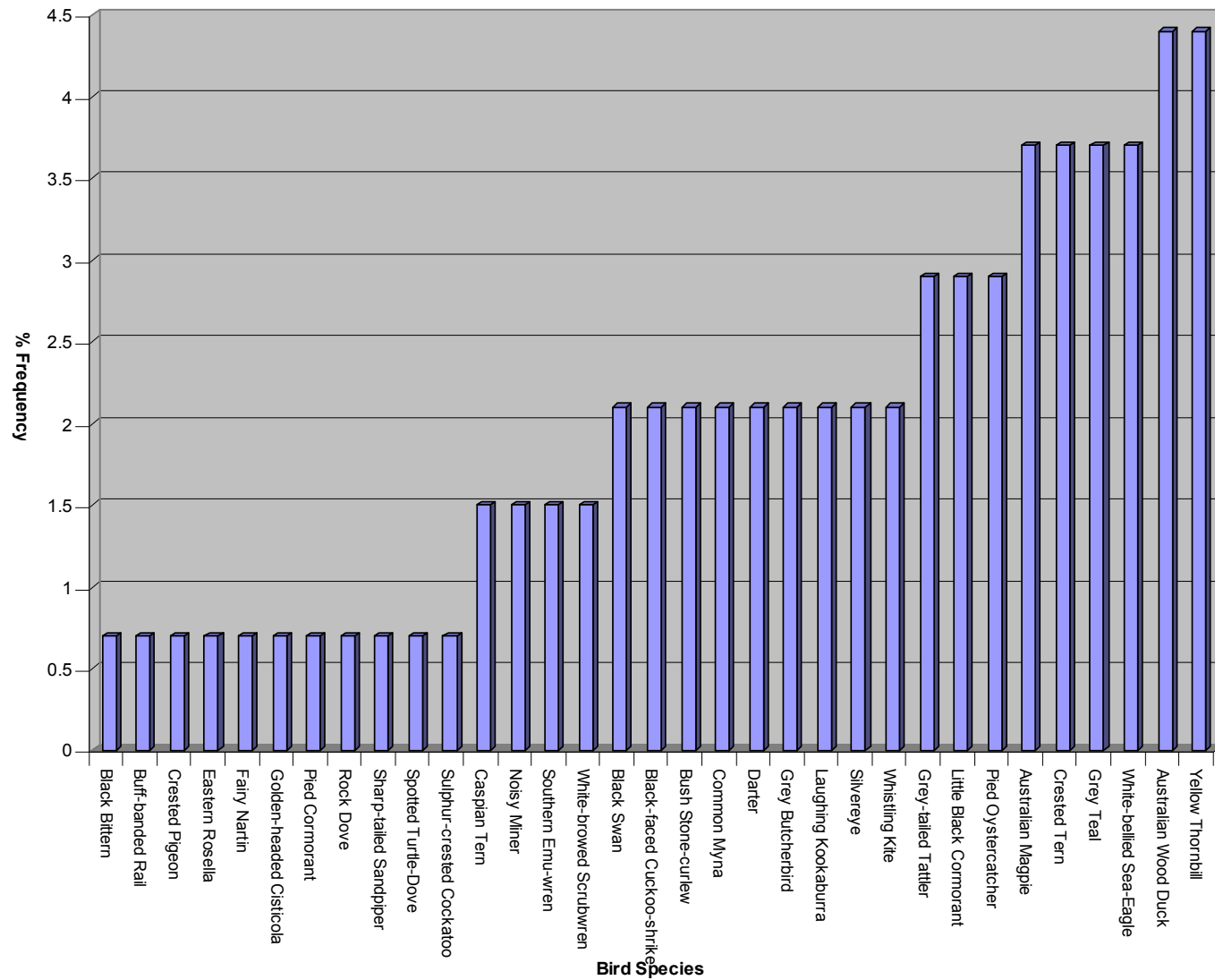


### 3.2. Field Survey

There were fifty-five species including four feral species recorded during the systematic early autumn surveys (Appendix 2). The most species rich group were the insectivores, then waders, piscivores and waterfowls (Figure 8).

The least species rich taxonomic/functional group were omnivores-scavenger (Silver Gull) and insectivore/nectarivore (Noisy Miner *Manorina melanocephala*) with one species each (Figure 6). The two most frequently recorded species (White-faced Heron *Egretta novaehollandiae* [c36% of sample sites]; Australian White Ibis *Threskiornis molucca* [31% of sample]) belong to the Large Wading bird group that had only four species present (Figure 3, 6) during the early autumn surveys. Equal third for frequency in the early autumn surveys included the resident wader, Masked Lapwing (*Vanellus miles*) and the aerial insectivore Welcome Swallow (*Hirundo neoxena*) (Figure 3). The fifth most species rich group included omnivores and seedeaters with five species each (Figure 6) including three of the four exotic species recorded in the autumn survey (Appendix 2).

Figure 4: Brisbane Water estuarine birds with &lt; 5 % frequency during early Autumn survey, 2006 (n=137)



**Figure 5: Brisbane Water Waterbird Count % Frequency (n=9)(7/1997-2/2003)(based on Alan Morris unpublished data)**

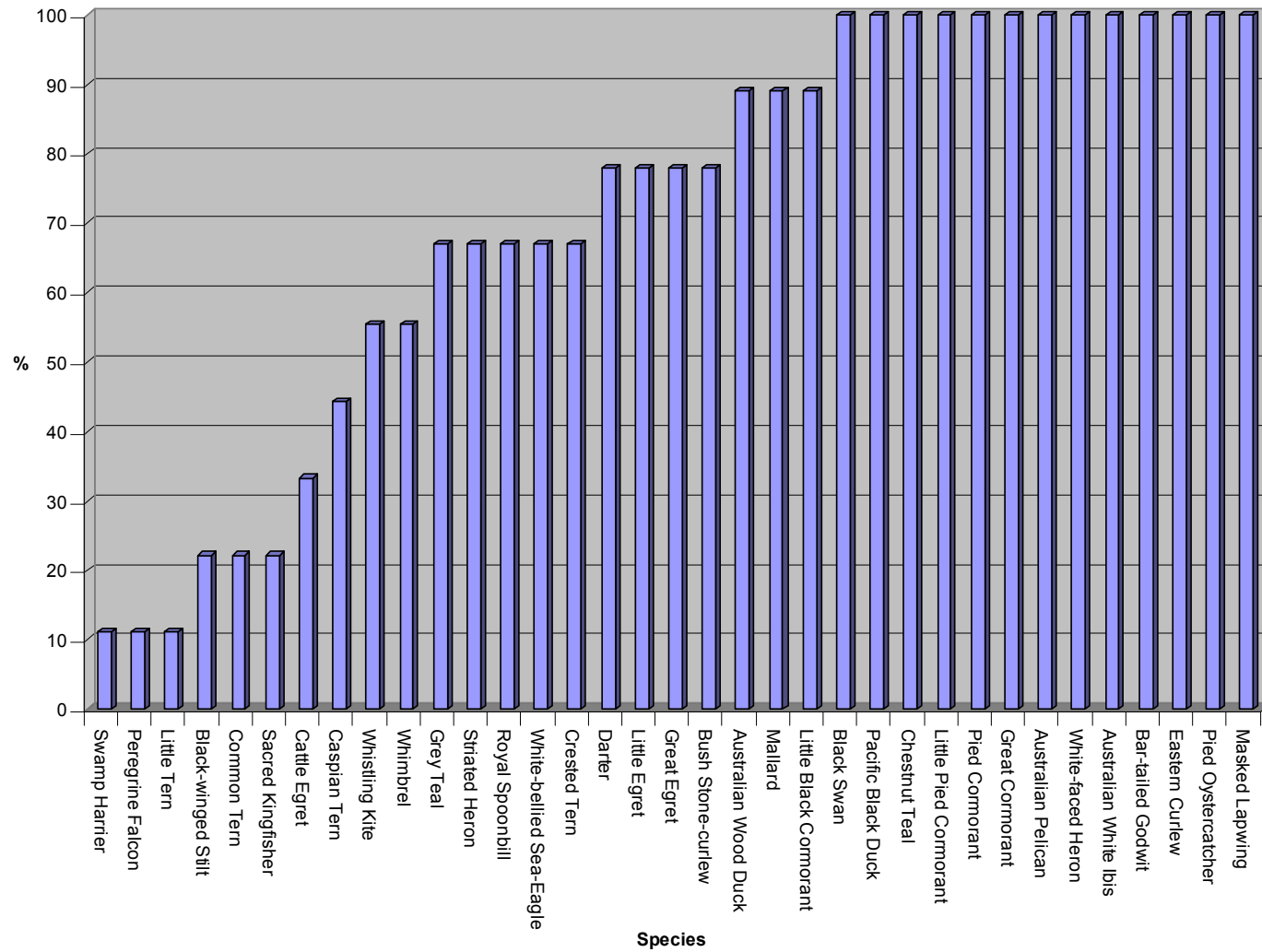
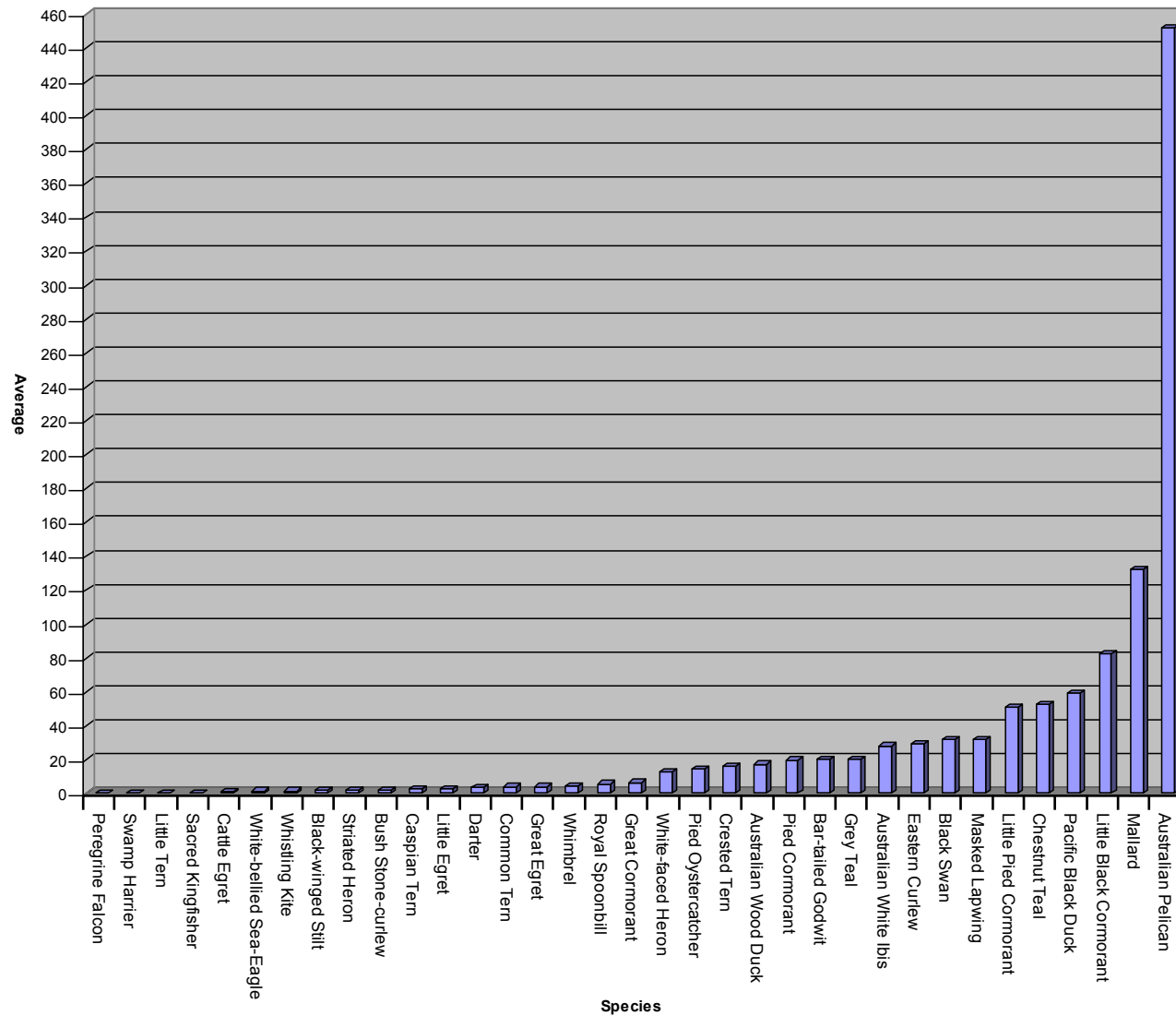
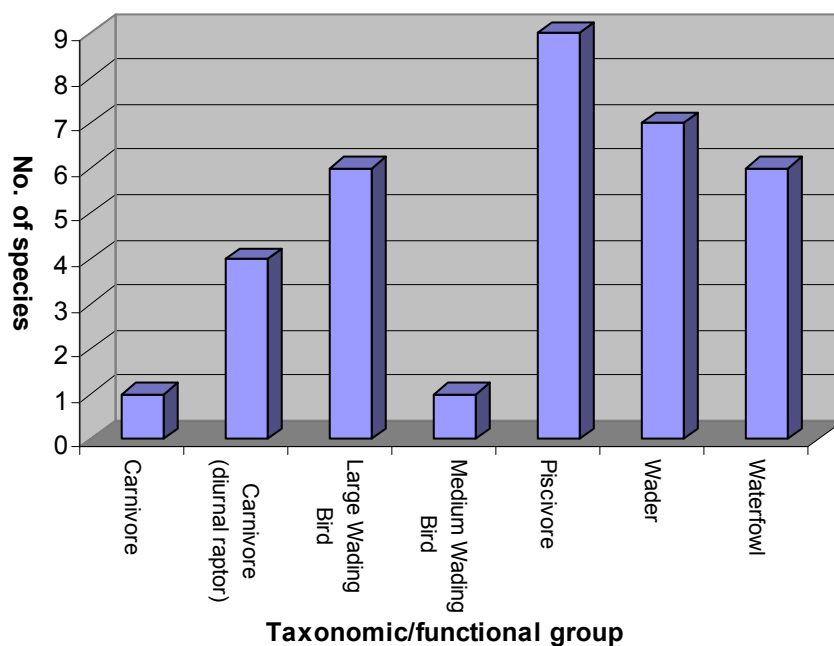




Figure 6: Average number of species observed from 9 sample periods from 11 sites between 07/1997-02/2002  
(Morris, unpublished data, 1997-2003)



**Figure 7: No. of species by taxonomic/functional group (x/35)(Morris unpublished data, 1997-2003)**



**Figure 8: No. of bird species by major taxonomic/functional group (early Autumn survey)(x/55 species)**

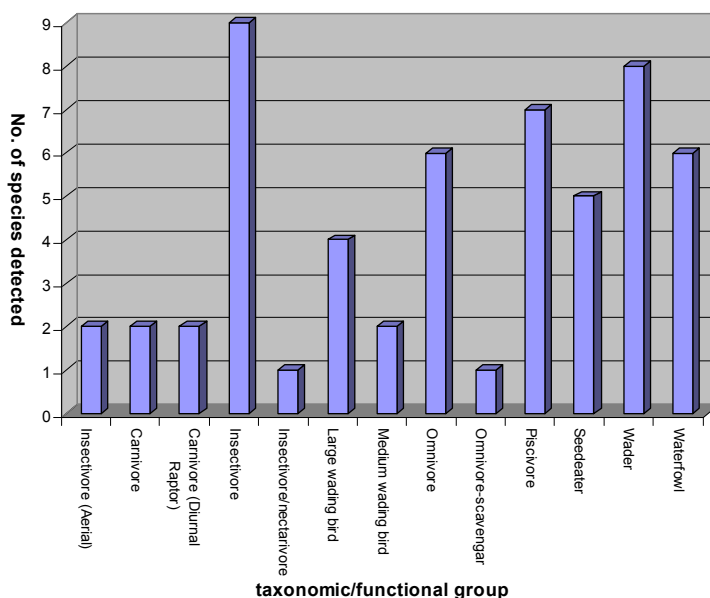
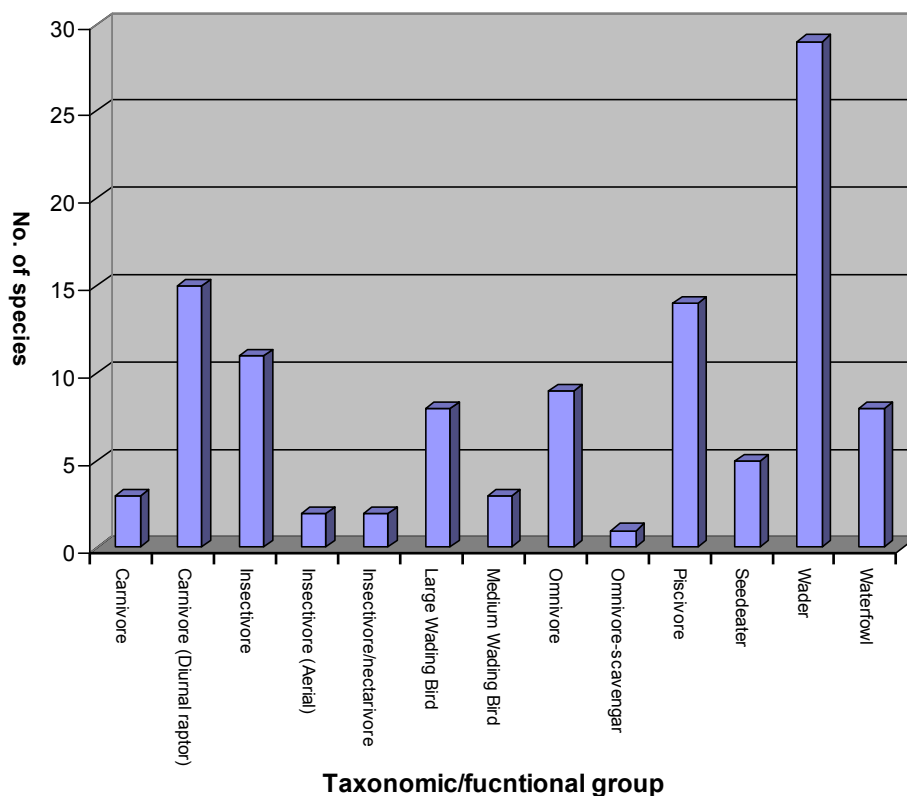


Figure 9: Taxonomic/fucntional group of bird species recorded in Brisbane Water estuary



### 3.3. Literature and Field Survey Data

Data from autumn surveys (this report) and a temporally more extensive data set (Morris unpublished, 1997-2003) provide a core list of species of bird expected to be observed in Brisbane Water estuary (Appendix 2, 4). Many of the species observed by these ornithologists are also listed in earlier compilations for the estuary (Department of Environment and Planning, 1983; EPA, 1994) however these earlier compilations also list several species not observed by this author and Alan Morris (unpublished data, 1997-2003) during their surveys e.g. Terek Sandpiper (*Xenus cinereus*); Red-necked Stint (*Calidris ruficollis*).

Regional bird assemblage profiles that included Brisbane Water sites (Morris, 2003, 2002, 2000, 1999, 1998, 1996, 1975; Morris *et al*, 1997) also add to the species richness known for the estuary. The Birds Australia (2006) data also lists several additional species not documented in these other data sets and also validates the presence of some of the least recorded species. There are at least 110 species (including 4 exotic species) from 13 Orders, 34 families (including 1 exotic family) and 79 genera (including 3 exotic genera) recorded in the Brisbane Water estuary habitats (Appendix 1, see references therein).

## 4.0. Discussion

### 4.1. The Brisbane Water Estuarine Bird Assemblage

#### 4.1.1. Waders

The most species rich group were waders (29 species) (Figure 8; Appendix 1) that included eight resident (Australian) and twenty-one migratory species although no vagrant waders to Australian shores have been documented for Brisbane Water estuary (Table 1). The migratory waders most frequently observed in the Brisbane Water estuary included Bar-tailed Godwit (*Limosa lapponica*), Whimbrel (*Numenius phaeopus*) and Eastern Curlew (*Numenius madagascariensis*) while the resident waders observed in most years included Bush Stone-curlew, Pied Oystercatcher (*Haematopus longirostris*) and Masked Lapwing (*Vanellus miles*). The remaining twenty-three waders (see Table 1) were infrequently recorded in the estuary or have not been observed recently in Brisbane Water.

Eight of these waders, Common Sandpiper (*Actitis hypoleucos*), Ruddy Turnstone (*Arenaria interpres*), Red Knot (*Calidris canutus*), Sanderling (*Calidris alba*), Broad-billed Sandpiper (*Limicola falcinellus*), Pacific Golden Plover (*Pluvialis fulva*), Grey Plover (*Pluvialis squatarola*) and Lesser Sand Plover (*Charadrius mongolus*) have no recent records for Brisbane Water and though suitable habitat is available for most of these species it may be suboptimal and not their preferred habitat (see reviews in section 4.2.1 & Appendix 7). Additionally the paucity of records for these infrequently or not recently recorded species could be due to the survey efforts that have been completed to date in the estuary and may not be adequate to detect these less common species (Lindenmayer & Burgman, 2005).

#### 4.1.2. Carnivores (diurnal raptors)

There are fifteen diurnal raptors recorded at the Brisbane Water that could hunt for prey in estuarine habitats (saltmarsh, mudflats, mangrove forest, open estuarine waterbody) however only four raptors would be considered species that frequently or are predominately based in estuarine and coastal habitats) (Appendix 1; Figure 4, 5). These species include White-bellied Sea-Eagle (*Haliaeetus leucogaster*), Whistling Kite (*Haliastur sphenurus*), Osprey (*Pandion haliaetus*) and Brahminy Kite (*Haliastur indus*) with the former three species known to have nested at the Brisbane Water (Morris, 1975, 1996, 2000).

#### 4.1.3. Piscivores

The piscivores are the third most abundant group of birds recorded in the estuary (14 species) (Figure 9) however the Fiordland Penguin (*Eudyptes pachyrrhynchus*) is a vagrant to Australia (Morris, 1975; Marchant & Higgins, 1990) and the Little Penguin (*Eudyptula minor*), Australasian Gannet (*Morus serrator*), Short-tailed Shearwater (*Puffinus tenuirostris*) and Little Tern (*Sterna albifrons*) are rarely recorded in Brisbane Water (Morris unpublished data, 1997-2003, see Figure 5; Birds Australia, 2006).

Common Tern (*Sterna hirundo*) are occasionally documented in Brisbane Water (Morris, 1999; Morris unpublished data, 1997-2003) and Caspian Tern (*Sterna caspia*) and Crested Terns (*Sterna bergii*) are more frequently recorded (Figure 5) though never in large numbers (Figure, 6; Appendix 4) (Morris unpublished data, 1997-2003).

The Phalacrocoracidae (cormorants) and Darter (*Anhinga melanogaster*) are regularly recorded and occur in Brisbane Water estuary year round (Morris, 2000; Morris unpublished data, 1997-2003) with nesting colonies of Little Black Cormorants (*Phalacrocorax sulcirostris*) documented (Morris, 1975) (Figure 5, Appendix 5). Little Black Cormorants can reach relatively high numbers (Figure 6) with up to 375 individuals recorded in one season (July, 1998) (Appendix 4) (Morris unpublished data, 1997-2003).

Australia's large piscivore, the Australian Pelican (*Pelecanus conspicillatus*) is the most abundant of any bird species recorded in the Brisbane Water estuary with a maximum of 810 (February, 2000) (Figure 6; Appendix 4) and is frequently recorded there (Figure 5) (Morris unpublished data, 1997-2003). Australian Pelicans in Brisbane Water do not rate a mention in early documentation of the birds of the region (Morris, 1975) though since then there have been breeding records on Ramsay Island (Blackwall Bay, Woy Woy) since at least 1995 (Morris, 1996, 1998, 1999, 2000, 2002a, 2003; unpublished data 1997-2003; Morris *et al*, 1997).

Table 1: Resident & migratory shorebird recorded in the Brisbane Water estuary (status based on Priest *et al*, 2002)

| <b>Scientific Name</b>           | <b>Common Name</b>     | <b>Resident</b> | <b>Migratory</b> | <b>Vagrant</b> |
|----------------------------------|------------------------|-----------------|------------------|----------------|
| <i>Gallinago hardwickii</i>      | Latham's Snipe         |                 | M                |                |
| <i>Limosa limosa</i>             | Black-tailed Godwit    |                 | M                |                |
| <i>Limosa lapponica</i>          | Bar-tailed Godwit      |                 | M                |                |
| <i>Numenius minutus</i>          | Little Curlew          |                 | M                |                |
| <i>Numenius phaeopus</i>         | Whimbrel               |                 | M                |                |
| <i>Numenius madagascariensis</i> | Eastern Curlew         |                 | M                |                |
| <i>Tringa stagnatilis</i>        | Marsh Sandpiper        |                 | M                |                |
| <i>Tringa nebularia</i>          | Common Greenshank      |                 | M                |                |
| <i>Xenus cinereus</i>            | Terek Sandpiper        |                 | M                |                |
| <i>Actitis hypoleucos</i>        | Common Sandpiper       |                 | M                |                |
| <i>Heteroscelus brevipes</i>     | Grey-tailed Tattler    |                 | M                |                |
| <i>Arenaria interpres</i>        | Ruddy Turnstone        |                 | M                |                |
| <i>Calidris canutus</i>          | Red Knot               |                 | M                |                |
| <i>Calidris alba</i>             | Sanderling             |                 | M                |                |
| <i>Calidris ruficollis</i>       | Red-necked Stint       |                 | M                |                |
| <i>Calidris acuminata</i>        | Sharp-tailed Sandpiper |                 | M                |                |
| <i>Calidris ferruginea</i>       | Curlew Sandpiper       |                 | M                |                |
| <i>Limicola falcinellus</i>      | Broad-billed Sandpiper |                 | M                |                |
| <i>Burhinus grallarius</i>       | Bush Stone-curlew      | R               |                  |                |
| <i>Haematopus longirostris</i>   | Pied Oystercatcher     | R               |                  |                |
| <i>Haematopus fuliginosus</i>    | Sooty Oystercatcher    | R               |                  |                |
| <i>Himantopus himantopus</i>     | Black-winged Stilt     | R               |                  |                |
| <i>Pluvialis fulva</i>           | Pacific Golden Plover  |                 | M                |                |
| <i>Pluvialis squatarola</i>      | Grey Plover            |                 | M                |                |
| <i>Charadrius mongolus</i>       | Lesser Sand Plover     |                 | M                |                |
| <i>Euseyonis melanops</i>        | Black-fronted Dotterel | R               |                  |                |
| <i>Erythronyx cinctus</i>        | Red-kneed Dotterel     | R               |                  |                |
| <i>Vanellus miles</i>            | Masked Lapwing         | R               |                  |                |
| <i>Vanellus tricolour</i>        | Banded Lapwing         | R               |                  |                |
| Total                            |                        | 8               | 21               | 0              |



#### 4.1.4. Insectivores

The early autumn survey (this report) provides the only systematic data on the insectivorous birds of Brisbane Water estuarine habitats (Appendix 1, 2) though Birds Australia (2006) record insectivorous species, their data is not habitat specific. None-the-less, despite data limitations, insectivorous birds are the fourth most species rich group of the overall bird assemblage in Brisbane Water (11 species) (Figure 9; Appendix 1) and the most species rich of the early autumn survey (Figure 8). All insectivorous species belong to the same order (Passeriformes) however this group were the most diverse at the family taxon level compared to all other major taxonomic/functional groups.

Superb Fairy-wren (*Malurus cyaneus*) was the most frequently recorded insectivore and was the sixth most frequently recorded species of all species recorded during the early autumn survey (Figure 3). The Superb Fairy-wren was regularly observed in mangrove and saltmarsh habitats (28% of all these habitats sampled) where in the latter habitat they made use of scattered mangrove shrubs/trees or the sedges of the high saltmarsh. Superb Fairy-wrens prefer a mosaic of dense low vegetation with clear open areas that are provided by mangrove and saltmarsh estuarine habitats (Higgins et al, 2001).

Magpie-lark (*Grallina cyanoleuca*) and Willy Wagtail (*Rhipidura leucophrys*) were recorded between 5-10% of all survey samples (Figure 3). The Willy Wagtail was recorded on mudflats, saltmarsh and mangroves while the Magpie-larks were recorded only in saltmarsh and mudflats. The remainder of the insectivores (Appendix 1) were recorded in less than 5% of autumn samples (Figure 4) and were variously recorded using mangrove or saltmarsh only or both habitats. In south-eastern Australia the Mangrove Warbler (*Gerygone levigaster*) is known occasionally to use adjacent forest but its habitat preferences are mangroves (Higgins et al, 2006). In NSW it has been recorded in paperbark Melaleuca swamp forest adjacent to mangroves and in Casuarina<sup>1</sup> (c100m) from mangroves (Higgins et al, 2006). All observations were in mangroves at Brisbane Water.

It should be noted that most of these species use other woody habitats including forest, woodland and/or shrub dominated habitats (Higgins & Peter, 2002; Higgins et al, 2006) but adjacent suitable habitats such as Swamp Forest were not surveyed in this study.

#### 4.1.5. Omnivores

This group of birds belong to three bird orders (Galliformes, quail; Gruiformes, rallids; and Passeriformes, perching birds) and can coarsely be divided into species associated more with wetland habitats or those more frequently recorded in terrestrial habitats. Lewins Rail (*Rallus pectoralis*), Purple Swamphen (*Porphyrio porphyrio*) (listed by O'Toole in Warman, 2004) and Spotless Crake (*Porzana tabuensis*), (Warman, 2004; Morris et al, 1997) are three omnivorous wetland bird group rarely recorded in Brisbane Water estuary though recorded elsewhere in this district (Morris, 1975). Buff-banded Rails (*Gallirallus philippensis*) are infrequently recorded at several estuarine wetland sites around Brisbane Water (Birds Australia, 2006) with one individual recorded in mangroves during the autumn survey.

The omnivorous Brown Quail (*Coturnix ypsilophora*) is rarely observed in Brisbane Water (Birds Australia, 2006; Morris, 1975) but the remaining omnivores are widespread in the region (e.g. Australian Magpie *Gymnorhina tibicen*; Grey Butcherbird *Cracticus torquatus*). The only omnivore

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<sup>1</sup> Probably Swamp Oak Casuarina glauca

recorded in more than 5% of sample sites in the autumn survey was the Australian Raven (*Corvus coronoides*) (Figure 3) in saltmarsh, mangroves and mudflats. The remainder were rarely recorded (< 5%) during the autumn survey (Figure 4; Appendix 1) and includes the feral Common Mynah (*Acridotheres tristis*) observed on foraging on saltmarsh and mudflats.

#### 4.1.6. Waterfowl

A total of eight species were recorded in this equally sixth largest group (Figure 9; Appendix 1). Waterfowl are regularly recorded in surveys in Brisbane Water (Figure 5) and include Chestnut Teal (*Anas castanea*), Pacific Black Duck (*Anas superciliosa*) and Black Swan (*Cygnus atratus*) (Morris unpublished data, 1997-2003). These waterfowl utilise the mudflats, estuarine waterbody, estuarine waterbody mudflat and rarely saltmarsh for foraging and loafing. The introduced Mallard (*Anas platyrhynchos*) is the most frequently recorded waterfowl during the autumn surveys (Figure 3), it is regularly recorded previously (Figure 5) and is on average the second most abundant species recorded in Brisbane Water (Figure 6) though numbers fluctuate (Appendix 4) (Morris unpublished data, 1997-2003). Musk Ducks (*Biziura lobata*) and Australasian Shoveler (*Anas rhynchos*) are rarely recorded in the Brisbane Water with one record each (Appendix 5) (Morris, 2002a; Birds Australia, 2006).

#### 4.1.7. Large Wading Birds

This equally sixth species rich group of waterbirds has members that are regularly recorded in Brisbane Water with White-faced Herons (*Egretta novaehollandiae*) and Australian White Ibis (*Threskiornis molucca*) some of the most frequently documented (Figures 3 & 5) and on occasion are quite abundant (e.g. 250 Australian White Ibis individuals documented at Woy Woy) (Appendix 5) (Morris *et al*, 1997). Both of these species regularly forage on mudflats, roost on mangroves and forage in saltmarsh. Some large waders are documented relatively frequently but in low numbers (e.g. Great Egret *Ardea alba*) (Figure 5) and are seen hunting on the edge of mudflats. Conversely, White-necked Herons (*Ardea pacifica*) were rarely recorded in the Brisbane Water (Birds Australia, 2006).

#### 4.1.8. Seed eaters

Seed eaters were rarely recorded at the estuarine habitats during the autumn survey and each of the five species were only recorded once (Figure 4). One species, the Eastern Rosella (*Platycercus eximius*) was observed roosting on mangroves, while the remainder (one cockatoo and three pigeon species) were recorded on mudflats (Appendix 1 for species). Two of the pigeons are feral species.

#### 4.1.9. Medium Wading Birds

Three medium wading birds were recorded for Brisbane Water estuary with only one species (Striated Heron *Butorides striatus*) consistently recorded (Figure 5), although never in large numbers (Figure 6) (Appendix 4, 5) (Morris unpublished data, 1997-2003; Morris, 1998, 2000, 2003; Morris *et al*, 1997). During the autumn surveys the Striated Heron was occasionally recorded (Figure 3) on the ground among mangroves, perched on mangroves or foraging on mudflats.

The Nankeen Night Heron (*Nycticorax caledonicus*) was rarely recorded in Brisbane Water (three records) (Birds Australia, 2006). The Black Bittern (*Ixobrychus flavicollis*) has only one record for the estuary which was observed during the autumn surveys at the edge of mangroves interface with adjacent mudflats.

#### 4.1.10. Aerial Insectivores

Though from the same family there are notable differences in the frequency of Welcome Swallow (*Hirundo neoxena*) and Fairy Martin (*Hirundo ariel*) during the autumn survey. Welcome Swallows were the third most frequently recorded birds during the autumn survey (Figure 3) where they were regularly observed foraging above mudflats, mangroves and saltmarsh. Fairy Martins, on the other hand were observed only once foraging above saltmarsh.

#### 4.1.11. Insectivore-nectarivore

Two insectivore-nectarivores are recorded in estuarine habitats of Brisbane though infrequently. Noisy Miner (*Manorina melanocephala*) were observed twice (Figure 4) foraging for invertebrates in mangroves near a suburban area. The Brown Honeyeater (*Lichmera indistincta*) has been recorded once in mangroves (Morris, 2002a).

#### 4.1.12. Omnivore-scavenger

Silver Gulls (*Larus novaehollandiae*) were the fifth most recorded species during the autumn surveys (Figure 3) regularly recorded on mudflats and estuarine waterbody mudflats with the latter habitat at Wagstaff having the maximum count of 57 individuals.

### 4.2. Species and Conservation

In the strictest definition of biodiversity and its conservation most native bird species documented in Brisbane Water could be valued for their role as examples of that species and their contribution to the genetic diversity of that species. Furthermore, these species may also be valued for their functional role in ecological processes within the Brisbane Water estuary such as nutrient cycling and population regulation through predation (including herbivory). However these attributes were not assessed to profile the contribution to the conservation of estuarine birds in Brisbane Water habitats. None-the-less a conservation assessment of the bird species in the estuary was identified and includes:

- Threatened Species
- Declining Species
- Regionally Significant Species
- Species recognised in international treaties that Australia is signatory

#### 4.2.1. Threatened Species

There are eleven species listed on the schedules of the NSW Threatened Species Conservation Act (TSCA) (1995) two of which are endangered and nine are vulnerable (Table 2). There are no threatened species listed under the federal government Environment Protection and Biodiversity act however the Eastern Curlew (*Numenius madagascariensis*) has been listed globally as Near Threatened by the IUCN (Wetlands International, 2005) (see Appendix 7 for species profile in Brisbane Water estuary). Australian birds had their conservation status assessed outside of the legislative framework but adopting IUCN criteria it was found that two species (Bush Stone-Curlew *Burhinus grallarius* and Lewins Rail *Rallus pectoralis*) recorded in Brisbane Water estuary have

been classed as Near Threatened<sup>2</sup> (Garnett & Crowley, 2000) (see Bush Stone-curlew profile below). The cryptic Lewin's Rail has been observed at Kincumber Creek (O'Toole cited Warman, 2004).

The following profiles summarise the occurrence of the TSCA listed species in Brisbane Water estuary and identifies their habitats as recorded from the autumn survey or from the literature. Six of these species are trans-equatorial migrants but their northern hemisphere ecology and habitats are not discussed (however see Higgins and Davies (1996), Marchant and Higgins (1993), Smith (1991), Lane (1987) and Hayman *et al.*, (1986) for an overview of their biology and ecology in the northern hemisphere).

**Table 2: Threatened Species as listed under NSW Threatened Species Conservation Act (1995) recorded for Brisbane Water estuary**

| Common Name            | Scientific Name                | Threatened Species Conservation Act (NSW) |
|------------------------|--------------------------------|---|
| Bush Stone-curlew      | <i>Burhinus grallarius</i>     | Endangered                                |
| Little Tern            | <i>Sterna albifrons</i>        | Endangered                                |
| Black Bittern          | <i>Ixobrychus flavicollis</i>  | Vulnerable                                |
| Black-tailed Godwit    | <i>Limosa limosa</i>           | Vulnerable                                |
| Broad-billed Sandpiper | <i>Limicola falcinellus</i>    | Vulnerable                                |
| Lesser Sand Plover     | <i>Charadrius mongolus</i>     | Vulnerable                                |
| Osprey                 | <i>Pandion haliaetus</i>       | Vulnerable                                |
| Pied Oystercatcher     | <i>Haematopus longirostris</i> | Vulnerable                                |
| Sanderling             | <i>Calidris alba</i>           | Vulnerable                                |
| Sooty Oystercatcher    | <i>Haematopus fuliginosus</i>  | Vulnerable                                |
| Terek Sandpiper        | <i>Xenus cinereus</i>          | Vulnerable                                |

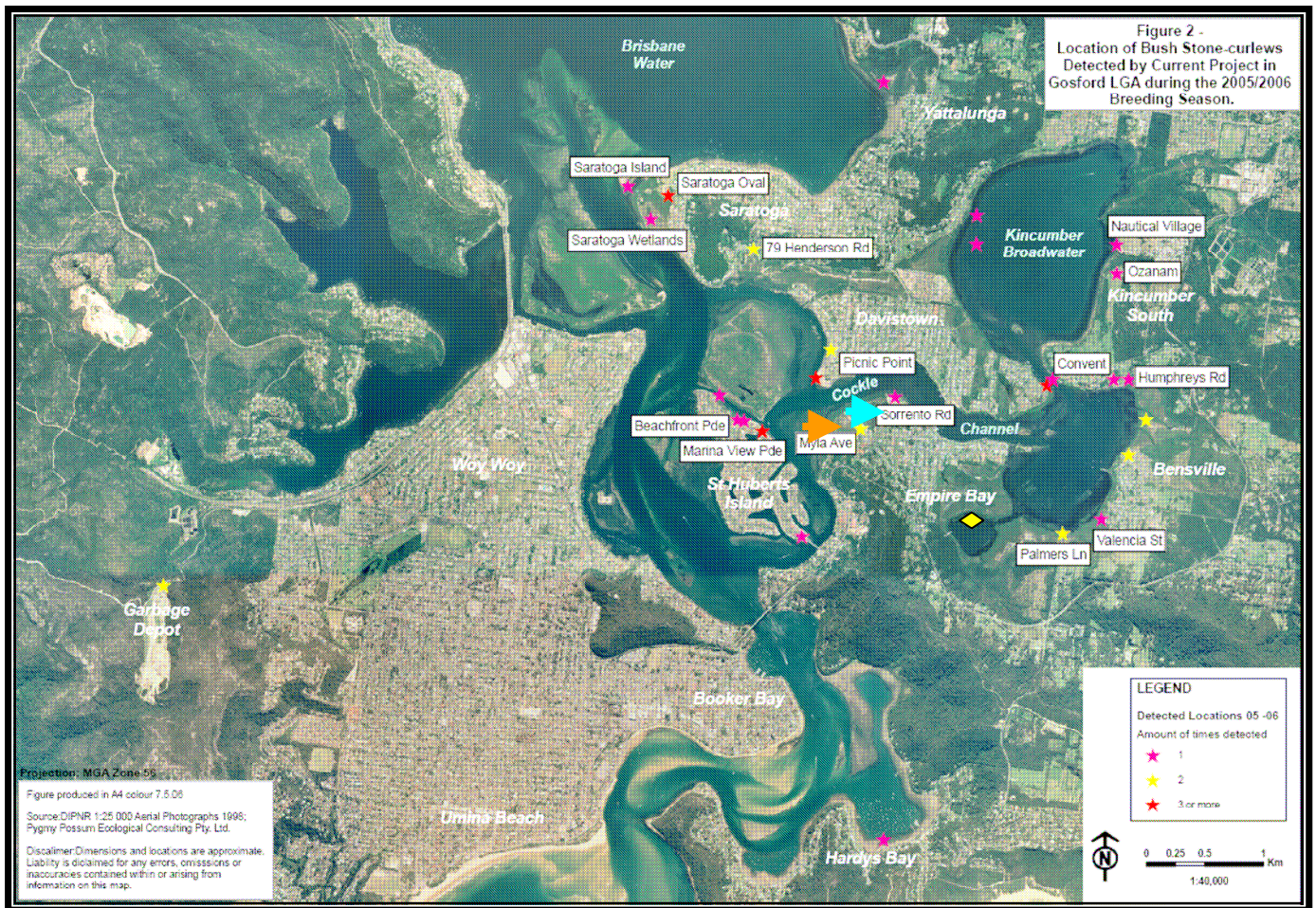
#### 4.2.1.1. Bush Stone-curlew (*Burhinus grallarius*)

The endemic Bush Stone-curlew's populations and geographic range have declined significantly in NSW mainly due to habitat modifications (Marchant & Higgins, 1993) hence its endangered category under NSW threatened species conservation (NSW DEC, 2006). It is considered rare east of the Great Dividing Range except for isolated populations (Marchant & Higgins, 1993) at Pittwater-Brisbane Water, Port Stephens-Pindimar, Valla-Coffs Harbour and Murwillimbah-Pottsville-Koala Beach (NSW DEC, 2006). South of Sydney they have been historically recorded in the Port Hacking area (Hindwood & Hoskin, 1954; Brooke, 1914) and they have been reported for Nowra, Narooma and Bermagui (NSW DEC, 2006). The Pittwater (Careel Bay) and Brisbane Water sites are the only known populations of the Bush Stone-curlew in estuarine habitats in the Sydney Basin Bioregion (after Thackway & Cresswell, 1995) though the above-mentioned Nowra population habitats are unspecified and may be estuarine.

Two recent detailed studies have surveyed and reviewed the Bush Stone-curlews in Brisbane Water (Morris, 2002b; Staines, 2006). The population estimates for Brisbane Water estuary vary from fourteen Bush Stone-curlews with 8-10 breeding pairs with a potential of at least 20 birds for the estuary (Morris, 2002b) to more recent surveys which found three known breeding pairs and four known individuals and another two possible additional individuals (Staines, 2006). In recent years Bush Stone-curlews may have declined at Brisbane Water as indicated by available data (Staines, 2006).

<sup>2</sup> Criteria used for this category include (a) Reduced area of occupancy &/or extent of occurrence; (b) Decline in abundance (c) Small populations (see Garnett & Crowley [2000] for details).





**Figure 10: Location of Bush Stone-curlew during the 2005-2006 surveys of Staines (2006).**

**Arrows indicate Bush Stone-curlew locations observed during early autumn surveys undertaken by this author. The apex of the yellow diamond is approximately the location of the observation of a single Black Bittern (Base image source: Figure 2, Staines, 2006)**

The habitats used by Bush Stone-curlews in Brisbane Water are Swamp Oak groves, saltmarsh and the ecotone of mangroves and saltmarsh and between the ecotone between saltmarsh and saltmarsh (Morris, 2002b). Bush Stone-curlews also utilise adjacent open habitats such as heavily grazed paddocks, playing fields, urban lawns, industrial sites and the open foreshore reserves and inter-tidal zones (Morris, 2002b). They roost during the day among fallen debris, mangrove roosts, among seaweed wrack, under low mangroves or other shrubs in open environments so that good visibility is maintained (Morris, 2002b). After dusk Bush Stone-curlews leave their day roost and forage in the open habitats mentioned above (Morris, 2002b).

During the autumn survey Bush Stone-curlews were observed at Empire Bay (Figure 10) initially as a pair at the edge of a Swamp Oak grove (blue arrow, Figure 10) (16/3/06), then they were observed as singletons separated by about 100m (20/3/06) where one was flushed from the saltmarsh among the cover of scattered mangroves (orange arrow) while the other was flushed from saltmarsh and stealthy retreated into the Swamp Oak grove (blue arrow). Similarly the pair was separated and one was flushed from the saltmarsh/mangrove mosaic as above, while the other was observed in the Swamp Oak grove (21/3/06). Quite clearly the pair of Bush Stone-curlews had separate daytime



roosts for two of the three days they were observed. Additionally the Swamp Oak and mosaic of saltmarsh/mangroves were used as daytime roosts and habitat to retreat to when disturbed.

Care was taken to minimise stress to the birds and their general locations were skirted to minimise disturbance when they were observed or landed after flushing. However it was noted that the Swamp Oak grove had a localised infestation of Asparagus Fern (*Asparagus aethiopicus*) that will undoubtedly expand in the Swamp Oak grove to the detriment of Bush Stone-curlews who would expectedly be adverse to this weeds dense ground coverage.

Morris (2002b) identifies potential habitat for future surveys that was later conducted by Staines (2006) and though several of those site were coincidentally surveyed during the autumn surveys, no additional Bush Stone-curlews were observed. However, an extensive saltmarsh on the western side of Erina Creek (E 348500; N 6299200, Gosford 1: 25000 map sheet) surveyed during the autumn has habitat attributes that would seemingly favour Bush Stone-curlews and it is recommended that that site be assessed in any future estuary wide survey of this endangered Australian wader.

The Bush Stone-curlew has been identified as a priority species for conservation actions in a review of NSW waders as its population is declining at an alarming rate and Brisbane Water estuary is recognised as significant as habitat for this endangered species (Smith, 1991).

#### 4.2.1.2. Little Tern (*Sterna albifrons*)

The endangered Little Tern migrates to eastern Australia to breed (Higgins & Davies, 1996) including breeding sites in the Sydney Basin e.g. The Entrance (Tuggerah Lakes) and Botany Bay (NSW NPWS, 2003). Little Terns are rarely recorded in Brisbane Water estuary with two record (02/1998) of two individuals (Figure 5; Appendix 4) (Morris unpublished data, 1997-2003) and another observation at Rileys Bay (1/04/2000) (Birds Australia, 2006). Little Terns are a rare but welcome visitor to Brisbane Water though this estuary would not be significant habitat for this species as exemplified by the lack of references to Brisbane Water in several important documents on this small tern (NSW NPWS, 2003; Keating & Jarmen, 2004; Smith, 1990).

#### 4.2.1.3. Black Bittern (*Ixobrychus flavicollis*)

The vulnerable Black Bittern habitats consist of both freshwater and estuarine littoral habitats usually in permanent wetlands fringed by dense vegetation (Marchant & Higgins, 1990). Coastal habitats include estuaries and the tidal reaches of creeks and rivers with mangroves (Marchant & Higgins, 1990). On available data there is only one Black Bittern record for Brisbane Water that was observed at Cockle Bay (Figure 10) (Cockle Bay NR) (23/03/2003) during the early autumn survey. That lone individual was crouched low at the edge of mangroves and adjacent mudflats where it would slowly move forward to search for prey on the mudflat and water edge and then slowly retreat among the pneumatophores and mangrove stems and foliage.

Black Bitterns nest in secluded places with densely vegetated wetlands with nests placed in leafy trees overhanging (Marchant & Higgins, 1990) or near water (Beruldsen, 2003).

#### 4.2.1.4. Black-tailed Godwit (*Limosa limosa*)

The vulnerable migratory Black-tailed Godwit habitats when in Australia are usually sheltered bays, estuaries and lagoons with large intertidal mudflats, sandflats, spits, banks and berms of mud, sand or shell grit though occasionally recorded on inland wetlands (Higgins & Davies, 1996). It forages on

the inter-tidal mudflats in soft mud or shallow water and sometimes forages among mangroves (Higgins & Davies, 1996). Black-tailed Godwits roost and loaf on low banks of mud, sand or shell grit, on bars, islets and beaches in sheltered areas and on sandflats behind mangroves, in unvegetated areas or on low vegetation such as saltmarsh (Higgins & Davies, 1996).

The Black-tailed Godwit has only been recorded once in Brisbane Water at Davistown (Magnolia Street swamp) where it stayed for almost one month (2/06/2001 to 30/06/2001) (Birds Australia, 2006) and would have to be considered rare in the estuary.

#### 4.2.1. 5. Broad-billed Sandpiper (*Limicola falcinellus*)

The vulnerable migratory Broad-billed Sandpiper has been documented for Brisbane Water (EPA, 1994) though there are no recent records. In coastal NSW from between Ballina to Shoalhaven Heads Broad-billed Sandpipers are considered a regular visitor but in small numbers (Higgins & Davies, 1996) with an estimated count of 10 individuals in mid-summer, although larger numbers were occasionally recorded (Smith, 1991).

Broad-billed Sandpiper habitats when in Australia are usually sheltered bays, estuaries and lagoons with large soft intertidal mudflats which may have shell or sandbanks nearby; they often prefer mud among or fringed by mangrove and sometimes in estuaries fringed by saltmarsh (Higgins & Davies, 1996). Broad-billed Sandpipers forage on exposed flats of soft mud, wet sand at edges of coastal and near coastal wetlands while they roost on banks of sheltered sand, shingle or shell beaches (Higgins & Davies, 1996). On available data this species is unlikely to be a frequent species in the Brisbane Water estuary.

#### 4.2.1.6. Lesser Sand Plover (*Charadrius mongolus*)

The vulnerable migratory Lesser Sand Plovers have been documented for Brisbane Water (EPA, 1994) and are recorded on a shingle beach at Empire Bay (Department of Environment & Planning, 1983) though there are no recent records for them in Brisbane Water and it would seem that this migratory wader is rare in this estuary. Generally this species is more common in northern NSW and become rarer further south (Marchant & Higgins, 1993).

Lesser Sand Plovers are usually coastal in littoral and estuarine environments and rarely use inland terrestrial wetlands (Marchant & Higgins, 1993). Coastal environments include sheltered bays, harbours and estuaries with large intertidal mudflats or sandflats and occasionally use sandy beaches, wave cut rock platforms and sometimes are in short saltmarsh and mangroves (Marchant & Higgins, 1993). Lesser Sand Plovers feed on freshly exposed intertidal flats of estuaries and beaches whilst they roost on beach sandbanks, spits and bars near feeding grounds (Marchant & Higgins, 1993).

#### 4.2.1.7. Osprey (*Pandion haliaetus*)

This vulnerable raptor occurs along the NSW coast with numbers declining further south (Marchant & Higgins, 1993) and is considered a very rare bird in the Sydney area (Hoskin, 1991) and Illawarra-Shoalhaven regions (Chafer *et al*, 1999). All known Osprey nests from between 1977-1998 were on the northern NSW north from Lake Macquarie (Clancy, 1991). In the Central Coast area most observations were recorded as singletons (Morris, 1975) with few records in Brisbane Water (e.g. 05/1991, Cockle Bay) (Morris, 1996). In 1996 an Osprey pair was observed year round in Brisbane Water predominately in the Broadwater, Cockle Bay and Saratoga areas (Morris *et al*, 1997). The pair attempted to nest at Kincumber Meadows between May and August 1996 but was unsuccessful

(Morris *et al*, 1997). Since that period there has only been one record for Daleys Point for August-September, 2000 (Morris, 2002a).

Though Ospreys prey upon small terrestrial vertebrates, seabirds and crabs (Marchant & Higgins, 1993) it mainly hunts fish (Clancy, 1991, 1995). This fishing raptor will most likely be observed in the Brisbane Water area again with the relative availability of prey items, and it is not impossible that it may attempt to breed again though no successful breeding has occurred in central and southern coastal NSW in recent years (Barrett *et al*, 2003).

The nest tree type at Kincumber was not documented however Ospreys traditionally return to the same nest tree providing it is still present and suitable (Clancy, 1991). Nest trees are mostly dead trees in NSW (Clancy, 1991) or they can use the dead crown of a live tree such as *Eucalyptus*, *Melaleuca*, *Angophora* and Hoop Pine (*Araucaria cunninghamia*) (Marchant & Higgins, 1993). Nests are near water usually within 1km from the shore of an estuary or river, though they will nest up to 40km from sea (Marchant & Higgins, 1993). Nests are also placed in mangroves, cliffs, rocks, islets and sometimes on rocky headlands and artificial structures such as jetties, towers, pylons (Marchant & Higgins, 1993) and rail bridges (pers. obs.).

#### 4.2.1.8. Pied Oystercatcher (*Haematopus longirostris*)

The vulnerable Pied Oystercatchers are frequently recorded in Brisbane Water estuary (Figure 5) but their numbers are never high compared to other flocking waders e.g. Bar-tailed Godwits (Figure 6) (Morris unpublished data, 1997-2003). Initial records document few birds (2 pairs at Woy Woy and 1 pair at Cockle Broadwater) (Morris, 1996) though numbers can fluctuate (e.g. 7 up to 22 individuals) (Appendix 4) (Morris unpublished data, 1997-2003) with the maximum count at 30 in 1988 at Saratoga (Smith, 1991). There have been estimates of 8 pairs in Brisbane Water estuary (Appendix 5) (Morris, 1999; 2002a).

Pied Oystercatchers have been recorded on mudflats (Kincumber Broadwater; Saratoga wetlands; Ettalong; Empire Bay; Blackwall Bay), estuarine waterbody mudflats (Wagstaff, Empire Bay) and roosts on oyster leases (Lintern Channel; Bensville). Other sites include Davistown (Alkoomie Close & Magnolia Street), Empire Bay (Palmer's Lane), St Hubert's Island, Ramsay Island (Woy Woy), Rileys Island NR, Rileys Bay and Cockle Bay (Empire Bay) (Birds Australia, 2006).

Breeding in southern Australia is typically from September to early January (Marchant & Higgins, 1993) with nesting recorded at Blackwall Bay on 19 September, 1998 (Woy Woy) (Appendix 5) (Morris, 1999). Nesting is a scrape on the ground which can be unlined or lined with shells, seaweed, dry seagrass, twigs, bark pieces leaves or grass clippings (Marchant & Higgins, 1993). Nest locations are on beaches, shores of tidal lagoons, estuaries and tidal creeks and on small islands (Marchant & Higgins, 1993).

#### 4.2.1.9. Sanderling (*Calidris alba*)

Sanderlings have been documented for Brisbane Water (EPA, 1994) though there are no recent records for them in Brisbane Water. During its visit in Australia the migratory Sanderling is almost always on the coast and mostly on open sandy beaches exposed to open sea-swell but also on exposed sandbars, spits and shingle banks (Higgins & Davies, 1996). It is less often on more sheltered sandy edges of estuaries, inlets and harbours and is rarely recorded on near-coastal wetlands such as lagoons, hypersaline lakes, salt ponds and saltmarsh (Higgins & Davies, 1996).

Foraging habitat includes sandy beaches, exposed sandflats at water's edge in wave-washed zone; it sometimes forages among seaweed wrack or edge of shallow pools on sand spits and nearby mudflats (Higgins & Davies, 1996). Roosts on bare sand, behind clumps of kelp wrack or in coastal dunes, rocky reefs and ledges and is known to shelter on tidal flats during storms (Higgins & Davies, 1996). The only authenticated records for Sanderlings on the Central Coast is an observation at Norah Head in December, 1989 on a coastal rock platform (Morris, 2003) and a count of 40 individuals at Tuggerah Lakes in 1983 (Smith, 1991). Though there is potential habitat for Sanderlings in Brisbane Water, its optimal habitat of wave-exposed beaches is limited and highly urbanised (Umina & Ettalong Beaches) however the estuarine habitats may provide respite (e.g. from inclement weather) during its passage further south and the return flight.

#### 4.2.1.10. Sooty Oystercatcher (*Haematopus fuliginosus*)

In southern Australia this endemic vulnerable wader prefers rocky coast lines and is most common on rocky shores, headlands, wave-cut platforms, rock stacks, reefs and outcrops with marine growth and rock pools and they use sand spits littered with wrack (Marchant & Higgins, 1993). Sometimes in sandy habitats especially beaches with rocky outcrops or near rocky promontories or mudflats and sheltered estuarine sand flats or sandbanks usually along or above high-tide line (Marchant & Higgins, 1993). Sooty Oystercatchers have been known to occasionally visit oyster leases at low tide that are about 2km from the ocean (Marchant & Higgins, 1993).

They breed and roost on off-shore islands and rock stacks often close to coast though they can sometimes breed on remote headlands, promontories and rocky outcrops (Marchant & Higgins, 1993). In Brisbane Water estuary there are two records of Sooty Oystercatcher with the first record of one individual at Davistown (Cockle Channel) (31/10/99) (Morris, 2002a) and the other observation is at Empire Bay (Palmer's Lane) (31/12/2002) (Birds Australia, 2006). Sooty Oystercatchers are mostly resident and maintain territories throughout year (Marchant & Higgins, 1993) though the paucity of records indicates that no territories are maintained in Brisbane Water. However, post-fledging Sooty Oystercatchers are known to disperse up to 50km distances (Marchant & Higgins, 1993) a distance within range of other Central Coast (e.g. Bateau Bay; Morris, 2003) and Sydney populations (e.g. Long Reef; Hoskin, 1991). Brisbane Water could not be considered core but is supplementary habitat for Sooty Oystercatchers.

#### 4.2.1.11. Terek Sandpiper (*Xenus cinereus*)

The migratory and vulnerable Terek Sandpiper is documented for Brisbane Water (EPA, 1994) and has been reported on mudflats on Rileys Island and to roost on saltmarsh (Department of Environment & Planning, 1983) however since then there has only been one other recent record. The Terek Sandpiper was at Davistown (Magnolia Street swamp) where it stayed for almost one month (1/12/2001 to 31/12/2001) (Birds Australia, 2006).

In NSW the Terek Sandpiper has a scattered distribution along the coast and mostly on intertidal mudflats in sheltered estuaries, embayments, harbours and lagoons where it uses islets, mud banks or sand banks and spits and is often around mangroves but is less often on sandy or shingle beaches or on rock reefs and platforms (Higgins & Davies, 1996).

Terek Sandpipers forage in open soft, wet intertidal mudflats especially near mangroves and occasionally in saltmarsh; they also forage occasionally on sandy beaches among seaweed and other wrack, while on rock platforms they will forage in the littoral zone (Higgins & Davies, 1996). Terek Sandpipers prefer to roost in or among mangroves and may perch in branches up to 2m from ground

or in the shade beneath them when it is hot; they also may roost in dead trees or among the tangle of driftwood (Higgins & Davies, 1996). Isolated banks of mangroves surrounded by water are used in Westernport Bay (Victoria) and elsewhere they may roost with other waders on flat shores, muddy spits, islets and banks (Higgins & Davies, 1996).

#### 4.2.2. Declining Species

An analysis of the differences in bird distribution between the first atlas (Blaker *et al*, 1994) and the new atlas reveals that at least fifteen species recorded in Brisbane Water estuary have declined nationally (Barrett *et al*, 2003) and include three species listed as vulnerable under NSW Threatened Species Conservation Act (Table 3). As expected for a wetland, the majority of these declining birds are waterbirds (67%) including shorebirds (6 migratory), large wading birds (2 species) and one medium wading bird species and one piscivore (Table 3). Five of the other declining birds are raptors including one species that includes fish in their diet (Table 3) (see Appendix 8).

**Table 3: Forest and waterbirds species from Brisbane Water estuary whose populations have declined nationally between the first (1977-81) and new atlases (Barrett *et al*, 2003; see this for statistical methods and assumptions) (V= vulnerable, NSW Threatened Species Conservation Act)**

| Common Name             | National                               | % Change | Sydney Basin          |
|-------------------------|--|----------|-----------------------|
| Black-tailed Godwit (v) | Declining (no regional variation)      | -35      | Not provided          |
| Pacific Golden Plover   | Declining (no regional variation)      | -33      | Not provided          |
| Terek Sandpiper (v)     | Declining (no regional variation)      | -29      | Not provided          |
| Curlew Sandpiper        | Declining (no regional variation)      | -26      | Not provided          |
| White-necked Heron      | Declining species (regional variation) | -58      | > 20% decrease        |
| Nankeen Kestrel         | Declining species (regional variation) | -44      | >20% decrease         |
| Brown Falcon            | Declining species (regional variation) | -38      | >20% decrease         |
| Lesser Sand Plover (v)  | Declining species (regional variation) | -37      | >20% decrease         |
| Great Cormorant         | Declining species (regional variation) | -31      | Not provided          |
| Wedge-tailed Eagle      | Declining species (regional variation) | -28      | >20% decrease         |
| Sharp-tailed Sandpiper  | Declining species (regional variation) | -24      | >20% decrease         |
| Nankeen Night Heron     | Declining species (regional variation) | -17      | Insufficient data     |
| Whistling Kite          | Declining species (regional variation) | -16      | > 20% decrease        |
| Little Eagle            | Declining species (regional variation) | -14      | No significant change |
| White-faced Heron       | Declining species (regional variation) | -13      | >20% decrease         |

There are at least twenty-eight species of bird recorded in the Brisbane Water estuary that have decreased (> 20%) within the Sydney Basin Bioregion between the first and new atlas sampling years (Appendix 8) (Barrett *et al*, 2002). At least twenty-five species from the Brisbane Water estuary have increased nationally during that same period though two of these species have declined in the Sydney Basin Bioregion (Appendix 8). Additionally there are forty-three species that have had no significant change between the first and new atlas however eighteen of these species have decreased (> 20%) within the Sydney Basin Bioregion (Appendix 8). It should be noted that for many species there is no data for its status nationally or in the Sydney Basin Bioregion (see Appendix 8).

### 4.2.3. Regionally Significant Species

In addition to the twenty-nine birds species that have declined in the Sydney Basin Bioregion (see above) there are several species in Brisbane Water estuary that could be considered regionally significant in the bioregion. These species and the reason why are profiled below.

#### 4.2.3.1. Brahminy Kite (*Haliastur indus*)

The Brahminy Kite is from Asia (extending to southern China) to Australia where it is widespread along the shores of northern Australia to coastal NSW (Marchant & Higgins, 1993). In Australia, Brahminy Kites main habitats are marine, estuarine and terrestrial wetlands and are usually associated with large sheets of open water though they range inland to sub-coastal districts (Marchant & Higgins, 1993). Specifically its habitats typically include inshore ocean waters, islands, beaches, rock platforms, sea-cliffs, estuaries, tidal reaches of rivers, mangrove swamps, *Melaleuca* swamps, saltmarsh and shrubby coastal dunes (Marchant & Higgins, 1993).

Breeding biology is poorly studied in Australia but it is known to regularly breed as far south as Coffs Harbour (Marchant & Higgins, 1993) though in 1966 it nested on the western side of Lake Illawarra (Chafer *et al*, 1999) but it is not noted if breeding was successful there. Brahminy Kite nesting habitats are located along creeks in mangrove and forest habitats up to 17km from coast but usually near water (Marchant & Higgins, 1993). Nests are placed on horizontal, sloping or vertical mangrove branches (*Avicennia*), tall trees (*Eucalyptus*, *Melaleuca*) among foliage of upper branches or dead branches (Marchant & Higgins, 1993).

Brahminy Kites are poorly known in the Sydney Basin Bioregion. There are several records in the Illawarra (last recorded 1996) where it is considered 'accidental' and reaches its southern geographic limit (Chafer *et al*, 1999). Hoskin (1991) notes that a Sydney specimen was painted by Watling in about 1790 and proposed that as it was given an Aboriginal name (inscription on painting) at that time it was 'sufficiently well known' to the local Aboriginal. In Brisbane Water it is considered a rare visitor where it was recorded in the Kincumber Broadwater (12/1993) (Morris, 1996) though there are no recent observations.

Brahminy Kites are considered regionally significant in Brisbane Water in the Sydney Basin Bioregion as they are a rare species near their geographic southern limit.

#### 4.2.3.2. Mangrove Gerygone (*Gerygone levigaster*)

Along the NSW coast Mangrove Gerygones are widespread but scattered where they reach their geographic southern limit in the Sydney Basin Bioregion at Botany Bay (Higgins & Peters, 2002). Mangrove Gerygones have expanded their range further south along the coast since the first record from Tweed Heads in 1942 (Higgins & Peters, 2002) and continuing south to the Manning River (Harrington) by at least the mid 1950's (Hindwood & McGill, 1956) to the Hunter estuary by 1967 (Morris, 1975) and eventually to Botany Bay by 1982 (Hoskin, 1991).

Throughout their range Mangrove Gerygones generally inhabit mangroves along watercourses and estuaries though they do use adjacent habitats with suggestions they expand out of mangroves in search of food during the breeding season (Higgins & Peters, 2002). Mangrove Gerygones can breed in any month but in eastern Australia they breed mostly in spring-summer with the nest usually placed in mangroves and less often in paperbarks (Higgins & Peters, 2002). Its nest is a dome-shaped

woven structure constructed from dry seaweed, dry grass and bark lined with feathers suspended from a mangrove branch (Beruldsen, 2003).

In Brisbane Water, Mangrove Gerygones were initially documented from Saratoga and Carawah Bay however there were no records of it during 1995, 1996 and in 1997 (Appendix 5) (Morris, 1996, 1998; Morris *et al*, 1997). Two individuals were subsequently recorded at the Cockle Channel (1/3/1998) but not noted in July 1998 (Morris, 1999), and two were observed at Brickwharf Road at Woy Woy (4/10/1999) (Morris, 2000) with two at Saratoga on 2/02/2000, 24/06/2000 and 2/12/2000; one was also observed at St Hubert's Island (23/07/2000) (Morris, 2002a).

During the early autumn surveys it was recorded in mangroves at Erina (near Gosford City Council depot), Saratoga wetlands, Davistown, Rileys Island, Empire Bay, Cockle Bay NR, and Bensville. Additional records are noted for Saratoga wetlands, Cockle Bay NR, St Hubert's Island, Riley Island NR, Davistown (Alkoomie Close) and Empire Bay (Palmer's Lane) (Birds Australia, 2006).

Mangrove Gerygones are considered regionally significant in Brisbane Water in the Sydney Basin Bioregion as they are close to their southern geographic limit.

#### 4.2.3.3. Brown Honeyeater (*Lichmera indistincta*)

Brown Honeyeaters are widespread across northern and south-western Australia however their distribution is more restricted in eastern Australia (see map Higgins *et al*, 2001). Brown Honeyeaters are widespread east of Great Dividing Range in north-eastern NSW (north of the Hunter Region) and documented on the northern tablelands and north western slopes (Higgins *et al*, 2001). Though recorded in small numbers in Sydney, it is said to rarely occur between Lake Macquarie and Parramatta River (Higgins *et al*, 2001).

With a wide geographic range the Brown Honeyeater habitats are diverse though its estuarine habitats have been described as mangrove forests near or merging into forest such as those dominated by Banksia or paperbarks (Higgins *et al*, 2001) and Swamp Oak forest (author pers. obs.). Elsewhere in the Sydney Basin it has been recorded in mangrove habitats at Homebush (Straw, 1996) and Kurnell (Hoskin, 1991) and in suburban garden at Thirroul where it reaches its southern geographic limit (Chafer *et al*, 1999). In the Brisbane Water estuary it was observed in mangroves at Davistown (Magnolia Street swamp, 29/10/2000) (Morris, 2002a) (Birds Australia, 2006).

Brown Honeyeaters are considered regionally significant in Brisbane Water in the Sydney Basin Bioregion as they are close to their southern geographic limit.

#### **4.2.4. Species Recognised in International Treaties**

Australia is signature to bilateral agreements with Japan (JAMBA, 1981) and China (CAMBA 1988) that has expressed aims to conserve migratory birds and their environment. Brisbane Water estuary is habitat for at least twenty-six JAMBA and twenty-four CAMBA listed species (Appendix 6).



## 4.3. Management Issues

The key management issues for the estuarine bird assemblage in Brisbane Water include:

- Disturbance
- Predation
- Climate Change
- Weed invasion
- Estuarine vegetation dynamics
- Oyster leases & jetties
- Bird Flu

### 4.3.1. Disturbance

The following section will not include a detailed analysis of habitat disturbance and the bird assemblage present but some general comment of disturbance to habitats observed in the field during the autumn survey. The following section also includes general comments on disturbance to the birds present by people, their pets and watercraft.

Of the extant estuarine habitats, saltmarsh seems the most vulnerable to habitat perturbations resulting in loss of biomass and substrate damage. Saltmarsh at Cockle Bay NR (west of Palmers Lane, Empire Bay), north of Bensville and Davistown had been damaged by 4WD, off-road motorbikes and pushbikes. The damage included ruts and severely churned substrate (from ‘doing donuts’) with damaged or destroyed Beaded Glasswort. Since the damage at Cockle Bay the site has been fenced and seems to be regenerating and no recent damage was apparent during the autumn surveys.

The saltmarsh-mangrove-Swamp Forest (Swamp Oak/*Melaleuca nodosa*) habitat configuration at Bensville proved suitable habitat for the endangered Bush Stone-Curlews (Staines, 2006; see Figure 10; 2<sup>nd</sup> yellow star north of the “Bensville” annotation). However the saltmarsh was damaged by motorbikes fairly recently but not in the immediate weeks prior to the survey (i.e. not ‘freshly damaged’). At the time of the autumn survey it seems that the disturbance at Bensville is not a frequent event (probably one visit) and it is expected that any Bush Stone-Curlew present would have fled (see also predation per this site). The Davistown saltmarshes have had indication of damage by motorised vehicles and are more frequently disturbed by push-bike activity.

Any immediate to long-term effects from saltmarsh habitat damage to the bird assemblage is unknown. It is expected that vehicle/motorbike/push-bike disturbance frequency will have a more immediate impact on bird biology by either disruption to activities while the disturbance is happening or how frequency can affect habitat regeneration i.e. continued frequent disturbance may damage regenerating species.

Pedestrian and pet walking activities disturbing avifauna has been identified as a concern in regard to waterbird management (Smith, 1991; Gill *et al*, 2001; Priest *et al*, 2002; Thomas *et al*, 2003; Burger *et al*, 2004; Rohweder, 2004; 2003b). It has been suggested that continual disturbance of waders may limit their food intake affecting their fat reserves that are needed during their lengthy return to Palearctic breeding areas (Smith, 1991).

The few studies assessing the impacts of human disturbance on waders report that the number and activity of people significantly reduce foraging times in particular the presence of free-running dogs (Thomas *et al*, 2003), and birds avoid areas with large numbers of people (Owner & Rohweder,

2003) or forage at night avoiding the normally busy beaches during the day (Rohweder & Baverstock, 1996). Some species such as the Eastern Curlew are sensitive to disturbance (Thompson, 1993). However some studies report no significant impact from human disturbance on the abundance or distribution of their study species (Gill *et al*, 2001; Owner & Rohweder, 2003).

No systematic study of pedestrian/pet walking activity and its impact on birds has been undertaken at Brisbane Water though during the autumn survey many observations of this affect were noted. Waders responded variously to disturbance. Pedestrian activity (including walking dogs) along foreshore reserves would not always elicit a negative response (stop foraging or take to the wing) but generally when people were in close proximity they would not forage, run along the mudflat, or take to the wing. Dogs on leash would inevitably run-along the mudflats or at waters-edge which would disrupt feeding and they would take to the wing.

Watercraft activities have been known to disrupt waterbirds affecting them when they are flightless during moult, when they are foraging and when they loaf (Hindle, 2005; Straw, 2003a; Keating & Pegler, 2003; Rodgers & Schwikert, 2002). Boats travelling on a fixed course at slow speed don't typically disturb waders and boats travelling at speed but at distance may not have much affect on birds (Straw, 2003a). In contrast, watercraft travelling at speed (erratically) can have a bigger impact on birds with a particular concern of jet skis that can travel in shallow water (Straw, 2003a) although there is no empirical evidence for these effects.

Casual observation during the survey indicated that the effects of passage of watercraft would vary with the speed of the vessel; birds either ignore the passing vessel or stop foraging and scurry from the boat wake as it washes over the mudflats. The frequency and extent of the disruption is unknown for Brisbane Water.

#### 4.3.2. Predation

The predation by feral and domestic animals is considered a threat to avifauna with at least 186 species eaten by cats including waterbirds and seabirds (Paton, 1993; Olsen *et al*, 2006). Predation by cats (*Felis catus*) and foxes (*Vulpes vulpes*) has been identified as a threat for the Near Threatened Lewins Rails (Garnett & Crowley, 2000) and foxes are known to kill adult and juvenile Bush Stone-curlews (NSW DEC, 2006). The declining White-necked Heron (see above) and ground dwelling Brown Quail have been identified in the stomach contents of cats (Croft & Hone, 1978). Domestic animals are also known to hunt native birds and damage nests of ground nesting including Bush Stone-Curlews (Paton & Rogers, 2006; Meek, 1999). Free-roaming domestic dogs have been recorded to go on 8-30km forays (Meek, 1999).

In addition to dogs with owners walking the foreshore (see above) dog prints were observed on mudflats and saltmarsh unaccompanied by human prints. A Red Fox was observed in the saltmarsh at Bensville where Bush Stone-curlews were recorded (see above re disturbed saltmarsh). A dead partially eaten White-faced Heron was observed at Davistown along a drainage line with mangroves in saltmarsh. The proximity of estuarine and urban habitats provides productive habitats for Red Foxes and a source of domesticated predators which is a major concern for wetland birdlife (Olsen & Weston, 2004).

#### 4.3.3. Climate Change

Climate change has been identified as a threat to biodiversity (Hobbs, 1992; Saunders *et al*, 1996; Lindenmayer & Burgman, 2005) with coastal habitats vulnerable (Hughes, 2003). Climate change

has been identified as a major threat to wetland birds due to changed rainfall and sea levels (Olsen & Weston, 2004). Kench (1999) considers sea level to be '*the ultimate control on position of estuaries*' and thus any changes in sea level that result from climate change will affect the geomorphological processes and the spatial configuration Quaternary habitats of the estuary e.g. mudflats.

Climate change and the potential impacts on the avifauna is recognised in Australia as an issue (Olsen & Weston, 2004; Olsen *et al*, 2003) and there has been little discussion or modelling on its impact on Australian wetland birds. For example, from a recent migratory wader conference proceeding of 27 papers (Straw, 2004) there was no modelling or empirical studies and only one paper that cites climate change as an issue for wader conservation (Priest, 2004). Modelling from Europe suggests that Arctic breeding waders will face reduction in their breeding distributions that will be shifted poleward resulting in them migrating further south to their non-breeding wintering grounds (Huntley *et al*, 2006). A recent Australian paper identifies potential impacts of climate change that include:

- a) Changes in the distribution of species both latitudinal and altitudinal
- b) Changed movement pattern
- c) Changes in abundances of species, including some local extinctions
- d) Changes in phenology
- e) Changes in community composition
- f) Changes in physiology, morphology & behaviour (Chambers *et al*, 2005).

While all these affects may not be applicable to the estuarine birds of Brisbane Water, some issues may be pertinent. Predicted rises in sea level will affect coastal nesting birds, birds in coastal wetlands and estuaries that may become inundated by sea levels rises (Chambers *et al*, 2005) including their coastal staging points in their trans-equatorial migration (Huntley *et al*, 2006).

There is evidence already that long-distance migrants have changed their arrival and departure dates (Beaumont *et al*, 2006). Changes in climate and ocean are proposed as cause for extended breeding periods for some seabirds (e.g. Pied Cormorant, *Phalacrocorax varius*; Silver Gulls) (Chambers *et al*, 2005). Community composition changes may occur with expansion and contraction of geographic range and associated changes in species interactions (Chambers *et al*, 2005); e.g. Silver Gull aggression (Smith, 1995). The expansion of a northern species Beach Stone Curlew (*Esacus neglectus*) further south and the temperate Hooded Plover (*Thinornis rubricollis*) that has contracted further south are the types of changes predicted under climate change (Chambers *et al*, 2005). It has been proposed that some coastal invertebrate species fecundity, spawning success and recruitment will be disrupted by climate change and this will have significant implications for over-wintering migratory birds (Lawrence & Soame, 2004).

In the uncertain future facing coastal wetland habitats under global climate change it is expected that Brisbane Water estuary will provide some functional role in supporting estuarine birds.

#### 4.3.4. Weed Invasion

An appraisal of weed invasion of the estuarine habitats is beyond the scope of this report however, as suggested above (section 4.2.1.1.), weed invasion is likely to affect some species (Olsen *et al*, 2006).

#### 4.3.5. Estuarine Vegetation Dynamics

Estuarine vegetation dynamics are complex processes involving interplay of tidal inundation, ocean currents, evaporation, rainfall, substrate, competition, available flora, salinity, elevation,

sedimentation, deposition and seed predation (Adam, 1994; Harty, 1994; Morrissey, 1995a, b; Clarke & Kerrigan, 2002). Like similar subtropical and temperate habitats elsewhere in Australia, Brisbane Water estuarine ecosystems of swamp forest, saltmarsh, mangroves and seagrasses have generally declined in extent since European occupation (Adams, 1994; Harty & Cheng, 2003; Bowen *et al*, 1996). Additionally, many remaining areas of these habitats have declined in condition but to what extent is generally poorly understood (Bowen *et al*, 1996)

Some coastal ecologists have proposed that temperate mangrove-saltmarsh dynamics have been disrupted and provide evidence for the decrease in saltmarsh area due to mangrove colonisation (Saintilan & Williams, 1999; Saintilan, 2003; Harty & Cheng, 2003). The possible reasons for mangrove expansion include increased precipitation decreasing saltmarsh salinity that favour mangroves, agricultural practices, altered tide regimes due to estuary management practices (e.g. training walls, dredging), altered sedimentation and nutrient regimes, land subsidence due to mining and sea level rises (Saintilan & Williams, 1999) with some evidence for it occurring in NSW (70mm rise at Fort Denison datum from 1940-2000) (Straw & Saintilan, 2004). Additional siltation and nutrients have also facilitated mangrove colonisation of tidal flats (Straw & Saintilan, 2004; Harty & Cheng, 2004). It has been predicted that increases in sea-levels and ongoing high siltation rates there will be continued mangrove expansion landward and seaward in NSW (Straw & Saintilan, 2004).

The shift of mangrove into saltmarsh and tidal flats has been deplored as deleterious to wader habitat for species that roost on the ground or forage on mudflats as woody mangroves provide cover for predators and the waders spend additional time being vigilante and less time foraging (Saintilan, 2003; Straw & Saintilan, 2004). In Brisbane Water estuary the colonisation of mangroves into saltmarsh has been identified as a possible future threat to Bush Stone-curlews that generally prefer extensive saltmarsh patches (Morris, 2002b).

The invasion of mangroves into saltmarsh is not ubiquitous and some saltmarshes-mangrove boundaries have remained stable (Saintilan & Williams, 1999) but the extent of the stability or invasion has not been quantified (or not sourced by the author) in Brisbane Water though it has been observed (Roberts & Sainty, 2006) and reported to occur at Saratoga, Davistown and Empire Bay (Harty & Cheng, 2003). Though unquantified from the autumn bird survey it would also seem that the colonisation process has also occurred at Bensville, however at Cockle Bay and Erina Creek (western site) the saltmarsh is still extensive and the occurrence of young mangroves landward from the channel is negligible or localised suggesting 'stability.'

The management issue here is what, if anything, can be done about the colonisation processes of mangroves in Brisbane Water? To ameliorate the impact of mangrove colonisation and to 'improve' wader habitat, mangroves have been removed in Australia (Straw & Saintilan, 2004) and overseas e.g. Singapore (Prietto & Young, 2004). Mangroves however are protected by the NSW Fisheries Management Act (FM Act) (1994) and permission is needed under that Act to prune, remove, transplant or smother mangroves and is not permissible in SEPP 14 wetlands (MacDonald, 2003).

The autumn survey was not at a fine enough scale to discern (see methods per definition of mangrove and saltmarsh) any trends to the bird assemblages from mangrove colonisation of saltmarsh. The high tide saltmarsh surveys only recorded a few migratory waders in that habitat however that could also be a temporal limitation as the surveys were conducted within a two week envelope in autumn. Surveys during high water spring tides may better improve our understanding of migratory waders' use of saltmarsh as some species are known to forage or roost in that habitat (see section 4.2.1. & Appendix 7).

None-the-less, the saltmarsh in its existing condition provides habitat for Sharp-tailed Sandpiper (*Calidris acuminata*) an infrequently recorded species in Brisbane Water. Furthermore, several other species documented in the literature would use saltmarsh (Appendix 7) although data sets are mostly not habitat specific (e.g. Birds Australia, 2006) to validate the role of saltmarsh as bird habitat in Brisbane Water estuary. Additionally the saltmarsh is known habitat for the endangered Bush Stone-curlew including several sites colonised by mangroves (Bensville, Empire Bay, Saratoga wetlands) (see Figure 10).

#### 4.3.6. Oyster Leases & Jetties

This survey did not target oyster leases despite the fact that they and jetties are extensive artificial habitats in Brisbane Water. There are at least seventeen bird species observed using oyster leases as roosting habitat including threatened Pied Oystercatchers and several migratory waders (Appendix 1). To the author's knowledge there are no empirical studies on the effects of oyster leases on the physical or biological attributes within Australian estuaries though several waders have been reported to roost on oyster leases, while many have not (section 4.2.1.; Appendix 7) (Marchant and Higgins, 1993; Higgins & Davies, 1996).

Studies overseas report significant changes in the macrofaunal community under oyster leases than adjacent uncultivated areas and are associated with increases in organic and silt composition and the reduction in the depth of oxygenated layers below the oyster leases (Nugues *et al*, 1996). Another study reported there was no increase in organic enrichment due to the dissipative tidal environment but the macrofaunal assemblage changed in species composition and numerical abundance in the laneways used by oyster workers compared to control sites (De Grave *et al*, 1998). The environmental effects of oyster cultivation are more severe in areas of large scale (hectares) cultivation (Nugues *et al*, 1996).

A study in America compared the waterbirds in oyster beds and adjacent tidal flats. It was found that seven of thirteen waders were more abundant on oyster beds while one plover was more abundant in control sites (Connolly & Colwell, 2005). Generally the community composition was similar in oyster beds and control sites but diversity ( $H'$ ) was greater on oyster beds (Connolly & Colwell, 2005). Most species' foraging behaviour were not negatively affected by oyster beds but the causes for the increase may in the long-term trigger impacts on other trophic levels (Connolly & Colwell, 2005).

It is important that consideration be given to the environmental effects of oyster leases on estuarine habitats in Brisbane Water. Any industry restructure needs to carefully consider the impacts of availability of bird roosts when decommissioning or developing new leases that may have an affect on bird populations including threatened species.

## 5.0. Conclusions

Brisbane Water estuary has been recognised as a wetland of national significance (Environment Australia, 2001) and this limited survey and review clearly support that notion. The estuarine bird assemblages consisted of at least twelve functional/taxonomic groups that included a suite of wetland birds (waterfowl, piscivores, large and medium wading birds, waders and omnivore-scavenger) and species usually associated with terrestrial habitats (carnivores including diurnal raptors, insectivore, aerial insectivore, insectivore-nectarivores and seedeaters). A total of 110 species were identified in Brisbane Water estuarine habitats.

There are eleven documented threatened species that use Brisbane Water habitats including two endemic threatened species whose populations are supported by the array of saltmarsh, mangroves and mudflats. Brisbane Water estuary is on the route of East Asian-Australasian Flyway that is used by twenty-one trans-equatorial migratory waders though several have not been recorded in recent times while other waders use the habitats infrequently. One species of migratory wader that regularly uses the habitats in Brisbane Water has a global population that is considered “Near Threatened”. The Brisbane Water estuarine bird assemblages included fifteen species that have declined nationally and twenty-eight species that have declined in the Sydney Basin Bioregion. Furthermore three species that reach their southern geographic limit in the Sydney Basin Bioregion have been known to use Brisbane Water habitats.

Though Brisbane Water estuarine habitats have been severely altered due to the intense urbanisation within its catchment, it still provides valuable bird habitat for resident, transient and migratory species. If birds from near and far are to persist into the next millennia in Brisbane Water estuary then more consideration and pro-active management needs to be undertaken involving multiple stakeholders and the wider community.

## 6.0. Management Considerations & Recommendations

### 6.1. Council Zoning & Planning

Local government has an important role in bird conservation especially in relation to wader conservation in estuaries. Priest *et al* (2002) identify the following steps that local government could undertake to improve bird [wader] conservation:

1. Identification of important shorebird sites in your jurisdiction
2. Incorporate shorebirds into planning
3. Use of regulatory tools such as zoning regulations and dog control acts to protect shorebirds and their habitat
4. Increase stakeholder involvement & develop partnerships (see education below)
5. Minimise disturbance (see education below)

**Bird sites:** This report and previous studies (e.g. see Figures 2 and 10) are an important initial step in identifying sites and habitats used by waterbirds though further research is needed (see below).

**Birds & planning:** A review of the LEP in relation to estuarine bird management is beyond the scope of this report however it is crucial that estuarine habitats including Swamp Forest are protected from development e.g. urban run-off.

Regulatory tools: It is crucial that public areas adjacent to foreshore tidal flats are zoned as “dogs on leash zones” (if not already zoned as such). Key area areas identified in this report include:

- Pathway at Saratoga (Henderson Road; Mimosa Avenue),
- Davistown (Lintern Street wharf; Illoura Reserve near boat ramp)
- Hardy Bay & Pretty Beach
- Woy Woy
- Ettalong Beach

Additional areas may be identified at a latter date after further research (see below)

## **6.2. Education**

### **6.2.1. Estuarine Bird Ecology**

An education programme needs to be developed that informs residents and visitors on general water bird ecology and biology emphasising the habitats of threatened and migratory species. In this regard the continued support of the Friends of the Bush Stone-curlew will be useful to maintain interest for this dedicated band of volunteers. Gosford City Council’s waterbird habitat education program that uses interpretation signage at Carawah Reserve could be expanded to include areas that have high regular visitation such as:

- Pathway at Saratoga (Henderson Road; Mimosa Avenue),
- Davistown (Lintern Street wharf; Illoura Reserve near boat ramp)
- Hardy Bay & Pretty Beach
- Woy Woy
- Ettalong Beach

In addition to signage it may be valuable to have an ornithologist in conjunction with Gosford Bushcare give tours at selected sites as part of ongoing education programmes. Additional information could be placed in the Bushcare Newsletter; for example, profiling select bird species.

### **6.2.2. Disturbance by People, Pets and Watercraft**

In conjunction with the above programme, there needs to be an education programme targeting pedestrians, dog-walkers, pet owners and watercraft users about the possible impacts of their activities on the estuarine bird assemblage, especially waders. The sites targeted for pedestrians could include those suggested above.

Pet owners need to be informed on the deleterious impacts that dogs can have on estuarine birds and can be targeted by signage (as above), pamphlets when registering dogs or given with rates notices. Press releases in spring and early autumn after migratory birds arrive or soon to depart would also be beneficial to impart information to a wider audience.

Watercraft users need to be informed on the possible impacts of their activities and could be targeted with signage near boat ramps and by pamphlets at bait suppliers and NSW Maritime offices. It has been suggested that the best way to protect birds from watercraft is to impose:

- A speed limit of four knots within 100m (or 200m for jet skis) of feeding birds and/or
- Exclusion zones (Straw, 2003a).



These distances may not be feasible for some of the narrow channels of Brisbane Water estuary however additional research is needed to identify how much of an issue and where watercraft disturbance occurs within the estuary (see future research below).

If conducted effectively, waterbird education programmes that include a range of media can be beneficial in changing behaviour and lessening the detrimental effects that people (& their pets) can have on bird life (Burger *et al*, 2004; Straw, 2003b; Priest *et al*, 2002).

In addition to an education programme, Council Rangers need to be vigilant in enforcing dogs-on-leash regulations in applicable zones adjacent to Brisbane Water estuary. NSW Maritime staff need to enforce speeds of watercraft.

### 6.2.3. Bird Influenza

It is recommended that Council Environmental officers, Building & Health inspectors and council public liaison staff be kept informed on the relationship between estuarine birds and bird influenza. This may be necessary if the above-mentioned education programme is implemented. To further inform council staff on this issue there is a recent paper by Tracey *et al* (2004) and a website link is provided below:

*Birds Australia Statement re Bird Influenza*

[http://www.birdsaustralia.com.au/downloads/BA\\_statement\\_avainflu\\_jun06.pdf](http://www.birdsaustralia.com.au/downloads/BA_statement_avainflu_jun06.pdf)

## 6.3. Predation: Pets and Ferals

Council have been proactive and have developed a fox control programme around estuarine habitats at Saratoga (Staines, 2006). It is recommended that Council continue to expand this programme in conjunction with NSW DEC staff for lands under their stewardship (See above re pets and owner education).

## 6.4. Future Research

### 6.4.1. People (pedestrians/watercraft) & Pet Disturbance Assessment

It would be valuable to undertake research into disturbance by people and determine the extent of disruption to feeding, loafing and roosting behaviour by waterbirds (especially shorebirds). This research would best be conducted prior to developing expensive education programmes (e.g. signage) or zone planning. If such education and planning programmes are developed then it would also be valuable to re-survey the disturbance effects (using same methodology as pre-survey) to assess if the management strategies were effective. See Dodge *et al*, (2004) for an example. The survey should be conducted but not limited to summer and include holiday periods, non-holiday periods, weekends and weekdays.

#### **6.4.2. Roosting sites including artificial site such as oyster leases**

The high-tide roosting sites in Brisbane Water are not completely known including natural and artificial roots such as oyster leases. This survey should at least be conducted between spring-autumn and could include a combination of boat and land-based observation points.

#### **6.4.3. The environmental effects of oyster leases**

The environmental effects of oyster leases are poorly understood though they are likely to affect estuarine birds. It is crucial that research be undertaken to facilitate ecologically sustainable management of this important commercial aquaculture.

#### **6.4.4. Bird movement around the estuary**

After completing the autumn survey one dynamic aspect of the estuary is the differences in the tides from near the entrance to Gosford. Delays in exposure of tidal flats ensure that the bird habitat resource has a complex temporal and spatial dynamic in Brisbane Water. It would be beneficial to undertake research that clarifies this dynamic.

#### **6.4.5. Saltmarsh as bird habitat**

A vastly improved knowledge of the estuarine birds would be gained with additional surveys in the saltmarsh-mangrove-mudflats habitats undertaken in other seasons. The autumn saltmarsh survey though providing an insight into saltmarsh bird assemblage is deemed temporarily inadequate and it is recommended that additional surveys be undertaken that are planned to coincide when the highest tides are predicted. It should also include replicated sampling in all seasons.

#### **6.4.6. Survey targeted habitats: Swamp Forest & Rocky Shores**

There is every indication that Swamp Forests are valuable habitats in the estuary yet there have been no systematic surveys (flora or birds) to develop an adequate information base that can assist in their management. This habitat is often the interface between development and the estuarine habitats, are used by the threatened species, are an endangered ecological community and are habitat for birds (especially passerines) yet little is known about their extent, condition and biota.

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## 8.0. Appendices

## Appendix 1

List of birds using Brisbane Water estuarine habitats (this survey; Morris, 1975; 2003, 2002, 2000, 1999, 1998, 1996; Morris *et al*, 1997; Department of Environment and Planning, 1983; EPA, 1994; O'Toole cited Warman, 2004; Birds Australia, 2006). OL = recorded on oyster lease NB Excludes forest bird except for diurnal raptors and forest birds recorded in the targeted estuarine habitats (mudflats, mangroves & saltmarsh)

| Order             | Family            | Scientific Name                    | Common Name                | Major taxonomic/functional group |
|-------------------|-------------------|------------------------------------|----------------------------|----------------------------------|
| Galliformes       |                   |                                    |                            |                                  |
|                   | Phasianidae       | <i>Coturnix ypsilophora</i>        | Brown Quail                | Omnivore                         |
| Anseriformes      |                   |                                    |                            |                                  |
|                   | Anatidae          | <i>Biziura lobata</i>              | Musk Duck                  | Waterfowl                        |
|                   | Anatidae          | <i>Cygnus atratus</i>              | Black Swan                 | Waterfowl                        |
|                   | Anatidae          | <i>Chenonetta jubata</i>           | Australian Wood Duck       | Waterfowl                        |
|                   | Anatidae          | <i>Anas platyrhynchos</i> *        | Mallard                    | Waterfowl                        |
|                   | Anatidae          | <i>Anas superciliosa</i>           | Pacific Black Duck         | Waterfowl                        |
|                   | Anatidae          | <i>Anas rhynchotis</i>             | Australasian Shoveler      |                                  |
|                   | Anatidae          | <i>Anas gracilis</i>               | Grey Teal                  | Waterfowl                        |
|                   | Anatidae          | <i>Anas castanea</i>               | Chestnut Teal (OL)         | Waterfowl                        |
| Podicipediformes  |                   |                                    |                            |                                  |
|                   | Podicipedae       | <i>Poliocephalus poliocephalus</i> | Horay-headed Grebe         | Insectivore                      |
| Sphenisciformes   |                   |                                    |                            |                                  |
|                   | Spheniscidae      | <i>Eudyptes pachyrrhynchus</i>     | Fiordland Penguin          | Piscivore                        |
|                   | Spheniscidae      | <i>Eudyptula minor</i>             | Little Penguin             | Piscivore                        |
| Procellariiformes |                   |                                    |                            |                                  |
|                   | Procellariidae    | <i>Puffinus tenuirostris</i>       | Short-tailed Shearwater    | Piscivore                        |
| Pelecaniformes    |                   |                                    |                            |                                  |
|                   | Sulidae           | <i>Morus serrator</i>              | Australasian Gannet        | Piscivore                        |
|                   | Anhingidae        | <i>Anhinga melanogaster</i>        | Darter (OL)                | Piscivore                        |
|                   | Phalacrocoracidae | <i>Phalacrocorax melanoleucos</i>  | Little Pied Cormorant (OL) | Piscivore                        |
|                   | Phalacrocoracidae | <i>Phalacrocorax varius</i>        | Pied Cormorant             | Piscivore                        |
|                   | Phalacrocoracidae | <i>Phalacrocorax sulcirostris</i>  | Little Black Cormorant     | Piscivore                        |
|                   | Phalacrocoracidae | <i>Phalacrocorax carbo</i>         | Great Cormorant            | Piscivore                        |
|                   | Pelecanidae       | <i>Pelecanus conspicillatus</i>    | Australian Pelican (OL)    | Piscivore                        |
| Ciconiiformes     |                   |                                    |                            |                                  |
|                   | Areidae           | <i>Egretta novaehollandiae</i>     | White-faced Heron (OL)     | Large Wading Bird                |
|                   | Areidae           | <i>Egretta garzetta</i>            | Little Egret               | Large Wading Bird                |
|                   | Areidae           | <i>Ardea pacifica</i>              | White-necked Heron         | Large Wading Bird                |
|                   | Areidae           | <i>Ardea alba</i>                  | Great Egret (OL)           | Large Wading Bird                |
|                   | Areidae           | <i>Ardea ibis</i>                  | Cattle Egret               | Large Wading Bird                |
|                   | Areidae           | <i>Butorides striatus</i>          | Striated Heron (OL)        | Medium Wading Bird               |
|                   | Areidae           | <i>Nycticorax caledonicus</i>      | Nankeen Night Heron        | Medium Wading Bird               |
|                   | Areidae           | <i>Ixobrychus flavicollis</i>      | Black Bittern              | Medium Wading Bird               |
|                   | Threskiornithidae | <i>Threskiornis molucca</i>        | Australian White Ibis      | Large Wading Bird                |
|                   | Threskiornithidae | <i>Threskiornis spinicollis</i>    | Straw-necked Ibis          | Large Wading Bird                |
|                   | Threskiornithidae | <i>Platelea regia</i>              | Royal Spoonbill            | Large Wading Bird                |
| Falconiformes     |                   |                                    |                            |                                  |
|                   | Accipitridae      | <i>Pandion haliaetus</i>           | Osprey                     | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Aviceda subcristata</i>         | Pacific Baza               | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Elanus axillaris</i>            | Black-shouldered Kite      | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Haliastur sphenurus</i>         | Whistling Kite             | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Haliastur indus</i>             | Brahminy Kite              | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Haliaeetus leucogaster</i>      | White-bellied Sea-Eagle    | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Circus approximans</i>          | Swamp Harrier              | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Accipiter fasciatus</i>         | Brown Goshawk              | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Accipiter novaehollandiae</i>   | Grey Goshawk               | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Accipiter cirrhocephalus</i>    | Collared Sparrowhawk       | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Aquila audax</i>                | Wedge-tailed Eagle         | Carnivore (Diurnal raptor)       |
|                   | Accipitridae      | <i>Hieraaetus morphnoides</i>      | Little Eagle               | Carnivore (Diurnal raptor)       |
|                   | Falconidae        | <i>Falco longipennis</i>           | Australian Hobby           | Carnivore (Diurnal raptor)       |
|                   | Falconidae        | <i>Falco peregrinus</i>            | Peregrine Falcon           | Carnivore (Diurnal raptor)       |
|                   | Falconidae        | <i>Falco cenchroides</i>           | Nankeen Kestrel            | Carnivore (Diurnal raptor)       |
| Gruiformes        |                   |                                    |                            |                                  |
|                   | Rallidae          | <i>Gallirallus philippensis</i>    | Buff-banded Rail           | Omnivore                         |



| Order           | Family           | Scientific Name                  | Common Name              | Major taxonomic/functional group |
|-----------------|------------------|----------------------------------|--------------------------|----------------------------------|
|                 | Rallidae         | <i>Rallus pectoralis</i>         | Lewins Rail              | Carnivore                        |
|                 | Rallidae         | <i>Porzana tabuensis</i>         | Spotless Crake           | Omnivore                         |
|                 | Rallidae         | <i>Porphyrio porphyrio</i>       | Purple Swamphen          | Omnivore                         |
| Charadriiformes |                  |                                  |                          |                                  |
|                 | Scolopacidae     | <i>Gallinago hardwickii</i>      | Latham's Snipe           | Wader                            |
|                 | Scolopacidae     | <i>Limosa limosa</i>             | Black-tailed Godwit      | Wader                            |
|                 | Scolopacidae     | <i>Limosa lapponica</i>          | Bar-tailed Godwit (OL)   | Wader                            |
|                 | Scolopacidae     | <i>Numenius minutus</i>          | Little Curlew            | Wader                            |
|                 | Scolopacidae     | <i>Numenius phaeopus</i>         | Whimbrel (OL)            | Wader                            |
|                 | Scolopacidae     | <i>Numenius madagascariensis</i> | Eastern Curlew (OL)      | Wader                            |
|                 | Scolopacidae     | <i>Tringa stagnatilis</i>        | Marsh Sandpiper          | Wader                            |
|                 | Scolopacidae     | <i>Tringa nebularia</i>          | Common Greenshank        | Wader                            |
|                 | Scolopacidae     | <i>Xenus cinereus</i>            | Terek Sandpiper          | Wader                            |
|                 | Scolopacidae     | <i>Actitis hypoleucos</i>        | Common Sandpiper         | Wader                            |
|                 | Scolopacidae     | <i>Heteroscelus brevipes</i>     | Grey-tailed Tattler (OL) | Wader                            |
|                 | Scolopacidae     | <i>Arenaria interpres</i>        | Ruddy Turnstone          | Wader                            |
|                 | Scolopacidae     | <i>Calidris canutus</i>          | Red Knot                 | Wader                            |
|                 | Scolopacidae     | <i>Calidris alba</i>             | Sanderling               | Wader                            |
|                 | Scolopacidae     | <i>Calidris ruficollis</i>       | Red-necked Stint         | Wader                            |
|                 | Scolopacidae     | <i>Calidris ferruginea</i>       | Curlew Sandpiper         | Wader                            |
|                 | Scolopacidae     | <i>Calidris acuminata</i>        | Sharp-tailed Sandpiper   | Wader                            |
|                 | Scolopacidae     | <i>Limicola falcinellus</i>      | Broad-billed Sandpiper   | Wader                            |
|                 | Burhinidae       | <i>Burhinus grallarius</i>       | Bush Stone-curlew        | Wader                            |
|                 | Haematopodidae   | <i>Haematopus longirostris</i>   | Pied Oystercatcher (OL)  | Wader                            |
|                 | Haematopodidae   | <i>Haematopus fuliginosus</i>    | Sooty Oystercatcher      | Wader                            |
|                 | Recurvirostridae | <i>Himantopus himantopus</i>     | Black-winged Stilt       | Wader                            |
|                 | Charadriidae     | <i>Pluvialis fulva</i>           | Pacific Golden Plover    | Wader                            |
|                 | Charadriidae     | <i>Pluvialis squatarola</i>      | Grey Plover              | Wader                            |
|                 | Charadriidae     | <i>Charadrius mongolus</i>       | Lesser Sand Plover       | Wader                            |
|                 | Charadriidae     | <i>Euseyonis melanops</i>        | Black-fronted Dotterel   | Wader                            |
|                 | Charadriidae     | <i>Erythronyx cinctus</i>        | Red-kneed Dotterel       | Wader                            |
|                 | Charadriidae     | <i>Vanellus tricolor</i>         | Banded Lapwing           | Wader                            |
|                 | Charadriidae     | <i>Vanellus miles</i>            | Masked Lapwing (OL)      | Wader                            |
|                 | Laridae          | <i>Larus novaehollandiae</i>     | Silver Gull (OL)         | Omnivore-scavenger               |
|                 | Laridae          | <i>Sterna caspia</i>             | Caspian Tern             | Piscivore                        |
|                 | Laridae          | <i>Sterna bergii</i>             | Crested Tern             | Piscivore                        |
|                 | Laridae          | <i>Sterna hirundo</i>            | Common Tern              | Piscivore                        |
|                 | Laridae          | <i>Sterna albifrons</i>          | Little Tern              | Piscivore                        |
| Columbiformes   |                  |                                  |                          |                                  |
|                 | Columbidae       | <i>Columba livia</i> *           | Rock Dove                | Seed-eater                       |
|                 | Columbidae       | <i>Streptopelia chinensis</i> *  | Spotted Turtle-Dove      | Seed-eater                       |
|                 | Columbidae       | <i>Ocyphaps lophotes</i>         | Crested Pigeon           | Seed-eater                       |
| Psittaciformes  |                  |                                  |                          |                                  |
|                 | Cacatuidae       | <i>Cacatua galerita</i>          | Sulphur-crested Cockatoo | Seed-eater                       |
|                 | Psittacidae      | <i>Platycercus eximius</i>       | Eastern Rosella          | Seed-eater                       |
| Coraciiformes   |                  |                                  |                          |                                  |
|                 | Halcyonidae      | <i>Dacelo novaeguineae</i>       | Laughing Kookaburra      | Carnivore                        |
|                 | Halcyonidae      | <i>Todiramphus sanctus</i>       | Sacred Kingfisher (OL)   | Carnivore                        |
| Passeriformes   |                  |                                  |                          |                                  |
|                 | Maluridae        | <i>Malurus cyaneus</i>           | Superb Fairy-wren        | Insectivore                      |
|                 | Maluridae        | <i>Stipiturus malachurus</i>     | Southern Emu-wren        | Insectivore                      |
|                 | Pardalotidae     | <i>Sericornis frontalis</i>      | White-browed Scrubwren   | Insectivore                      |
|                 | Pardalotidae     | <i>Gerygone levigaster</i>       | Mangrove Gerygone        | Insectivore                      |
|                 | Pardalotidae     | <i>Acanthiza nana</i>            | Yellow Thornbill         | Insectivore                      |
|                 | Meliphadidae     | <i>Manorina melanoccephala</i>   | Noisy Miner              | Insectivore/nectarivore          |
|                 | Meliphadidae     | <i>Lichmera indistincta</i>      | Brown Honeyeater         | Insectivore/nectarivore          |

| Order | Family        | Scientific Name                 | Common Name               | Major taxonomic/functional group |
|-------|---------------|---------------------------------|---------------------------|----------------------------------|
|       | Dicruridae    | <i>Grallina cyanoleuca</i>      | Magpie-lark (OL)          | Insectivore                      |
|       | Dicruridae    | <i>Rhipidura leucophrys</i>     | Willie Wagtail            | Insectivore                      |
|       | Campephagidae | <i>Coracina novaehollandiae</i> | Black-faced Cuckoo-shrike | Insectivore                      |
|       | Artamidae     | <i>Cracticus torquatus</i>      | Grey Butcherbird          | Omnivore                         |
|       | Artamidae     | <i>Gymnorhina tibicen</i>       | Australian Magpie         | Omnivore                         |
|       | Corvidae      | <i>Corvus coronoides</i>        | Australian Raven          | Omnivore                         |
|       | Hirundinidae  | <i>Hirundo neoxena</i>          | Welcome Swallow (OL)      | Insectivore (Aerial)             |
|       | Hirundinidae  | <i>Hirundo ariel</i>            | Fairy Nartin              | Insectivore (Aerial)             |
|       | Sylviidae     | <i>Megalurus gramineus</i>      | Little Grassbird          | Insectivore                      |
|       | Sylviidae     | <i>Cisticola exilis</i>         | Golden-headed Cisticola   | Insectivore                      |
|       | Zosteropidae  | <i>Zosterops lateralis</i>      | Silvereye                 | Omnivore                         |
|       | Sturnidae     | <i>Acridotheres tristis</i> *   | Common Myna               | Omnivore                         |

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## Appendix 2

Frequency of birds recorded in estuarine habitats sampled (n=137) in this survey.

| Order           | Family            | Scientific Name                   | Common Name              | Frequency (%)<br>(n=137) | Major<br>taxonomic/functional<br>group (diet) |
|-----------------|-------------------|-----------------------------------|--------------------------|--------------------------|---|
| Anseriformes    |                   |                                   |                          |                          |   |
|                 | Anatidae          | <i>Cygnus atratus</i>             | Black Swan               | 2.1                      | Waterfowl                                     |
|                 | Anatidae          | <i>Chenonetta jubata</i>          | Australian Wood Duck     | 4.4                      | Waterfowl                                     |
|                 | Anatidae          | <i>Anas platyrhynchos</i> *       | Mallard                  | 12.4                     | Waterfowl                                     |
|                 | Anatidae          | <i>Anas superciliosa</i>          | Pacific Black Duck       | 5.1                      | Waterfowl                                     |
|                 | Anatidae          | <i>Anas gracilis</i>              | Grey Teal                | 3.7                      | Waterfowl                                     |
|                 | Anatidae          | <i>Anas castanea</i>              | Chestnut Teal            | 10.2                     | Waterfowl                                     |
| Pelecaniformes  |                   |                                   |                          |                          |   |
|                 | Anhingidae        | <i>Anhinga melanogaster</i>       | Darter                   | 2.1                      | Piscivore                                     |
|                 | Phalacrocoracidae | <i>Phalacrocorax melanoleucos</i> | Little Pied Cormorant    | 7.2                      | Piscivore                                     |
|                 | Phalacrocoracidae | <i>Phalacrocorax varius</i>       | Pied Cormorant           | 0.7                      | Piscivore                                     |
|                 | Phalacrocoracidae | <i>Phalacrocorax sulcirostris</i> | Little Black Cormorant   | 2.9                      | Piscivore                                     |
|                 | Pelecanidae       | <i>Pelecanus conspicillatus</i>   | Australian Pelican       | 8.8                      | Piscivore                                     |
| Ciconiiformes   |                   |                                   |                          |                          |   |
|                 | Ardeidae          | <i>Egretta novaehollandiae</i>    | White-faced Heron        | 36.5                     | Large wading bird                             |
|                 | Ardeidae          | <i>Egretta garzetta</i>           | Little Egret             | 5.1                      | Large wading bird                             |
|                 | Ardeidae          | <i>Ardea alba</i>                 | Great Egret              | 8                        | Large wading bird                             |
|                 | Ardeidae          | <i>Butorides striatus</i>         | Striated Heron           | 8.8                      | Medium wading bird                            |
|                 | Ardeidae          | <i>Ixobrychus flavicollis</i>     | Black Bittern            | 0.7                      | Medium wading bird                            |
|                 | Threskiornithidae | <i>Threskiornis molucca</i>       | Australian White Ibis    | 31.4                     | Large wading bird                             |
| Falconiformes   |                   |                                   |                          |                          |   |
|                 | Accipitridae      | <i>Haliastur sphenurus</i>        | Whistling Kite           | 2.1                      | Diurnal raptor                                |
|                 | Accipitridae      | <i>Haliaeetus leucogaster</i>     | White-bellied Sea-Eagle  | 3.7                      | Diurnal Raptor                                |
| Gruiformes      |                   |                                   |                          |                          |   |
|                 | Rallidae          | <i>Gallirallus philippensis</i>   | Buff-banded Rail         | 0.7                      | Omnivore                                      |
| Charadriiformes |                   |                                   |                          |                          |   |
|                 | Scolopacidae      | <i>Limosa lapponica</i>           | Bar-tailed Godwit        | 9.5                      | Wader   |
|                 | Scolopacidae      | <i>Numenius phaeopus</i>          | Whimbrel                 | 8.8                      | Wader   |
|                 | Scolopacidae      | <i>Numenius madagascariensis</i>  | Eastern Curlew           | 10.9                     | Wader   |
|                 | Scolopacidae      | <i>Heteroscelus brevipes</i>      | Grey-tailed Tattler      | 2.9                      | Wader   |
|                 | Scolopacidae      | <i>Calidris acuminata</i>         | Sharp-tailed Sandpiper   | 0.7                      | Wader   |
|                 | Burhinidae        | <i>Burhinus grallarius</i>        | Bush Stone-curlew        | 2.1                      | Wader   |
|                 | Haematopodidae    | <i>Haematopus longirostris</i>    | Pied Oystercatcher       | 2.9                      | Wader   |
|                 | Charadriidae      | <i>Vanellus miles</i>             | Masked Lapwing           | 24.8                     | Wader   |
|                 | Laridae           | <i>Larus novaehollandiae</i>      | Silver Gull              | 20.4                     | Omnivore-scavenger                            |
|                 | Laridae           | <i>Sterna caspia</i>              | Caspian Tern             | 1.5                      | Piscivore                                     |
|                 | Laridae           | <i>Sterna bergii</i>              | Crested Tern             | 3.7                      | Piscivore                                     |
|                 |                   |                                   |                          |                          |   |
|                 | Columbidae        | <i>Columba livia</i> *            | Rock Dove                | 0.7                      | Seed eater                                    |
|                 | Columbidae        | <i>Streptopelia chinensis</i> *   | Spotted Turtle-Dove      | 0.7                      | Seed eater                                    |
|                 | Columbidae        | <i>Ocyphaps lophotes</i>          | Crested Pigeon           | 0.7                      | Seed eater                                    |
| Psittaciformes  |                   |                                   |                          |                          |   |
|                 | Cacatuidae        | <i>Cacatua galerita</i>           | Sulphur-crested Cockatoo | 0.7                      | Seed eater                                    |
|                 | Psittacidae       | <i>Platycercus eximius</i>        | Eastern Rosella          | 0.7                      | Seed eater                                    |
| Coraciiformes   |                   |                                   |                          |                          |   |
|                 | Halcyonidae       | <i>Dacelo novaeguineae</i>        | Laughing Kookaburra      | 2.1                      | Carnivore                                     |
|                 | Halcyonidae       | <i>Todiramphus sanctus</i>        | Sacred Kingfisher        | 11                       | Carnivore                                     |
| Passeriformes   |                   |                                   |                          |                          |   |
|                 | Maluridae         | <i>Malurus cyaneus</i>            | Superb Fairy-wren        | 13.9                     | Insectivore                                   |
|                 | Maluridae         | <i>Stipiturus malachurus</i>      | Southern Emu-wren        | 1.5                      | Insectivore                                   |
|                 | Pardalotidae      | <i>Sericornis frontalis</i>       | White-browed Scrubwren   | 1.5                      | Insectivore                                   |

| Order | Family        | Scientific Name                 | Common Name               | Frequency (%)<br>(n=137) | Major<br>taxonomic/functional<br>group (diet) |
|-------|---------------|---------------------------------|---------------------------|--------------------------|---|
|       | Pardalotidae  | <i>Gerygone levigaster</i>      | Mangrove Gerygone         | 7.2                      | Insectivore                                   |
|       | Pardalotidae  | <i>Acanthiza mana</i>           | Yellow Thornbill          | 4.4                      | Insectivore                                   |
|       | Meliphagidae  | <i>Manorina melanocephala</i>   | Noisy Miner               | 1.5                      | Insectivore/nectarivore                       |
|       | Dicruridae    | <i>Grallina cyanoleuca</i>      | Magpie-lark               | 8                        | Insectivore                                   |
|       | Dicruridae    | <i>Rhipidura leucophrys</i>     | Willie Wagtail            | 6.6                      | Insectivore                                   |
|       | Campephagidae | <i>Coracina novaehollandiae</i> | Black-faced Cuckoo-shrike | 2.1                      | Insectivore                                   |
|       | Artamidae     | <i>Cracticus torquatus</i>      | Grey Butcherbird          | 2.1                      | Omnivore                                      |
|       | Artamidae     | <i>Gymnorhina tibicen</i>       | Australian Magpie         | 3.7                      | Insectivore                                   |
|       | Corvidae      | <i>Corvus coronoides</i>        | Australian Raven          | 7.2                      | Omnivore                                      |
|       | Hirundinidae  | <i>Hirundo neoxena</i>          | Welcome Swallow           | 24.8                     | Aerial Insectivore                            |
|       | Hirundinidae  | <i>Hirundo ariel</i>            | Fairy Martin              | 0.7                      | Aerial Insectivore                            |
|       | Sylviidae     | <i>Cisticola exilis</i>         | Golden-headed Cisticola   | 0.7                      | Insectivore                                   |
|       | Zosteropidae  | <i>Zosterops lateralis</i>      | Silvereye                 | 2.1                      | Omnivore                                      |
|       | Sturnidae     | <i>Acridotheres tristis</i> *   | Common Myna               | 2.1                      | Omnivore                                      |

## **Appendix 3**

Birds recorded Department of Environment and Planning (1983), EPA (1994) in using Brisbane Water estuarine habitats and at Kincumber Creek (O'Toole cited Warman, 2004). NB: O'Toole includes forest birds e.g. Swamp Forest)

| Order Family      | Scientific Name                   | Common Name             | DEP (1983)  | EPA (1994; app. 3) | Warman (2004) |
|-------------------|-----------------------------------|-------------------------|---|--------------------|---------------|
| Anseriformes      |                                   |                         |   |                    |               |
| Anatidae          | <i>Biziura lobata</i>             | Musk Duck               |   |                    | Kincumber Ck  |
| Anatidae          | <i>Cygnus atratus</i>             | Black Swan              | Seen in large numbers with drought inland; decrease with inland rains           |                    | Kincumber Ck  |
| Anatidae          | <i>Anas platyrhynchos</i> *       | Mallard                 |   |                    | Kincumber Ck  |
| Anatidae          | <i>Anas superciliosa</i>          | Pacific Black Duck      | As above  |                    | Kincumber Ck  |
| Anatidae          | <i>Anas gracilis</i>              | Grey Teal               | As above  |                    | Kincumber Ck  |
| Anatidae          | <i>Anas castanea</i>              | Chestnut Teal           | As above  |                    | Kincumber Ck  |
| Anhingidae        | <i>Anhinga melanogaster</i>       | Darter                  |   |                    | Kincumber Ck  |
| Phalacrocoracidae | <i>Phalacrocorax melanoleucos</i> | Little Pied Cormorant   | roost on OL, trees; comm., res.; br   | EPA (1994)         | Kincumber Ck  |
| Phalacrocoracidae | <i>Phalacrocorax varius</i>       | Pied Cormorant          | Feed in shallows & open water; uncomm.; res.                                    | EPA (1994)         | Kincumber Ck  |
| Phalacrocoracidae | <i>Phalacrocorax sulcirostris</i> | Little Black Cormorant  | uncomm. Res.; br.   | EPA (1994)         | Kincumber Ck  |
| Phalacrocoracidae | <i>Phalacrocorax carbo</i>        | Great Cormorant         | comm., res.;  | EPA (1994)         | Kincumber Ck  |
| Pelecanidae       | <i>Pelecanus conspicillatus</i>   | Australian Pelican      | Feeds in shallows; rests on sand; comm. resident, seen in large no. in droughts | EPA (1994)         | Kincumber Ck  |
| Ciconiiformes     |                                   |                         |   |                    |               |
| Areidae           | <i>Egretta novaehollandiae</i>    | White-faced Heron       | Feeds in shallows; roosts in Casuarina & mangroves                              |                    | Kincumber Ck  |
| Areidae           | <i>Egretta garzetta</i>           | Little Egret            |   |                    | Kincumber Ck  |
| Areidae           | <i>Ardea pacifica</i>             | White-necked Heron      |   |                    | Kincumber Ck  |
| Areidae           | <i>Ardea alba</i>                 | Great Egret             | As above  | EPA (1994)         | Kincumber Ck  |
| Areidae           | <i>Ardea ibis</i>                 | Cattle Egret            |   |                    | Kincumber Ck  |
| Areidae           | <i>Butorides striatus</i>         | Striated Heron          | Feeds on mudflats; nests/roostin mangrove`                                      |                    | Kincumber Ck  |
| Areidae           | <i>Nycticorax caledonicus</i>     | Nankeen Night Heron     | Feeds in shallows; roost/nest in trees  |                    | Kincumber Ck  |
| Areidae           | <i>Ixobrychus flavicollis</i>     | Black Bittern           |   |                    | Kincumber Ck  |
| Threskiornithidae | <i>Threskiornis molucca</i>       | Australian White Ibis   | Feeds in shallows; nests in rushes, reeds & trees                               |                    | Kincumber Ck  |
| Threskiornithidae | <i>Threskiornis spinicollis</i>   | Straw-necked Ibis       |   |                    | Kincumber Ck  |
| Threskiornithidae | <i>Platelea regia</i>             | Royal Spoonbill         | As above  |                    | Kincumber Ck  |
| Falconiformes     |                                   |                         |   |                    |               |
| Accipitridae      | <i>Pandion haliaetus</i>          | Osprey                  |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Aviceda subcristata</i>        | Pacific Baza            |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Elanus axillaris</i>           | Black-shouldered Kite   |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Haliastur sphenurus</i>        | Whistling Kite          |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Haliaeetus leucogaster</i>     | White-bellied Sea-Eagle |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Circus approximans</i>         | Swamp Harrier           |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Accipiter fasciatus</i>        | Brown Goshawk           |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Accipiter novaehollandiae</i>  | Grey Goshawk            |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Accipiter cirrhocephalus</i>   | Collared Sparrowhawk    |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Aquila audax</i>               | Wedge-tailed Eagle      |   |                    | Kincumber Ck  |
| Accipitridae      | <i>Hieraaetus morphnoides</i>     | Little Eagle            |   |                    | Kincumber Ck  |
| Falconidae        | <i>Falco longipennis</i>          | Australian Hobby        |   |                    | Kincumber Ck  |
| Falconidae        | <i>Falco peregrinus</i>           | Peregrine Falcon        |   |                    | Kincumber Ck  |

|                 |                                  |                              |   |            |              |
|-----------------|----------------------------------|------------------------------|---|------------|--------------|
| Falconidae      | <i>Falco cenchroides</i>         | Nankeen Kestrel              |   |            | Kincumber Ck |
| Gruiformes      |                                  |                              |   |            |              |
| Rallidae        | <i>Gallirallus philippensis</i>  | Buff-banded Rail             |   |            | Kincumber Ck |
| Rallidae        | <i>Rallus pectoralis</i>         | Lewins Rail                  |   |            | Kincumber Ck |
| Rallidae        | <i>Porzana tabuensis</i>         | Spotless Crane               |   |            | Kincumber Ck |
| Rallidae        | <i>Porphyrio porphyrio</i>       | Purple Swamphen              |   |            | Kincumber Ck |
| Charadriiformes |                                  |                              |   |            |              |
| Scolopacidae    | <i>Gallinago hardwickii</i>      | Latham's Snipe               |   |            | Kincumber Ck |
| Scolopacidae    | <i>Limosa lapponica</i>          | Bar-tailed Godwit            | Feeds on mudflats; common visitor   | EPA (1994) | Kincumber Ck |
| Scolopacidae    | <i>Numenius phaeopus</i>         | Whimbrel                     | Feeds in shallows, rests in saltmarsh; common visitor                                   | EPA (1994) |              |
| Scolopacidae    | <i>Numenius madagascariensis</i> | Eastern Curlew               | Feeds in shallows, rests in saltmarsh; common visitor                                   | EPA (1994) | Kincumber Ck |
| Scolopacidae    | <i>Tringa stagnatilis</i>        | Marsh Sandpiper              |   |            | Kincumber Ck |
| Scolopacidae    | <i>Xenus cinereus</i>            | Terek Sandpiper              | seed on mudflats Rileys island, rests on saltmarsh                                      |            |              |
| Scolopacidae    | <i>Actitis hypoleucos</i>        | Common Sandpiper             | Seen on shingle beaches, Riles is & St Hub. Channel; rests on saltmarsh                 | EPA (1994) |              |
| Scolopacidae    | <i>Heteroscelus brevipes</i>     | Grey-tailed Tattler          | Feeds in shallows, roosts on oyster leases; common visitor                              | EPA (1994) |              |
| Scolopacidae    | <i>Arenaria interpres</i>        | Ruddy Turnstone              |   | EPA (1994) |              |
| Scolopacidae    | <i>Calidris alba</i>             | Sanderling                   |   | EPA (1994) |              |
| Scolopacidae    | <i>Calidris ruficollis</i>       | Red-necked Stint             |   | EPA (1994) |              |
| Scolopacidae    | <i>Calidris ferruginea</i>       | Curlew Sandpiper             | Rileys Island; uncommon   | EPA (1994) |              |
| Scolopacidae    | <i>Calidris acuminata</i>        | Sharp-tailed Sandpiper       | Feed on mudflats near Saratoga & Rileys Is. Saltmarsh after rain                        | EPA (1994) |              |
| Scolopacidae    | <i>Limicola falcinellus</i>      | Broad-billed Sanpiper        |   | EPA (1994) |              |
| Burhinidae      | <i>Burhinus grallarius</i>       | Bush Stone-curlew            | feeds in saltmarsh, roosts on OL, nests in saltmarsh; Rileys island & recently Emp. Bay | EPA (1994) | Kincumber Ck |
| Haematopodidae  | <i>Haematopus longirostris</i>   | Pied Oystercatcher           |   | EPA (1994) | Kincumber Ck |
| Charadriidae    | <i>Pluvialis fulva</i>           | Pacific Golden Plover        | Seen on shingle beaches, Emp. Bay; always seen in summer                                | EPA (1994) |              |
| Charadriidae    | <i>Pluvialis squatarola</i>      | Grey Plover                  | Seen on shingle beaches, Emp. Bay   | EPA (1994) |              |
| Charadriidae    | <i>Charadrius mongolus</i>       | Lesser Sand Plover           | Seen on shingle beaches, Emp. Bay   | EPA (1994) |              |
| Charadriidae    | <i>Elseyornis melanops</i>       | Black-fronted Dotterel       | Resident, possibly br.; seen on Rileys Island   |            |              |
| Charadriidae    | <i>Vanellus miles</i>            | Masked Lapwing               |   |            | Kincumber Ck |
| Laridae         | <i>Larus novaehollandiae</i>     | Silver Gull                  |   |            | Kincumber Ck |
| Laridae         | <i>Sterna caspia</i>             | Caspian Tern                 |   |            | Kincumber Ck |
| Laridae         | <i>Sterna hirundo</i>            | Common Tern                  |   |            | Kincumber Ck |
| Columbiformes   |                                  |                              |   |            |              |
| Columbidae      | <i>Columba livia</i> *           | Rock Dove                    |   |            | Kincumber Ck |
| Columbidae      | <i>Columba leucomela</i>         | White-headed Pigeon          |   |            | Kincumber Ck |
| Columbidae      | <i>Macropygia amboinensis</i>    | Brown Cuckoo-Dove            |   |            | Kincumber Ck |
| Columbidae      | <i>Ocyphaps lophotes</i>         | Crested Pigeon               |   |            | Kincumber Ck |
| Columbidae      | <i>Lopholaimus antarcticus</i>   | Topknot Pigeon               |   |            | Kincumber Ck |
| Psittaciformes  |                                  |                              |   |            |              |
| Cactuidae       | <i>Calyptrorhynchus lathami</i>  | Glossy Black-Cockatoo        |   |            | Kincumber Ck |
| Cactuidae       | <i>Calyptrorhynchus funereus</i> | Yellow-tailed Black-Cockatoo |   |            | Kincumber Ck |



|                  |                                  |                           |  |  |              |
|------------------|----------------------------------|---------------------------|--|--|--------------|
| Cactuidae        | <i>Cacatua roseicapilla</i>      | Galah                     |  |  | Kincumber Ck |
| Cactuidae        | <i>Cacatua tenuirostris</i>      | Long-billed Corella       |  |  | Kincumber Ck |
| Cactuidae        | <i>Cacatua sanguinea</i>         | Little Corella            |  |  | Kincumber Ck |
| Cactuidae        | <i>Cacatua galerita</i>          | Sulphur-crested Cockatoo  |  |  | Kincumber Ck |
| Psittacidae      | <i>Trichoglossus haematodus</i>  | Rainbow Lorikeet          |  |  | Kincumber Ck |
| Psittacidae      | <i>Glossopsitta concinna</i>     | Musk Lorikeet             |  |  | Kincumber Ck |
| Psittacidae      | <i>Alisterus scapularis</i>      | Australian King-Parrot    |  |  | Kincumber Ck |
| Psittacidae      | <i>Platycercus elegans</i>       | Crimson Rosella           |  |  | Kincumber Ck |
| Psittacidae      | <i>Platycercus eximius</i>       | Eastern Rosella           |  |  | Kincumber Ck |
| Cuculiformes     |                                  |                           |  |  |              |
| Cuculidae        | <i>Cuculus pallidus</i>          | Pallid Cuckoo             |  |  | Kincumber Ck |
| Cuculidae        | <i>Cacomantis variolosus</i>     | Brush Cuckoo              |  |  | Kincumber Ck |
| Cuculidae        | <i>Cacomantis flabelliformis</i> | Fan-tailed Cuckoo         |  |  | Kincumber Ck |
| Cuculidae        | <i>Eudynamys scolopacea</i>      | Common Koel               |  |  | Kincumber Ck |
| Cuculidae        | <i>Scythrops novaehollandiae</i> | Channel-billed Cuckoo     |  |  | Kincumber Ck |
| Centropodidae    | <i>Centropus phasianinus</i>     | Pheasant Coucal           |  |  | Kincumber Ck |
| Strigiformes     |                                  |                           |  |  |              |
| Strigidae        | <i>Ninox strenua</i>             | Powerful Owl              |  |  | Kincumber Ck |
| Strigidae        | <i>Ninox novaeseelandiae</i>     | Southern Boobook          |  |  | Kincumber Ck |
| Tytonidae        | <i>Tyto alba</i>                 | Barn Owl                  |  |  | Kincumber Ck |
| Caprimulgiformes |                                  |                           |  |  |              |
| Podargidae       | <i>Podargus strigoides</i>       | Tawny Frogmouth           |  |  | Kincumber Ck |
| Caprimulgidae    | <i>Eurostopodus mystacalis</i>   | White-throated Nightjar   |  |  | Kincumber Ck |
| Apodiformes      |                                  |                           |  |  |              |
| Apodidae         | <i>Hirundapus caudacutus</i>     | White-throated Needletail |  |  | Kincumber Ck |
| Coraciiformes    |                                  |                           |  |  |              |
| Alcedinidae      | <i>Alcedo azurea</i>             | Azure Kingfisher          |  |  | Kincumber Ck |
| Halcyonidae      | <i>Dacelo novaeguineae</i>       | Laughing Kookaburra       |  |  | Kincumber Ck |
| Halcyonidae      | <i>Todiramphus sanctus</i>       | Sacred Kingfisher         |  |  | Kincumber Ck |
| Coraciidae       | <i>Eurystomus orientalis</i>     | Dollarbird                |  |  | Kincumber Ck |
| Passeriformes    |                                  |                           |  |  |              |
| Maluridae        | <i>Malurus cyaneus</i>           | Superb Fairy-wren         |  |  | Kincumber Ck |
| Pardalotidae     | <i>Gerygone mouki</i>            | Brown Gerygone            |  |  | Kincumber Ck |
| Pardalotidae     | <i>Acanthiza pusilla</i>         | Brown Thornbill           |  |  | Kincumber Ck |
| Pardalotidae     | <i>Acanthiza chrysorrhoa</i>     | Yellow-rumped Thornbill   |  |  | Kincumber Ck |
| Pardalotidae     | <i>Acanthiza nana</i>            | Yellow Thornbill          |  |  | Kincumber Ck |
| Pardalotidae     | <i>Acanthiza lineata</i>         | Striated Thornbill        |  |  | Kincumber Ck |
| Meliphagidae     | <i>Anthochaera carunculata</i>   | Red Wattlebird            |  |  | Kincumber Ck |
| Meliphagidae     | <i>Anthochaera chrysoptera</i>   | Little Wattlebird         |  |  | Kincumber Ck |
| Meliphagidae     | <i>Philemon corniculatus</i>     | Noisy Friarbird           |  |  | Kincumber Ck |

|                   |                                     |                           |  |  |              |
|-------------------|-------------------------------------|---------------------------|--|--|--------------|
| Meliphagidae      | <i>Manorina melanocephala</i>       | Noisy Miner               |  |  | Kincumber Ck |
| Meliphagidae      | <i>Meliphaga lewinii</i>            | Lewin's Honeyeater        |  |  | Kincumber Ck |
| Meliphagidae      | <i>Lichenostomus chrysops</i>       | Yellow-faced Honeyeater   |  |  | Kincumber Ck |
| Meliphagidae      | <i>Phylidonyris novaehollandiae</i> | New Holland Honeyeater    |  |  | Kincumber Ck |
| Meliphagidae      | <i>Phylidonyris nigra</i>           | White-cheeked Honeyeater  |  |  | Kincumber Ck |
| Meliphagidae      | <i>Acanthorhynchus tenuirostris</i> | Eastern Spinebill         |  |  | Kincumber Ck |
| Meliphagidae      | <i>Myzomela sanguinolenta</i>       | Scarlet Honeyeater        |  |  | Kincumber Ck |
| Pachycephalidae   | <i>Colluricincla harmonica</i>      | Grey Shrike-thrush        |  |  | Kincumber Ck |
| Dicuridae         | <i>Myiagra inquieta</i>             | Restless Flycatcher       |  |  | Kincumber Ck |
| Dicuridae         | <i>Grallina cyanoleuca</i>          | Magpie-lark               |  |  | Kincumber Ck |
| Dicuridae         | <i>Rhipidura rufifrons</i>          | Rufous Fantail            |  |  | Kincumber Ck |
| Dicuridae         | <i>Rhipidura fuliginosa</i>         | Grey Fantail              |  |  | Kincumber Ck |
| Dicuridae         | <i>Rhipidura leucophrys</i>         | Willie Wagtail            |  |  | Kincumber Ck |
| Dicuridae         | <i>Dicrurus bracteatus</i>          | Spangled Drongo           |  |  | Kincumber Ck |
| Campephagidae     | <i>Coracina novaehollandiae</i>     | Black-faced Cuckoo-shrike |  |  | Kincumber Ck |
| Campephagidae     | <i>Coracina tenuirostris</i>        | Cicadabird                |  |  | Kincumber Ck |
| Oriolidae         | <i>Oriolus sagittatus</i>           | Olive-backed Oriole       |  |  | Kincumber Ck |
| Oriolidae         | <i>Sphecothes viridis</i>           | Figbird                   |  |  | Kincumber Ck |
| Artamidae         | <i>Cracticus torquatus</i>          | Grey Butcherbird          |  |  | Kincumber Ck |
| Artamidae         | <i>Gymnorhina tibicen</i>           | Australian Magpie         |  |  | Kincumber Ck |
| Artamidae         | <i>Strepera graculina</i>           | Pied Currawong            |  |  | Kincumber Ck |
| Corvidae          | <i>Corvus coronoides</i>            | Australian Raven          |  |  | Kincumber Ck |
| Ptilonorhynchidae | <i>Sericulus chrysocephalus</i>     | Regent Bowerbird          |  |  | Kincumber Ck |
| Ptilonorhynchidae | <i>Ptilonorhynchus violaceus</i>    | Satin Bowerbird           |  |  | Kincumber Ck |
| Motacillidae      | <i>Anthus novaeseelandiae</i>       | Australian Pipit          |  |  | Kincumber Ck |
| Passeridae        | <i>Passer domesticus</i> *          | House Sparrow             |  |  | Kincumber Ck |
| Passeridae        | <i>Neochmia temporalis</i>          | Red-browed Finch          |  |  | Kincumber Ck |
| Hirundinidae      | <i>Hirundo neoxena</i>              | Welcome Swallow           |  |  | Kincumber Ck |
| Sylviidae         | <i>Megalurus gramineus</i>          | Little Grassbird          |  |  | Kincumber Ck |
| Zosteropidae      | <i>Zosterops lateralis</i>          | Silvereye                 |  |  | Kincumber Ck |
| Sturnidae         | <i>Sturnus vulgaris</i> *           | Common Starling           |  |  | Kincumber Ck |
| Sturnidae         | <i>Acridotheres tristis</i> *       | Common Myna               |  |  | Kincumber Ck |

## Appendix 4

Brisbane Water Waterbird Counts 1997-2003 (Alan Morris unpublished data)

NB: The count data is the pooled survey results for eleven sites around Brisbane Water (see below)

| Location                    | Latitude |    |    | Longitude |    |    |
|-----------------------------|----------|----|----|-----------|----|----|
|                             | °        | '  | '' | °         | '  | '' |
| Bensville Wharf             | 33       | 29 | 49 | 151       | 22 | 36 |
| Cockle Bay South            | 33       | 29 | 56 | 151       | 21 | 43 |
| Cockle Broadwater           | 33       | 29 | 21 | 151       | 21 | 09 |
| Cockle Channel              | 33       | 29 | 35 | 151       | 21 | 51 |
| Empire Bay Wharf            | 33       | 29 | 45 | 151       | 22 | 02 |
| Lintern Point               | 33       | 29 | 25 | 151       | 21 | 07 |
| Ramsay Is., Blackwall Bay   | 33       | 30 |    | 151       | 21 |    |
| Saratoga (Henderson Rd)     | 33       | 28 | 47 | 151       | 20 | 51 |
| Saratoga Wetlands           | 33       | 28 | 28 | 151       | 20 | 08 |
| Veterans Hall               | 33       | 28 | 56 | 151       | 21 | 07 |
| Woy Woy North Burge Reserve | 33       | 29 | 32 | 151       | 20 | 30 |

**Birds of the Brisbane Water Estuary**

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| Order Family      | Scientific Name                   | Common Name             | Jul-97 | Feb-98 | Jul-98 | Feb-99 | Jul-99 | Feb-00 | Feb-01 | Feb-02 | Feb-03 | Total (all years) | % frequency (n = 9) |
|-------------------|-----------------------------------|-------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------------------|---------------------|
| Anseriformes      |                                   |                         |        |        |        |        |        |        |        |        |        |                   |                     |
| Anatidae          | <i>Cygnus atratus</i>             | Black Swan              | 8      | 80     | 11     | 9      | 3      | 33     | 8      | 66     | 66     | 284               | 100                 |
| Anatidae          | <i>Chenonetta jubata</i>          | Australian Wood Duck    | 0      | 12     | 6      | 32     | 16     | 18     | 24     | 42     | 4      | 154               | 89                  |
| Anatidae          | <i>Anas platyrhynchos*</i>        | Mallard                 | 0      | 161    | 63     | 56     | 159    | 155    | 217    | 254    | 126    | 1191              | 89                  |
| Anatidae          | <i>Anas superciliosa</i>          | Pacific Black Duck      | 22     | 71     | 22     | 147    | 2      | 73     | 45     | 4      | 146    | 532               | 100                 |
| Anatidae          | <i>Anas gracilis</i>              | Grey Teal               | 6      | 8      | 0      | 4      | 3      | 12     | 0      | 0      | 148    | 181               | 67                  |
| Anatidae          | <i>Anas castanea</i>              | Chestnut Teal           | 32     | 42     | 28     | 19     | 52     | 84     | 8      | 8      | 196    | 469               | 100                 |
| Pelecaniformes    |                                   |                         |        |        |        |        |        |        |        |        |        |                   |                     |
| Anhingidae        | <i>Anhinga melanogaster</i>       | Darter                  | 3      | 1      | 7      | 0      | 7      | 0      | 2      | 6      | 3      | 29                | 78                  |
| Phalacrocoracidae | <i>Phalacrocorax melanoleucos</i> | Little Pied Cormorant   | 82     | 18     | 74     | 22     | 76     | 33     | 43     | 32     | 76     | 456               | 100                 |
| Phalacrocoracidae | <i>Phalacrocorax varius</i>       | Pied Cormorant          | 2      | 14     | 29     | 26     | 30     | 27     | 11     | 21     | 16     | 176               | 100                 |
| Phalacrocoracidae | <i>Phalacrocorax sulcirostris</i> | Little Black Cormorant  | 96     | 36     | 375    | 14     | 209    | 87     | 0      | 10     | 156    | 983               | 89                  |
| Phalacrocoracidae | <i>Phalacrocorax carbo</i>        | Great Cormorant         | 4      | 7      | 6      | 5      | 3      | 11     | 16     | 2      | 3      | 57                | 100                 |
| Pelecanidae       | <i>Pelecanus conspicillatus</i>   | Australian Pelican      | 423    | 402    | 213    | 533    | 484    | 810    | 656    | 261    | 281    | 4063              | 100                 |
| Ciconiiformes     |                                   |                         |        |        |        |        |        |        |        |        |        |                   |                     |
| Areidae           | <i>Egretta novaehollandiae</i>    | White-faced Heron       | 8      | 3      | 1      | 9      | 4      | 69     | 2      | 3      | 12     | 111               | 100                 |
| Areidae           | <i>Egretta garzetta</i>           | Little Egret            | 7      | 0      | 4      | 0      | 5      | 2      | 2      | 2      | 3      | 25                | 78                  |
| Areidae           | <i>Ardea alba</i>                 | Great Egret             | 3      | 0      | 2      | 0      | 14     | 2      | 1      | 5      | 8      | 35                | 78                  |
| Areidae           | <i>Ardea ibis</i>                 | Cattle Egret            | 0      | 1      | 0      | 0      | 0      | 0      | 4      | 0      | 2      | 7                 | 33.3                |
| Areidae           | <i>Butorides striatus</i>         | Striated Heron          | 1      | 3      | 0      | 2      | 1      | 7      | 0      | 2      | 0      | 16                | 67                  |
| Threskiornithidae | <i>Threskiornis molucca</i>       | Australian White Ibis   | 60     | 27     | 21     | 1      | 33     | 92     | 1      | 5      | 10     | 250               | 100                 |
| Threskiornithidae | <i>Platylea regia</i>             | Royal Spoonbill         | 5      | 7      | 15     | 0      | 17     | 0      | 0      | 1      | 5      | 50                | 67                  |
| Falconiformes     |                                   |                         |        |        |        |        |        |        |        |        |        |                   |                     |
| Accipitridae      | <i>Haliastur spheurnus</i>        | Whistling Kite          | 2      | 1      | 3      | 0      | 5      | 0      | 0      | 0      | 2      | 13                | 55.5                |
| Accipitridae      | <i>Haliaeetus leucogaster</i>     | White-bellied Sea-Eagle | 2      | 2      | 0      | 1      | 3      | 0      | 1      | 0      | 2      | 11                | 67                  |
| Accipitridae      | <i>Circus approximans</i>         | Swamp Harrier           | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 1                 | 11.1                |
| Falconidae        | <i>Falco peregrinus</i>           | Peregrine Falcon        | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 1                 | 11.1                |
| Charadriiformes   |                                   |                         |        |        |        |        |        |        |        |        |        |                   |                     |
| Scolopacidae      | <i>Limosa lapponica</i>           | Bar-tailed Godwit       | 19     | 11     | 14     | 12     | 16     | 8      | 35     | 49     | 15     | 179               | 100                 |
| Scolopacidae      | <i>Numenius phaeopus</i>          | Whimbrel                | 5      | 8      | 0      | 4      | 0      | 9      | 13     | 0      | 0      | 39                | 55.5                |

| Order Family     | Scientific Name                  | Common Name        | Jul-97 | Feb-98 | Jul-98 | Feb-99 | Jul-99 | Feb-00 | Feb-01 | Feb-02 | Feb-03 | Total (all years) | % frequency (n = 9) |
|------------------|----------------------------------|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------------------|---------------------|
| Scolopacidae     | <i>Numenius madagascariensis</i> | Eastern Curlew     | 8      | 52     | 2      | 31     | 5      | 41     | 37     | 32     | 56     | 264               | 100                 |
| Burhinidae       | <i>Burhinus grallarius</i>       | Bush Stone-curlew  | 2      | 2      | 0      | 2      | 1      | 5      | 4      | 2      | 0      | 18                | 78                  |
| Haematopodidae   | <i>Haematopus longirostris</i>   | Pied Oystercatcher | 16     | 11     | 16     | 22     | 17     | 7      | 15     | 10     | 15     | 129               | 100                 |
| Recurvirostridae | <i>Himantopus himantopus</i>     | Black-winged Stilt | 0      | 0      | 0      | 0      | 14     | 0      | 2      | 0      | 0      | 16                | 22.2                |
| Charadriidae     | <i>Vanellus miles</i>            | Masked Lapwing     | 35     | 10     | 48     | 40     | 30     | 30     | 30     | 25     | 39     | 287               | 100                 |
| Laridae          | <i>Sterna caspia</i>             | Caspian Tern       | 7      | 0      | 11     | 0      | 5      | 0      | 0      | 0      | 1      | 24                | 44.4                |
| Laridae          | <i>Sterna bergii</i>             | Crested Tern       | 0      | 12     | 0      | 25     | 44     | 46     | 6      | 0      | 12     | 145               | 67                  |
| Laridae          | <i>Sterna hirundo</i>            | Common Tern        | 0      | 10     | 0      | 25     | 0      | 0      | 0      | 0      | 0      | 35                | 22.2                |
| Laridae          | <i>Sterna albifrons</i>          | Little Tern        | 0      | 2      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 2                 | 11.1                |
| Coraciiformes    |                                  |                    |        |        |        |        |        |        |        |        |        |                   |                     |
| Halcyonidae      | <i>Todiramphus sanctus</i>       | Sacred Kingfisher  | 0      | 0      | 1      | 0      | 0      | 2      | 0      | 0      | 0      | 3                 | 22.2                |

## Appendix 5

List of birds using Brisbane Water estuarine habitats (Morris, 1975; 2003, 2002, 2000, 1999, 1998, 1996; Morris *et al*, 1997) NB Excludes forest bird except for diurnal raptors and forest birds recorded in the targeted estuarine habitats (mudflats, mangroves & saltmarsh)

| Order Family      | Scientific Name                   | Common Name           | Morris (1975)            | CCBR95   | CCBR96                        | CCBR97                            | CCBR98                   | CCBR99  | CCBR00                        | CCBR01  |
|-------------------|-----------------------------------|-----------------------|--------------------------|--|-------------------------------|-----------------------------------|--------------------------|---|-------------------------------|---|
| Phasianidae       | <i>Coturnix ypsilophora</i>       | Brown Quail           |                          |  |                               |                                   | 5 Riley Is.<br>1/3/98    |   |                               |   |
| Anseriformes      |                                   |                       |                          |  |                               |                                   |                          |   |                               |   |
| Anatidae          | <i>Biziura lobata</i>             | Musk Duck             |                          |  |                               |                                   |                          |   | 1 St Hub Is Channle<br>3/1/00 |   |
| Anatidae          | <i>Cygnus atratus</i>             | Black Swan            | May have large flocks    |  |                               |                                   |                          | 9 BW 07/1999  |                               |   |
| Anatidae          | <i>Chenonetta jubata</i>          | Australian Wood Duck  |                          |  |                               |                                   |                          |   |                               | 2 adult + 6 young,<br>Besnville<br>14/11/01                       |
| Anatidae          | <i>Anas platyrhynchos</i> *       | Mallard               |                          | Mainly Woy Woy Bay, St. Hub Is., Blackwall Bay |                               | Mainly Blackall Bay               | 161 2/1998;<br>63 7/1998 | 159 BW 07/1999; br 1 ad+ 5 young 1/3/99; nest+ 12 eggs & F+12 duckling St Hub. Is 8/10/99 | 155 BW 9/2/00                 | 217 Brisbane Water 7/02/01;<br>1 adult+ 6 young Davistown 12/9/01 |
| Anatidae          | <i>Anas superciliosa</i>          | Pacific Black Duck    |                          |  | Present all yr; br Oct-Jan    |                                   |                          |   | 73 BW 02/2000                 |   |
| Anatidae          | <i>Anas gracilis</i>              | Grey Teal             |                          |  |                               |                                   |                          |   |                               |   |
| Anatidae          | <i>Anas castanea</i>              | Chestnut Teal         |                          |  | Present all yr; br J Sep-Feb. | Present all yr; br Jan; Oct & Nov |                          | 52 BW 07/99   | 84 BW 02/2000                 |   |
| Sphenisciformes   |                                   |                       |                          |  |                               |                                   |                          |   |                               |   |
| Spheniscidae      | <i>Eudyptes pachyrhynchus</i>     | Fiordland Penguin     | Ettalong Beach 5/12/07   |  |                               |                                   |                          |   |                               |   |
| Pelecaniformes    |                                   |                       |                          |  |                               |                                   |                          |   |                               |   |
| Anhingidae        | <i>Anhinga melanogaster</i>       | Darter                |                          |  |                               |                                   | Uncommon BW              | All year  |                               |   |
| Phalacrocoracidae | <i>Phalacrocorax melanoleucos</i> | Little Pied Cormorant | Nesting annually Nov-Feb |  |                               |                                   | Max. 74 BW 13/2/98       | All year  |                               |   |
| Phalacrocoracidae | <i>Phalacrocorax varius</i>       | Pied Cormorant        |                          |  |                               |                                   | 29 BW 13/2/98            |   |                               |   |

| Order Family      | Scientific Name                   | Common Name            | Morris (1975)    | CCBR95                                   | CCBR96                                | CCBR97  | CCBR98                                  | CCBR99   | CCBR00   | CCBR01                               |
|-------------------|-----------------------------------|------------------------|------------------|--|---------------------------------------|---|---|--|--|--------------------------------------|
| Phalacrocoracidae | <i>Phalacrocorax sulcirostris</i> | Little Black Cormorant | Nesting colonies |  |                                       |   | 375 BW, mostly Davistown Chanel 13.2.98 | Max. 209 BW 07/1999  |  |                                      |
| Phalacrocoracidae | <i>Phalacrocorax carbo</i>        | Great Cormorant        |                  |  |                                       |   |   | All year   | 39 BW 2/12/00  |                                      |
| Pelecanidae       | <i>Pelecanus conspicillatus</i>   | Australian Pelican     |                  | Max. 200 pr. Br. island in Blackwall Bay | c. 200 pr. br. island in Blackall Bay | Blackwall Bay island 423 ad. & 200 juv. 22/6/97 | 402 BW include c300pr Ramsay island     | 533 BW 02/1999; 100+ nest & 100+juv, Ramsay Is. 29/10/1999 | 569 ad & 250 nests 9/2/00, 60 chicks, 6 pr on egg 21/04/00 Ramsay Island | Max BW 656 7/2/01; nesting Ramsay Is |
| Ciconiiformes     |                                   |                        |                  |  |                                       |   |   |  |  |                                      |
| Areidae           | <i>Egretta novaehollandiae</i>    | White-faced Heron      |                  |  |                                       |   |   |  | 69 BW 9/2/00   |                                      |
| Areidae           | <i>Egretta garzetta</i>           | Little Egret           |                  |  | All year                              |   |   |  |  |                                      |
| Areidae           | <i>Ardea pacifica</i>             | White-necked Heron     |                  |  |                                       |   |   |  |  |                                      |
| Areidae           | <i>Ardea alba</i>                 | Great Egret            |                  |  | All year                              |   |   | All year, max. 14 07/1999                                  | present  |                                      |
| Areidae           | <i>Ardea ibis</i>                 | Cattle Egret           |                  |  |                                       |   |   |  | 8+ @ Cockle Broadwater 1/4/00; 10+ Saratoga wetlands 1/7/00              |                                      |
| Areidae           | <i>Butorides striatus</i>         | Striated Heron         |                  |  | Small no. all year                    | Small no. all year                              |   | All year   |  | Small no.                            |
| Areidae           | <i>Nycticorax caledonicus</i>     | Nankeen Night Heron    |                  |  |                                       |   |   |  |  |                                      |
| Areidae           | <i>Ixobrychus flavicollis</i>     | Black Bittern          |                  |  | Kincumber Ck, Sth side 1995           |   |   |  |  |                                      |
| Threskiornithidae | <i>Threskiornis molucca</i>       | Australian White Ibis  |                  |  | larger no. @ BW                       | 250 Woy Woy 16/7/97                             |   | Small no. all year; max 33 07/1999                         | 92 BW 9/02/00  |                                      |
| Threskiornithidae | <i>Threskiornis spinicollis</i>   | Straw-necked Ibis      |                  |  |                                       |   |   |  | 4+ Saratoga wetlands 1/7/00  |                                      |
| Threskiornithidae | <i>Platelea regia</i>             | Royal Spoonbill        |                  |  |                                       |   | Max 15 BW 07/1998                       | All year, max, 17 BW 07/1999                               |  | 12 Davistown 06/2001                 |

I



| Order Family  | Scientific Name                  | Common Name             | Morris (1975) | CCBR95                                  | CCBR96  | CCBR97 | CCBR98             | CCBR99                             | CCBR00   | CCBR01                          |
|---------------|----------------------------------|-------------------------|---------------|---|---|--------|--------------------|------------------------------------|--|---------------------------------|
| Falconiformes |                                  |                         |               |   |   |        |                    |                                    |  |                                 |
| Accipitridae  | <i>Pandion haliaetus</i>         | Osprey                  |               | Cockle Bay, 5/1991                      | A pair present all yr @ BW, mostly Broadwater, Cockle Bay & Saratoga, nested unsuccessfully Kincumber meadows |        |                    |                                    | 1 Daleys Pt 08-09/2000                         |                                 |
| Accipitridae  | <i>Aviceda subcristata</i>       | Pacific Baza            |               | Cockle Bay NR                           | All yr @ BW; Kincumber Ck, 1995   |        |                    |                                    | 3 Pretty Beach/ Hardys Bay 3/08/00; Empire Bay |                                 |
| Accipitridae  | <i>Elanus axillaris</i>          | Black-shouldered Kite   |               |   |   |        |                    |                                    |  |                                 |
| Accipitridae  | <i>Haliastur sphenurus</i>       | Whistling Kite          |               |   |   |        |                    | Nesting, Cockle Chanel, BW 07/1999 |  |                                 |
| Accipitridae  | <i>Haliastur indus</i>           | Brahiminy Kite          |               | Rare visitor; 12/1993 Kincumber B'water |   |        |                    |                                    |  |                                 |
| Accipitridae  | <i>Haliaeetus leucogaster</i>    | White-bellied Sea-Eagle | 2 pairs nest  |   |   |        |                    |                                    |  |                                 |
| Accipitridae  | <i>Circus approximans</i>        | Swamp Harrier           |               |   |   |        |                    |                                    | 1 Empire Bay 19/02/00                          |                                 |
| Accipitridae  | <i>Accipiter fasciatus</i>       | Brown Goshawk           |               |   |   |        |                    |                                    | 1 Cockle Bay NR 1/05/00                        |                                 |
| Accipitridae  | <i>Accipiter novaehollandiae</i> | Grey Goshawk            |               | Cockle Bay NR                           |   |        |                    |                                    |  |                                 |
| Falconidae    | <i>Falco longipennis</i>         | Australian Hobby        |               | Cockle Bay 29/07/95                     |   |        |                    |                                    |  |                                 |
| Falconidae    | <i>Falco peregrinus</i>          | Peregrine Falcon        |               |   |   |        | 1 Daleys Pt 7/9/98 |                                    |  |                                 |
| Gruiformes    |                                  |                         |               |   |   |        |                    |                                    |  |                                 |
| Rallidae      | <i>Gallirallus philippensis</i>  | Buff-banded Rail        |               |   |   |        |                    |                                    | 1 Rileys Island NR 2/12/00                     | 1 Alkoomie Pl, Davistown 2/3/01 |
| Rallidae      | <i>Porzana tabuensis</i>         | Spotless Crake          |               |   | Kincumber Ck 10/1995  |        |                    |                                    |  |                                 |

| Order Family    | Scientific Name                  | Common Name       | Morris (1975)                                       | CCBR95   | CCBR96   | CCBR97  | CCBR98  | CCBR99   | CCBR00   | CCBR01   |
|-----------------|----------------------------------|-------------------|---|--|--|---|---|--|--|--|
| Charadriiformes |                                  |                   |   |  |  |   |   |  |  |  |
| Scolopacidae    | <i>Limosa lapponica</i>          | Bar-tailed Godwit |   | BW & Cockle B'water  | All year @ BW  | 10 Bensville Wharf, 6/7/97                            |   | 12 BW 02/1999; 16 BW 07/1999   | 8 BW 9/02/00; 55 2/12/00   | 35 BW 7/01   |
| Scolopacidae    | <i>Numenius minutus</i>          | Little Curlew     |   | Rare visitor 04/1995; single                                 |  |   |   |  |  |  |
| Scolopacidae    | <i>Numenius phaeopus</i>         | Whimbrel          |   |  |  | 5 BW 22/6/97  | 7 BW 9/2/98   | 4 BW 02/1999; 1 Bensville Wharf 20/3/99; 1 Palmers Lane, Emp. Bay 19/9/999   | 9 BW 9/02/00; 1 Cockle Bay NR 17/09/00   | 1 Palmers Lane, Bensville 21/1/01; 13 BW 7/2/01  |
| Scolopacidae    | <i>Numenius madagascariensis</i> | Eastern Curlew    | Normally 60 @ BW                                    |  | Seen more regularly @ BW than elsewhere in CC        | 13 Blackwall Bay is 12/10/97; 8 BW overwinter 22/6/97 | 54 BW 9/2/98  | 31 BW 02/1999; 5 BW 07/1999  | 41 BW 9/2/00; 26 BW 2/12/00; 50 Cockle Channel, Davistown 12/12/00   | 37 BW 7/2/01   |
| Scolopacidae    | <i>Tringa nebularia</i>          | Common Greenshank |   | Carawah Res. 02/1995   |  |   |   |  |  |  |
| Burhinidae      | <i>Burhinus grallarius</i>       | Bush Stone-curlew | At least 5 pair Rileys Is.; formerly St Huberts Is. | 13/01/95 Davistown release Rileys Is; 3 St Hub. Is. 16/07/95 | 1 Davistown I garden 19/10/96; 2 St Hub. Is; 2/06/96 | 2 Davistown 22/6/97                                   | 2 Cockle Chanel 9/2.98; 1 Nautical Village, Kincumber 03/98; 2+ br St Hub. Is 11/98 | 2 Cockle Chanel, Davistown 10/2/99; 1 Cockle Chanel, Emp. Bay 1/3/99; 2 St Hub. Is 24/4/99; 1 Emp. Bay 4/7/99; 1 Cockle Bay NR 17/8/99; Willaroo Ave (call), Saratoga 23/11/99; Br Nest + 2 egg (5/10/99), 2 ad + 2 young (29/11/99) St Hub Is | 1 01/2000 & 3 11/10/00 Saratoga; 3 St Hu. Is, 9/02/00, 2 23/07/00; 2 Cockle Channel, Davistown 9 /02 & 1/05/00; Alkoomie Close (call) Davistown 2-9/05/00, 21/08/00, 19/09/00 & 31/10/00; Daleys Pt (call) 08/00-09; 2 ad & 2 young St Hub. Is, 30/1/00; on eggs 16/9/00; 2 young 28/10/00 | At least 8 pairs around BW (Alkoomie Close Davistown; Cockle Bay wetlands; St Huberst island; Davistown rd, Davisotonw; Nautical Village, Kincumber) |

| Order Family     | Scientific Name                | Common Name           | Morris (1975)                                     | CCBR95                                 | CCBR96 | CCBR97                    | CCBR98  | CCBR99   | CCBR00   | CCBR01   |
|------------------|--------------------------------|-----------------------|---|--|--------|---------------------------|---|--|--|--|
| Haematopodidae   | <i>Haematopus longirostris</i> | Pied Oystercatcher    |   | 2 pr BW (Woy Woy); 1 pr Cockle B'water |        | All year, max. 16 22/6/97 | 13 at 9/2/98<br>16 at 07/1998; 4 Woy Woy 22/8/98; Nesting Blackwater Bay 19/9/98; suggest 8 pr BW | 22 BW 10/2/99; 17 BW 07/1999                     | 7 BW 9/02/99, 10 on 2/12/99; est. 8 pr BW                  | 15 BW 7/2/01   |
| Haematopodidae   | <i>Haematopus fuliginosus</i>  | Sooty Oystercatcher   |   |  |        |                           |   |  | 1 Cockle Channle, Davistown 31/10/99                       |  |
| Recurvirostridae | <i>Himantopus himantopus</i>   | Black-winged Stilt    |   |  |        |                           |   | 14 BW, mostly Cockle Broadwater 07/1999          |  |  |
| Charadriidae     | <i>Pluvialis fulva</i>         | Pacific Golden Plover | Kooragang Is (350, L. Mac. (120), lesser no. @ BW |  |        |                           |   |  |  |  |
| Charadriidae     | <i>Vanellus miles</i>          | Masked Lapwing        |   |  |        |                           |   | 48 BW 02/1999                                    |  | Br, Davistown  |
| Laridae          | <i>Sterna caspia</i>           | Caspian Tern          |   | 1-2 BW                                 | BW     | 7 bW 22/6/97              | 11 BW 07/98; 4 Ettalong 8/11/98   | 5 Woy Woy Chanel 07/1999; possible absent summer | Generally absent summer in BW; 1 Saratoga wetlands 1/07/99 |  |
| Laridae          | <i>Sterna hirundo</i>          | Common Tern           |   |  |        |                           | Last date 13/2/98 Ettalong  |  |  |  |
| Strigiformes     |                                |                       |   |  |        |                           |   |  |  |  |
| Strigidae        | <i>Ninox novaeseelandiae</i>   | Southern Boobook      |   |  |        |                           |   |  |  | 2 Alkoomie Pl, Davistown 3-7/01/2001, 12-18/09/01; few breeding sites in urban/mangrove habitats |

| Order Family  | Scientific Name              | Common Name       | Morris (1975) | CCBR95                                  | CCBR96        | CCBR97    | CCBR98                           | CCBR99  | CCBR00   | CCBR01                                     |
|---------------|------------------------------|-------------------|---------------|---|---------------|-----------|----------------------------------|---|--|--|
| Coraciiformes |                              |                   |               |   |               |           |                                  |   |  |  |
| Halcyonidae   | <i>Todiramphus sanctus</i>   | Sacred Kingfisher |               |   |               |           |                                  | 1 St. Hub Is mangrove 24/4/99; 1 Cockle Bay 13/6/99 | 1 Bensville Wharf 1/4/99, 1 Davistown 1/5/99; 2 overwinter @ Saratoga 24/6-1/7/99, 1 Davistown 18/5/99 | 1 overwinter Palmers Lan, Emp. Bay 28/4/01 |
| Passeriformes |                              |                   |               |   |               |           |                                  |   |  |  |
| Maluridae     | <i>Stipiturus malachurus</i> | Southern Emu-wren |               | Cockle Bay                              |               |           | 4+ Cockle Bay NR 30/4/98         |   | 4 Cockle Bay NR  |  |
| Pardalotidae  | <i>Gerygone levigaster</i>   | Mangrove Gerygone |               | Known Saratoga & Carawah Bay; 0 in 1995 | 0 record 1996 | 0 in 1997 | 2 Cockle Chanel 1/3/98, 0 in Jul | 2 Brickwharf Rd, Woy Woy 4/10/99                    | 2 Saratoga, 2/02, 24/06 & 2/12/2000; 1 St Hub. Is 23/07/2000   |  |
| Meliphagidae  | <i>Lichmera indistincta</i>  | Brown Honeyeater  |               |   |               |           |                                  |   | 1 Magnolia Ave, Davistown 29/10/99, in mangroves   |  |

## **Appendix 6**

Species in Brisbane Water listed on JAMBA and CAMBA treaties

| <i>Scientific Name</i>           | <i>Common Name</i>      | Jamba | Camba |
|----------------------------------|-------------------------|-------|-------|
| <i>Puffinus tenuirostris</i>     | Short-tailed Shearwater | J     |       |
| <i>Ardea ibis</i>                | Cattle Egret            | J     | C     |
| <i>Ardea alba</i>                | Great Egret             | J     | C     |
| <i>Gallinago hardwickii</i>      | Latham's Snipe          | J     | C     |
| <i>Limosa limosa</i>             | Black-tailed Godwit     | J     | C     |
| <i>Limosa lapponica</i>          | Bar-tailed Godwit       | J     | C     |
| <i>Numenius minutus</i>          | Little Curlew           | J     | C     |
| <i>Numenius phaeopus</i>         | Whimbrel                | J     | C     |
| <i>Numenius madagascariensis</i> | Eastern Curlew          | J     | C     |
| <i>Tringa stagnatilis</i>        | Marsh Sandpiper         | J     | C     |
| <i>Tringa nebularia</i>          | Common Greenshank       | J     | C     |
| <i>Xenus cinereus</i>            | Terek Sandpiper         | J     | C     |
| <i>Actitis hypoleucos</i>        | Common Sandpiper        | J     |       |
| <i>Heteroscelus brevipes</i>     | Grey-tailed Tattler     | J     |       |
| <i>Arenaria interpres</i>        | Ruddy Turnstone         | J     | C     |
| <i>Calidris canutus</i>          | Red Knot                | J     | C     |
| <i>Calidris alba</i>             | Sanderling              | J     | C     |
| <i>Calidris ruficollis</i>       | Red-necked Stint        | J     | C     |
| <i>Calidris acuminata</i>        | Sharp-tailed Sandpiper  | J     | C     |
| <i>Calidris ferruginea</i>       | Curlew Sandpiper        | J     | C     |
| <i>Limicola falcinellus</i>      | Broad-billed Sandpiper  | J     | C     |
| <i>Pluvialis fulva</i>           | Pacific Golden Plover   |       |       |
| <i>Pluvialis squatarola</i>      | Grey Plover             | J     | C     |
| <i>Charadrius mongolus</i>       | Lesser Sand Plover      | J     | C     |
| <i>Sterna caspia</i>             | Caspian Tern            |       | C     |
| <i>Sterna bergii</i>             | Crested Tern            | J     |       |
| <i>Sterna hirundo</i>            | Common Tern             | J     | C     |
| <i>Sterna albifrons</i>          | Little Tern             | J     | C     |
| <i>Haliaeetus leucogaster</i>    | White-bellied Sea-Eagle |       | C     |
| TOTAL                            |                         | 26    | 24    |

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## Appendix 7

Annotated list of waders recorded for Brisbane Water

## Annotated wader list

### Waders (regularly observed)

#### Bar-tailed Godwit (*Limosa lapponica*)

This migratory species is recorded regularly at Brisbane Water (Figure 5) (Morris unpublished data, 1997-2003) and some can over-winter here (Appendix 5) (Morris, 1998, 2000; Morris *et al*, 1997). It was the second most frequently recorded wader during the early autumn survey (Figure 3). The largest count for the estuary is 55 individuals (2/12/2000) (Morris, 2002a). Sites observed for this species include mudflats near Erina GCC depot, Saratoga wetlands, Lintern Channel, Bensville and the estuarine waterbody mudflats at Empire Bay and Lintern Channel. Other sites Bar-tailed Godwits are recorded include Ramsay Island (Woy Woy) Palmers Lane (Empire Bay), Alkoomie Close and Magnolia Street wetland (Davistown), Rileys Bay (Appendix 5)(Morris, 2002a; Morris, 1998; Birds Australia, 2006).

It is regularly observed on oyster leases and occasionally on private jetties though the use of these artificial habitats has yet to be quantified. On several occasions it was disturbed by boats and people walking dogs of the leash.

#### Whimbrel (*Numenius phaeopus*)

This migratory species is recorded regularly at Brisbane Water though not every year (Figure 5) (Morris unpublished data, 1997-2003). It is reported to roost on saltmarsh at Brisbane Water (Department of Environment & Planning, 1983) though none were recorded in that habitat during the autumn survey. During that survey it was mostly recorded on mudflats (Erina GCC depot, Saratoga wetlands, Lintern Channel, Hardy's Bay, and Bensville) though it was once recorded in mangroves (Saratoga). Other sites recorded for this species includes Bensville, Cockle Channel (Davistown), Cockle Bay NR (Appendix 5)(Morris, 2000, 2002a, 2003), Burge Reserve (Woy Woy) Cockle Bay south and Palmers Lane (Empire Bay), Alkoomie Close (Davistown), Kincumber (Appendix 5)(Morris, 2002a; Morris, 1998; Birds Australia, 2006; Warman, 2004).

The maximum count is 13 individuals for Brisbane Water (Appendix 4) (Morris unpublished data, 1997-2003). This species was also observed roosting on oyster leases and private jetties.

#### Eastern Curlew (*Numenius madagascariensis*)

This migratory species is recorded regularly at Brisbane Water (Figure 5)(Morris unpublished data, 1997-2003) and was the most frequently encountered migratory wader during the autumn survey (Figure 3) and some individuals are known to overwinter in the estuary (Morris, 1998, 2000). Eastern Curlew counts vary (see Appendix 4, 5) but normally about 60 are in Brisbane Water (Morris, 1975) and are said to be seen more regularly here than elsewhere in the Central Coast (Appendix 5)(Morris *et al*, 1997). The largest count for the estuary in recent times was 56 individuals (Appendix 4) (Morris unpublished data, 1997-2003).

The habitats recorded for Eastern Curlews during the autumn survey include estuarine waterbody mudflats (Empire Bay, Lintern Channel) though is more frequently recorded on mudflats (Erina GCC depot, Empire Bay, Saratoga wetlands, Lintern Channel, Cockle Bay, Bensville) and once on



saltmarsh (Cockle Bay NR). Other sites include Cockle Channel (Davistown) Blackwall Bay, Ramsay Island and Burge Reserve (Woy Woy) Cockle Bay and Palmers Lane (Empire Bay), St Hubert's Island, Rileys Island, Alkoomie Close and Magnolia Street wetland (Davistown) (Appendix 5)(Morris, 2002a; Morris, 1998; Birds Australia, 2006).

This species is considered globally Near Threatened (Wetlands International, 2005).

**Bush Stone-curlew (*Burhinus grallarius*)**

See threatened species (section 4.2.1.1.)

**Pied Oystercatcher (*Haematopus longirostris*)**

See threatened species (section 4.2.1.8.)

**Masked Lapwing (*Vanellus miles*)**

This resident wader species is recorded regularly at Brisbane Water (Figure 5) (Morris unpublished data, 1997-2003) and was the most frequently recorded wader during the autumn surveys (Figure 3). On average it has the highest count of all the waders with maximum count of 48 individuals (Figure 6) (Morris unpublished data, 1997-2003) and is known to breed in Brisbane Water estuary (Davistown) (Morris, 2003). It is mostly regularly recorded on mudflats (Erina GCC depot, Saratoga wetlands, Saratoga, Lintern Channel, Empire Bay, Hardy's Bay, Pretty Beach), occasionally on estuarine waterbody mudflats (Wagstaff, Lintern Channel, Empire Bay) and rarely on saltmarsh (Cockle Bay NR). Other sites it has been recorded include Cockle Bay and Palmers Lane (Empire Bay), St Hubert's Island, Davistown (Alkoomie Close and Magnolia Street wetland) and Kincumber (Appendix 5)( Birds Australia, 2006).

**Waders (Irregularly observed)**

**Latham's Snipe (*Gallinago hardwickii*)**

This migratory wader is rarely recorded in Brisbane Water and is documented for Kincumber Creek (O'Toole cited Warman, 2004) and St Hubert's Island (Birds Australia, 2006). After breeding in Japan (Higgins & Davies, 1996) most of the world population moves through NSW and arrives in southern Australian states in August with peaks in October-November (Smith, 1991). In NSW it occurs on the coast, inland and western slopes and occasionally on western plains and inland rivers; it has been suggested that it is mainly a passage migrant north of the Hunter River (Higgins & Davies, 1996).

Its habitat in Australia are permanent and ephemeral wetlands preferring open freshwater wetlands with nearby cover however it will use brackish habitats such as saltmarsh and mangrove creeks (Higgins & Davies, 1996). Elsewhere the author has observed it on a Beaded Glasswort saltmarsh among high marsh species or in scattered high marsh fringing Swamp Oak forest in grazing lands. There are suitable sites scattered elsewhere in Brisbane Water e.g. Erina Creek saltmarsh.

**Black-tailed Godwit (*Limosa limosa*)**

See threatened species (section 4.2.1.4.)

**Little Curlew (*Numenius minutus*)**

This migratory wader though generally abundant in Australia (180,000) (Wetland International, 2005) is however rare in the Brisbane Water with one record (04/1995) (Morris, 1996). Its Australian habitats includes short, dry grasslands and sedgeland with scattered freshwater pools and can use artificially created short grass (e.g. mown lawns; ovals) though occasionally uses dry saltmarshes or tidal flats of estuaries (Higgins & Davies, 1996).

**Marsh Sandpiper (*Tringa stagnatilis*)**

This migratory wader though generally abundant in Australia (100,000) (Wetland International, 2005) is however rare in the Brisbane Water with only two records, one at Kincumber Creek (O'Toole cited Warman, 2004) and Cockle Bay (south) (25/11/2001) (Birds Australia, 2006). Its Australian habitats are permanent and ephemeral wetlands of varying salinity but include saltmarshes and intertidal mudflats but infrequently around mangroves in southeast Australia (Higgins & Davies, 1996). It forages usually in the shallow water at edge of wetlands (Higgins & Davies, 1996).

**Common Greenshank (*Tringa nebularia*)**

This migratory species is rarely recorded in Brisbane Water with one record at Carawah Reserve (West Gosford) (Morris, 1996) and another at Palmers Lane (Empire Bay) (28/02/2004) (Birds Australia, 2006). Its Australian habitats vary to include coastal and inland wetlands of varying salinity but incorporate sheltered coastal habitats typically with large mudflats, saltmarsh, mangroves or seagrass in harbours and river estuaries, deltas and lagoons (Higgins & Davies, 1996).

**Terek Sandpiper (*Xenus cinereu*)**

See threatened species (section 4.2.1.11.)

**Common Sandpiper (*Actitis hypoleucos*)**

Reported by Department of Environment & Planning (1983) on shingle beaches of Riley and St Hubert Islands however there are no recent records of this migratory wader in Brisbane Water. Its Australian habitats are a wide range of inland and coastal habitats of variable salinity; mainly muddy margins or rocky shores of wetlands (Higgins & Davies, 1996). Large coastal flats are not favoured but can use narrow, muddy, even steep margins of mangroves and sometimes in muddy areas littered with snags and rocks (Higgins & Davies, 1996). Generally forages in soft substrate at margins of wetlands and often where obstacles such as rocks or mangrove rocks project from substrate (Higgins & Davies, 1996). Common Sandpipers mostly roosts or loafs on rocks, or on roots and branches of vegetation, especially mangroves (Higgins & Davies, 1996).

**Grey-tailed Tattler (*Heteroscelus brevipes*)**

This migratory species is said to be a common visitor to Brisbane Water where it feeds in shallows and roosts on oyster leases (Department of Environment & Planning, 1983) however on available data it is not always recorded in the estuary; for example it was not recorded during regular surveys (Morris unpublished data, 1997-2003). During the autumn surveys it was infrequently observed (< 5% samples)(Figure 4) and was recorded on mudflats adjacent to waterfront housing (Saratoga; Empire Bay) or mudflats adjacent to mangroves (Empire Bay) where the highest count was recorded (12 individuals) and where it was also observed roosting and foraging among oyster leases. At

Saratoga it was observed foraging among seagrass wrack, roosting on exposed rocks and utilising the cover of some woody debris among the seagrass.

It has also been recorded at Lintern Channel (6/08/2002), Palmers Lane (Empire Bay) (28/02/2004) and Empire Bay wharf (4/12/2004) (Birds Australia, 2006).

### **Ruddy Turnstone (*Arenaria interpres*)**

This migratory species is reported by EPA (1994) for Brisbane Water however from available data there are no other records for this species. Its Australian habitats are mainly exposed rock platforms and shelves and often with tidal pools and rocky, gravel or shingle beaches and is occasionally in estuaries, bays, lagoons among saltmarsh or on exposed seagrass beds and on mudflats; in southern Australia its preference is for rockier coastlines (Higgins & Davies, 1996). It is only expected to be a rare visitor to Brisbane Water and its confirmed presence there awaits future observation. The rocky shores were not sampled during the autumn surveys however the Hawkesbury Sandstone and Terrigal Formation rocky shoreline may not be suitable habitat.

### **Red Knot (*Calidris canutus*)**

The migratory Red Knot is rare to Brisbane Water with no data available though it has been recorded in the estuary (Alan Morris pers. comm.). Red Knot habitats in Australia are mainly intertidal mudflats, sandflats and sandy beaches of sheltered coasts in estuaries, bays, lagoons and harbours (Higgins & Davies, 1996). It usually forages in soft substrates near the edge of water or on mudflats exposed at low tides including on beds of exposed eelgrass; they roost on sandy beaches, spits, islets and mudflats (Higgins & Davies, 1996). It is not reported by Higgins and Davies (1996) to roost on artificial habitats.

### **Sanderling (*Calidris alba*)**

See threatened species (section 4.2.1.9.)

### **Red-necked Stint (*Calidris ruficollis*)**

The Red-necked Stint is reported for Brisbane Water (EPA, 1994) however there is only one record for this tiny migratory species at Cockle Bay, [south] (Empire Bay) on the 22/01/2000 (Birds Australia, 2006). The habitats in Australia are mostly coastal, including sheltered bays, lagoons and estuaries on mudflats and often near protected spits, islets and banks (Higgins & Davies, 1996).

Red-necked Stints mostly forages on bare wet mud on tidal flats or in shallow water and mostly in areas with film of surface water < 2.5cm deep and <30cm from water edge (Higgins & Davies, 1996). May also forage in non-tidal wetlands during high tide where they feed in wet mud above water edge or in shallow water; may also forage in saltmarsh and generally avoid beds of seagrass though may feed at its edge (Higgins & Davies, 1996). Red-necked Stints roost on sheltered beaches, spits, banks or islets of sand, mud or shingle and often in saltmarsh or other vegetation (Higgins & Davies, 1996). It is not reported by Higgins and Davies (1996) to roost on artificial habitats.

### **Sharp-tailed Sandpiper (*Calidris acuminata*)**

The migratory Sharp-tailed Sandpiper is reported to feed on mudflats at Saratoga and Riley Island and on saltmarsh after rain (Department of Environment & Planning, 1983). There have been few

records of Sharp-tailed Sandpiper in Brisbane Water except for recent observations in Cockle Bay NR and Empire Bay (Palmers Lane). During the autumn survey an individual was observed in Cockle Bay NR (east of Kendall Road) foraging on the mud on the edge of a saltpan creek (14/03/2006) which when startled ran to the opposite shore to use uncanopied exposed pneumatophores of Grey Mangrove as cover. There have been three other records at Cockle Bay [south] (26/01/2002, 31/08/2002, 26/10/2002) and one at Palmers Lane (7/08/2002) (Birds Australia, 1996).

Sharp-tailed Sandpiper habitat preferences in Australia are muddy edges of freshwater or brackish wetlands with inundated or emergent low open vegetation such as sedges, grass and saltmarsh (Higgins & Davies, 1996) with the saltmarsh and brackish wetland habitat attributes clearly met at Cockle Bay. Sharp-tailed Sandpipers occasionally use intertidal mudflats in sheltered bays, inlets and estuaries (Higgins & Davies, 1996) and it has been suggested that they may occupy inter-tidal mudflats between December and March in southern Australia after inland wetlands have dried (Lane, 1987). There is evidence for this in a study undertaken at Westernport (Victoria) where there was an increase of Sharp-tailed Sandpipers during the dry than after inland wetlands become available after rains (Dann *et al*, 1994) though this relationship has not been reported for coastal NSW. It forages in shallow water and mud at the edges of wetlands or islets and can be close to low fringing or emergent vegetation (Higgins & Davies, 1996) where they may roost (Smith, 1991). It is not reported by Higgins and Davies (1996) to roost on artificial habitats.

### **Curlew Sandpiper (*Calidris ferruginea*)**

Curlew Sandpipers have been documented for Brisbane Water (EPA, 1994) though considered uncommon (Department of Environment & Planning, 1983). Curlew Sandpipers have been noted for Rileys Island (Department of Environment & Planning, 1983) though the only recent record for Brisbane Water is at Cockle Bay [south](28/09/2002) (Birds Australia, 2006). The habitat in Australia is mainly intertidal mudflats in estuaries, bays and lagoons but they can use non-tidal wetlands (Higgins & Davies, 1996).

Foraging occurs on mudflats and nearby shallow water while in non-tidal wetlands Curlew Sandpipers can wade in water up to 60mm deep but usually in water 15-30mm deep (Higgins & Davies, 1996). Curlew Sandpipers forage at the edge of shallow pools and drainage line of intertidal mudflats and sandy shores Curlew Sandpipers (Higgins & Davies, 1996). During high tides, Curlew Sandpipers feed among low sparse emergent vegetation such as saltmarsh (Higgins & Davies, 1996). Roosting is generally on dry shingle, shell or sand beaches, sand spits and islets in, or around coastal or near-coastal wetlands (Higgins & Davies, 1996). It is not reported by Higgins and Davies (1996) to roost on artificial habitats.

### **Broad-billed Sandpiper (*Limicola falcinellus*)**

See threatened species (section 4.2.1.5.)

### **Sooty Oystercatcher (*Haematopus fuliginosus*)**

See threatened species (section 4.2.1.10)

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**Black-winged Stilt (*Himantopus himantopus*)**

This resident wader isn't frequently recorded on Brisbane Water (Figure 5) and usually in small numbers (Figure 6) (Morris unpublished data, 1997-2003). Many of the records are from Cockle Broadwater (07/1999)(Morris, 2000), also at Davistown (Close and Magnolia Street wetland), Cockle Bay [south](Empire Bay)(Birds Australia, 2006) and Kincumber Broadwater (near Eulalia Wharf and South Kincumber) where it was foraging on mudflats and in shallow water at edges of mangrove mudflats (author pers. obs.).

Black-winged Stilts prefer open shallow freshwater wetlands \especially those with dense growth of short vegetation (Marchant & Higgins, 1993) and are known from other wetlands in the Central Coast where their numbers are higher (Morris, 2003). Black-winged Stilts roost in shallow water or on islets and banks in sheltered wetlands and sandflats in estuaries (Marchant & Higgins, 1993)

**Pacific Golden Plover (*Pluvialis fulva*)**

The migratory Pacific Golden Plovers have been documented for Brisbane Water (Morris, 1975; EPA, 1994) and are always seen in summer (Department of Environment & Planning, 1983) though there are no recent records for them in Brisbane Water. An early record documents them on a shingle beach at Empire Bay (Department of Environment & Planning, 1983). It would seem that this migratory wader is rare on the Brisbane Water.

Pacific Golden Plovers are rarely inland and are usually coastal where they use sandy, muddy and rocky shores, estuaries, lagoons, reefs, saltmarsh and short grass in paddocks (Marchant & Higgins, 1993). They can occur among mangroves or exposed seagrass beds, saltmarsh with sparse or low Beaded Glasswort (Marchant & Higgins, 1993). Pacific Golden Plovers roost near foraging areas on beaches, spits, islets, rocky points and sometimes under shrubs and trees (Marchant & Higgins, 1993).

**Grey Plover (*Pluvialis squatarola*)**

Grey Plovers have been documented for Brisbane Water (EPA, 1994) and are recorded on a shingle beach at Empire Bay (Department of Environment & Planning, 1983) though there are no recent records for them in Brisbane Water and it would seem that this migratory wader is rare visitor in this estuary. Furthermore most NSW record for this species is when they are transient and enroute to southern Australia though some may stay for summer (Smith, 1991). With an estimated ten individuals in mid-summer for NSW (Smith, 1991) would indicate that this species is rare also in this state.

In Australia this migratory wader is mostly coastal on marine shores, islets, estuaries and lagoons where there are nearby large tidal or sand flats where they forage (Marchant & Higgins, 1993). Grey Plovers also use rocky coasts and rock platforms and beaches with abundant seaweed wrack as habitat (Marchant & Higgins, 1993).

**Lesser Sand Plover (*Charadrius mongolus*)**

See threatened species (section 4.2.1.6.)

**Black-fronted Dotterel (*Elseyornis melanops*)**

This resident wader is the most widespread wader in Australia (Marchant & Higgins, 1993) though there are few records for Brisbane Water. Black-fronted Dotterels has been documented at Rileys Island and there is suggestion that it may be a resident breeding wader in Brisbane Water (Department of Environment & Planning, 1983) though there is no evidence of that in available literature. Recent sightings are in the Empire Bay area (Palmer Lane 5/05/1999, 7/08/2002 & 28/09/2002; Cockle Bay [south] 10/04/1999) (Birds Australia, 2006).

Black-fronted Dotterels habitat preferences are for freshwater wetlands and are rarely on tidal mudflats or inter-tidal pools and are rarely recorded in estuarine habitats (Higgins & Davies, 1996). Black-fronted Dotterels are known to roost along rivers and among saltmarsh and on mud besides ponds (Higgins & Davies, 1996).

**Red-kneed Dotterel (*Erythrogonys cinctus*)**

This resident wader prefers temporary or permanent freshwater wetlands and are rarely at brackish or saline wetlands though have been known to use saltmarsh (Marchant & Higgins, 1993). Red-kneed Dotterels generally avoid tree-lined wetlands and is often found in open areas among scattered or emergent vegetation such as short (< 12cm) grass tussocks, reeds, rushes and dense clumps of bush including saltmarsh species (Marchant & Higgins, 1993). These tiny dotterels avoid pebbly shores and stretches of bare mud or dry ground (Marchant & Higgins, 1993).

There is only one record of a Red-kneed Dotterel in Brisbane Water and that's at Cockle Bay [south] at Empire Bay (28/09/2002)(Birds Australia, 2006).

**Banded Lapwing (*Vanellus tricolour*)**

This endemic wader is recorded throughout NSW but less common east of the Great Dividing Range (Marchant & Higgins, 1993). Its habitats include open short grasslands, agricultural lands, saline herblands and open woodlands (Marchant & Higgins, 1993). In eastern Australia it is suggested that Banded Lapwings prefer drier habitats and are not dependent on wetlands (Marchant & Higgins, 1993). Marchant and Higgins (1993) review of this species habitat does not document its use of estuarine habitats. There is one record of Banded Lapwings in the Brisbane Water estuary at Cockle Bay [south](1/03/1999)(Birds Australia, 2006) thus making it rare at the estuary however it is generally a rare visitor to the Central Coast where there are three other records (Morris, 2003).

## Appendix 8

Changes in the Australian distribution of birds recorded in the Brisbane Water Estuary (data source: Barrett *et al*, 2003)

| Common Name              | National   | % Change | Sydney Basin          |
|--------------------------|--|----------|-----------------------|
| Black-tailed Godwit      | Declining (no regional variation)  | -35      | Not provided          |
| Pacific Golden Plover    | Declining (no regional variation)  | -33      | Not provided          |
| Terek Sandpiper          | Declining (no regional variation)  | -29      | Not provided          |
| Curlew Sandpiper         | Declining (no regional variation)  | -26      | Not provided          |
| White-necked Heron       | Declining species (regional variation)                                       | -58      | > 20% decrease        |
| Nankeen Kestrel          | Declining species (regional variation)                                       | -44      | >20% decrease         |
| Brown Falcon             | Declining species (regional variation)                                       | -38      | >20% decrease         |
| Lesser Sand Plover       | Declining species (regional variation)                                       | -37      | >20% decrease         |
| Great Cormorant          | Declining species (regional variation)                                       | -31      | Not provided          |
| Wedge-tailed Eagle       | Declining species (regional variation)                                       | -28      | >20% decrease         |
| Sharp-tailed Sandpiper   | Declining species (regional variation)                                       | -24      | >20% decrease         |
| Nankeen Night Heron      | Declining species (regional variation)                                       | -17      | Insufficient data     |
| Whistling Kite           | Declining species (regional variation)                                       | -16      | > 20% decrease        |
| Little Eagle             | Declining species (regional variation)                                       | -14      | No significant change |
| White-faced Heron        | Declining species (regional variation)                                       | -13      | >20% decrease         |
| Eastern Rosella          | Increasing (no regional variation)   | 14       | Not provided          |
| Sanderling               | Increasing (no regional variation)   | 35       | Not provided          |
| Marsh Sandpiper          | Increasing (no regional variation)   | 41       | Insufficient data     |
| Buff-banded Rail         | Increasing (no regional variation)   | 88       | Not provided          |
| Willie Wagtail           | Increasing (regional variation)  | 11       | No significant change |
| Brown Goshawk            | Increasing (regional variation)  | 28       | > 20% increase        |
| Crested Pigeon           | Increasing (regional variation)  | 28       | >20 % increase        |
| Pacific Black Duck       | Increasing (regional variation)  | 29       | >20% increase         |
| Darter                   | Increasing (regional variation)  | 29       | No significant change |
| Australian Wood Duck     | Increasing (regional variation)  | 32       | >20% increase         |
| Sacred Kingfisher        | Increasing (regional variation)  | 33       | > 20% decrease        |
| White-bellied Sea-Eagle  | Increasing (regional variation)  | 35       | No significant change |
| Grey Butcherbird         | Increasing (regional variation)  | 38       | >20% increase         |
| Sulphur-crested Cockatoo | Increasing (regional variation)  | 40       | >20 % increase        |
| Purple Swamphen          | Increasing (regional variation)  | 41       | No significant change |
| Australian Raven         | Increasing (regional variation)  | 43       | No significant change |
| Little Grassbird         | Increasing (regional variation)  | 48       | No significant change |
| Collared Sparrowhawk     | Increasing (regional variation)  | 49       | Insufficient data     |
| Chestnut Teal            | Increasing (regional variation)  | 50       | >20% increase         |
| Silvereye                | Increasing (regional variation)  | 58       | No significant change |
| Yellow Thornbill         | Increasing (regional variation)  | 64       | > 20% increase        |
| Superb Fairy-wren        | Increasing (regional variation)  | 64       | No significant change |
| Intermediate Egret       | Increasing (regional variation)  | 70       | >20% decrease         |
| Brown Honeyeater         | Increasing (regional variation)  | 81       | > 20% increase        |
| White-browed Scrubwren   | Increasing (regional variation)  | 91       | No significant change |
| Grey Plover              | No significant change  | -11      | Not provided          |
| Mangrove Gerygone        | No significant change  | 38       | Not provided          |
| Little Tern              | No significant change (regional variation & reporting rates)                 | -10      | Not provided          |
| Bar-tailed Godwit        | No significant change (regional variation & reporting rates)                 | -2       | Not provided          |
| Cattle Egret             | No significant change (regional variation & reporting rates)                 | 0        | Not provided          |
| Common Sandpiper         | No significant change (regional variation & reporting rates)                 | 1        | Not provided          |
| Australasian Gannet      | No significant change (regional variation & reporting rates)                 | 2        | Not provided          |
| Red-necked Stint         | No significant change (regional variation & reporting rates)                 | 3        | Not provided          |
| Grey-tailed Tattler      | No significant change (regional variation & reporting rates)                 | 4        | Not provided          |
| Sooty Oystercatcher      | No significant change (regional variation & reporting rates)                 | 13       | Not provided          |
| Eastern Curlew           | No significant differences (reporting rates); significant regional variation | -28      | > 20% decrease        |
| Latham's Snipe           | No significant differences (reporting rates); significant regional variation | -23      | > 20% decrease        |
| Short-tailed Shearwater  | No significant differences (reporting rates); significant regional variation | -23      | No significant change |
| Southern Emu-wren        | No significant differences (reporting rates); significant regional variation | -21      | > 20 % decrease       |
| Rock Dove                | No significant differences (reporting rates); significant regional variation | -17      |                       |
| Great Egret              | No significant differences (reporting rates); significant regional variation | -14      | > 20 % decrease       |



| Common Name               | Birds of the Brisbane Water Estuary  | % Change | Sydney Basin          |
|---------------------------|--|----------|-----------------------|
| Australian Pelican        | No significant differences (reporting rates); significant regional variation | -14      | No significant change |
| Straw-necked Ibis         | No significant differences (reporting rates); significant regional variation | -13      | > 20 % decrease       |
| Fairy Martin              | No significant differences (reporting rates); significant regional variation | -13      | > 20% decrease        |
| Silver Gull               | No significant differences (reporting rates); significant regional variation | -11      | No significant change |
| Common Tern               | No significant differences (reporting rates); significant regional variation | -10      | Not provided          |
| Black-shouldered Kite     | No significant differences (reporting rates); significant regional variation | -7       | > 20% decrease        |
| Common Greenshank         | No significant differences (reporting rates); significant regional variation | -7       | > 20% decrease        |
| Black-winged Stilt        | No significant differences (reporting rates); significant regional variation | -5       | > 20% decrease        |
| Grey Teal                 | No significant differences (reporting rates); significant regional variation | -5       | >20% decrease         |
| Black-fronted Dotterel    | No significant differences (reporting rates); significant regional variation | -4       | > 20% decrease        |
| Greater Sand Plover       | No significant differences (reporting rates); significant regional variation | -4       | Insufficient data     |
| Black-faced Cuckoo-shrike | No significant differences (reporting rates); significant regional variation | -4       | No significant change |
| Australian Magpie         | No significant differences (reporting rates); significant regional variation | -4       | No significant change |
| Little Black Cormorant    | No significant differences (reporting rates); significant regional variation | -3       | > 20% decrease        |
| Whimbrel                  | No significant differences (reporting rates); significant regional variation | -3       | > 20% decrease        |
| Crested Tern              | No significant differences (reporting rates); significant regional variation | -2       | No significant change |
| Ruddy Turnstone           | No significant differences (reporting rates); significant regional variation | 0        | > 20% decrease        |
| Osprey                    | No significant differences (reporting rates); significant regional variation | 0        | Insufficient data     |
| Brahminy Kite             | No significant differences (reporting rates); significant regional variation | 0        | Insufficient data     |
| Grey Goshawk              | No significant differences (reporting rates); significant regional variation | 0        | Insufficient data     |
| Magpie-lark               | No significant differences (reporting rates); significant regional variation | 0        | No significant change |
| Welcome Swallow           | No significant differences (reporting rates); significant regional variation | 0        | No significant change |
| Pied Cormorant            | No significant differences (reporting rates); significant regional variation | 3        | No significant change |
| Little Pied Cormorant     | No significant differences (reporting rates); significant regional variation | 6        | No significant change |
| Pied Oystercatcher        | No significant differences (reporting rates); significant regional variation | 7        | No significant change |
| Noisy Miner               | No significant differences (reporting rates); significant regional variation | 10       | > 20% increase        |
| Masked Lapwing            | No significant differences (reporting rates); significant regional variation | 10       | No significant change |
| Laughing Kookaburra       | No significant differences (reporting rates); significant regional variation | 11       | No significant change |
| Little Egret              | No significant differences (reporting rates); significant regional variation | 13       | > 20% decrease        |
| Australian White Ibis     | No significant differences (reporting rates); significant regional variation | 14       | > 20 % decrease       |
| Swamp Harrier             | No significant differences (reporting rates); significant regional variation | 14       | > 20% decrease        |
| Royal Spoonbill           | No significant differences (reporting rates); significant regional variation | 18       | > 20 % decrease       |
| Caspian Tern              | No significant differences (reporting rates); significant regional variation | 18       | > 20% increase        |
| Musk Duck                 | No significant differences (reporting rates); significant regional variation | 20       | Insufficient data     |
| Black Swan                | No significant differences (reporting rates); significant regional variation | 20       | No significant change |
| Striated Heron            | No significant differences (reporting rates); significant regional variation | 38       | Insufficient data     |
| Pacific Baza              | No significant regional variation (possible increases)                       | 39       | Not provided          |
| Fiordland Penguin         | Not provided   |          | Not provided          |
| Little Penguin            | Not provided   |          | Not provided          |
| Black Bittern             | Not Provided   |          | Not provided          |
| Australian Hobby          | Not Provided   |          | Not provided          |
| Peregrine Falcon          | Not Provided   |          | Not provided          |
| Lewin's Rail              | Not Provided   |          | Not provided          |
| Spotless Crake            | Not Provided   |          | Not provided          |
| Little Curlew             | Not Provided   |          | Not provided          |
| Red Knot                  | Not Provided   |          | Not provided          |
| Pectoral Sandpiper        | Not Provided   |          | Not provided          |
| Buff-breasted Sandpiper   | Not Provided   |          | Not provided          |
| Broad-billed Sandpiper    | Not Provided   |          | Not provided          |
| Bush Stone-curlew         | Not Provided   |          | Not provided          |
| Spotted Turtle-Dove       | Not Provided   |          | Not provided          |
| Golden-headed Cisticola   | Not Provided   |          | Not Provided          |
| Brown Quail               | Not provided   |          |                       |
| Mallard                   | Not provided   |          |                       |